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EDUCATION AND RESEARCH IN PROSTHETICS & ORTHOTICS

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Abstract:

Prosthetics and orthotics is a field of knowledge that is experiencing exciting developments in both education and research. The relatively recent recognition and positioning of the profession Prosthetist/Orthotist as a Health Profession in many countries (1) has meant that safer standards of patient care have been promoted through statutory regulation of the profession.

Multidisciplinary teams working in prosthetics and orthotics rehabilitation continue to forge ahead with the development of special clinical interest groups. These groups of rehabilitation professionals can demonstrate a real growth in expertise through a shared interest and associated knowledge exchange in a clinical topic. They have the potential to agree treatment options and so enhance the patient/user rehabilitation experience. Where evidence based practice is compromised because of a lack of scientific evidence, consensus agreement within a special interest group can help to address any gaps in the knowledge base. Further to this, special interest groups can also generate new knowledge and contribute to the evidence base by conducting and disseminating clinical audit and research.

Programmes of undergraduate education in prosthetics and orthotics for student prosthetists/orthotists have seen regional (European) growth that has been assisted by the policies of the European Commission. In particular, the Bologna agreement has meant that countries within the European Union can make use of a prescribed higher education framework for education that describes a number of levels, including Bachelor and Masters level education. Although, there are several pathways of professional education, there is a growing trend for new bachelor programmes for budding prosthetists/orthotists. These programmes combine the disciplines of engineering and health and are more frequently adopting patient centred, case study based learning experiences (2). More established prosthetics/orthotics programmes are enhancing the student learning experience by ensuring a focus on inter-professional learning. Research methods for healthcare are increasingly being taught at undergraduate level to ensure that the graduate prosthetist/orthotist can contribute to evidence based practice.

Conversely, there has been a rather worrying trend for doctors, physicians, surgeons and therapists educational programmes to reduce pre-registration student exposure to prosthetics and orthotics.

Postgraduate education and development is paramount for all professions involved in prosthetic and orthotic rehabilitation services. Continuing professional development can take the form of both informal and informal formal education. Professional skills and knowledge development around critical appraisal of the literature and research methodology should be promoted and supported for rehabilitation professional so that they can play a bigger part in development of patient services. Health services and health insurances are less likely to make investment decisions in clinical services where evidence of service effectiveness is lacking. It is therefore up to clinicians to prove the value of rehabilitation treatment methods and they can do this in partnership with others within special clinical interest groups.

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SEARCHING FOR EVIDENCE IN PROSTHETICS AND AMPUTEE REHABILITATION: A REHABILITATION PHYSICIAN'S PERSPECTIVE

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The philosophical principles of evidence based medicine have existed for a long time , but more recently in the 1990s and currently in the early 21st century has become a hot topic for planners and the public. While originally this applied mainly in the medical model of investigations, drug or surgical treatments the philosophy now quite rightly encompass all aspects of the health care and therefore a more appropriate term like evidence based practice has now been adopted. Throughout my medical career I have developed a healthy scepticism and critical thinking and am not easily persuaded by glossy brochures or sales representative's speech or inducements Unfortunately, in my practice in the field of Rehabilitation Medicine since mid 1980s, especially in the field of prosthetics and amputee rehabilitation good quality evidence to the effectiveness of rehabilitation process and individual prosthetic components and their fabrication techniques had been sparse and not of the highest quality to provide guidance to practitioners for best possible service to their patients. Over the last 10-15 years considerable developments have taken place in prosthetic technology and fitting techniques giving clinicians and patients/users a much wider choice with little quality independent evidence in terms of effectiveness. More often than not the newer innovations are very expensive and not surprisingly the funding bodies are asking for evidence to justify expenditure.

There are several definitions available for Evidence Based Practice but the fundamental principle incorporates

- Best available external clinical evidence
- Individual clinical expertise
- Efficacy
- Safety
- Patient circumstances and preferences

One simple definition by J Muir Gray in 1997 I find useful is" Evidence based clinical practice is an approach to decision making in which the clinician uses the best evidence available, in consultation with patient to decide upon which suits the patient best"

I shall discuss the barriers and bridges to evidence based clinical practice with particular reference
to the issues in the field of rehabilitation of amputees and prosthetics and a possible way forward.

GAIT ANALYSIS IN LOWER LIMB AMPUTEES

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Abstract

Amputee patients often adapt a unique way of ambulating with prosthesis. Observation analysis is not sufficient to note walking complexity. Objective gait analysis consists of measurement technologies designed to capture temporal, spatial, kinematic, kinetic, and muscle activation pattern of an individual's gait. Walking speed, cadence, step length are useful because they provide gross indications of walking ability. Joint kinematics, ground reaction forces and energy expenditure, require more sophisticated equipment that is not practical for clinical purposes. Gait analysis discloses asymmetries between the amputated and sound legs, as well between amputees and non-disabled persons. Amputees' patterns are adopted according to the amputation level and the type of prosthetic components. Quantitative gait evaluations provide objective information to supplement the clinical observation, and it is useful in documenting the rehabilitation progress. Despite limited clinical utility because of its complexity and cost, it is useful to researchers of gait and lower-limb prosthetics.

INTRODUCTION

Prosthesis users typically demonstrate gait patterns that are different from those of able-bodied individuals. The more distal the amputation, the better control the amputee has of his prosthesis, the more efficient the gait, and the more closely their pattern of walking resembles that of ablebodied persons. Even when deviations from a normal gait pattern can be readily discerned in the quantitative data, diagnosing the origin of the problem can be difficult. Gait analysis encompasses a wide range of the temporal, spatial, kinematic, kinetic and muscle activation pattern. Results are presented with large quantities of descriptive measurements and it can take a tremendous amount of time and effort to interpret them. The first goal of gait analysis was the comparison of normal gait pattern with abnormal patterns. Another, difficult part in task of understanding the mechanisms of gait disorders is discrimination of primary mechanisms of abnormal performance from the compensatory mechanisms (1-14).

Kinematic analysis - Temporal-spatial gait parameters

Kinematic procedures measure the motion of the body and limb segments through space during representative walking strides. Temporal-spatial parameters provide fundamental timing and position information about a person's gait; the most common used are walking speed, stride length, step length and cadence. Walking speed probably provides a better indication of a person's walking ability than any other quantitative gait measure (2,3). Amputees have been reported to walk slower than able-bodied persons (2-4,15-17). Dysvascular transtibial amputees have been shown to walk with significantly slower freely selected walking speeds than traumatic amputees (18). The amputee subjects demonstrated a significantly shorter step length with their sound leg than with their prosthesis (0.64 m vs. 0.72 m)(3,19-21). Temporal-spatial measures are particularly useful measurements for prosthetic evaluation because they are simple to acquire and easy to comprehend. Unfortunately, they appear to lack consistency and repeatability as a dependable outcome measure when evaluating prosthetic gait.

Kinematic gait measures

Kinematics provides detailed information about the linear and angular motions of the trunk and body segments. Quantitative gait studies have repeatedly shown that amputees perform different gait kinematics than able-bodied individuals. More proximal levels of amputation demand greater compensatory actions to walk, so deviations from normal movement patterns are often observed in the anatomical joints of the residual limb and of the sound limb. Transtibial amputees tend to walk with similar kinematics as able-bodied individuals, but subtle differences can be distinguished. Primarily, the ankle kinematics of their prosthetic limb will differ from the normal pattern due to the inability to plantarflex in late stance phase. Some of them have reduced prosthetic-side knee flexion in early stance phase of walking (22). On the sound side, excessive stance-phase knee flexion angles during early stance phase have been speculated to be a compensatory action to reduce impact forces due to impaired ability to transfer body weight from the prosthetic limb onto the sound side (23). Transfemoral amputees have

been reported to walk with slightly reduced prosthetic swing phase knee flexion compared with their sound leg or legs of able-bodied persons (24, 25). Although that kinematic data can be useful, there are inconsistencies that have been reported in literature, under comparable testing conditions, therefore, kinematic data do not appear to be particularly useful as outcome measures for prosthetic ambulation.

Kinetic gait measures

Kinetic analysis is used to determine the net forces and torques (moment) exerted on the body as a result of the combined effects of the ground reaction force, inertia, and muscle contraction. Kinetic analysis requires the simultaneous collection of kinematic information and ground reaction forces, which are collected when subjects walk over force plates. These measures may relate to the user's perception of the interaction between their residual limb and the prosthesis during walking. Persons with unilateral transtibial or transfemoral amputations have been reported to walk with decreased vertical and fore-aft ground reaction forces under their prosthetic limb compared with able-bodied individuals, whereas the forces under their sound limb are slightly greater (26,24,27). Amputee subjects consistently demonstrate reduced ankle power in late prosthetic stance phase but increase power generation by the anatomical knee and hip joints of their residual limbs, compared with ablebodied ambulators (28). Kinetic measures of walking are useful because they convey information that cannot be discerned visually by an observer, and they may directly relate to what the prosthetic user perceives while they walk. Research studies have failed to demonstrate consistent results in kinetic measures, therefore, kinetic data do not appear to be reliable clinical outcome measures for assessing prosthetic gait performance.

Energy expenditure

The energy cost has been shown to increase with more proximal levels of leg amputation (29,30). At freely selected speeds, unilateral transtibial amputees have been reported to expend approximately 9% more energy than able-bodied individuals, unilateral transfemoral amputees approximately 49% more, and bilateral transfemoral amputees nearly 280% more (29,30). Significantly greater energy cost was measured in vascular amputees compared with traumatic amputees..The inconsistency in energy expenditure measures between studies that have similar experimental protocols currently without a satisfactory explanation.

EMG gait analysis

Dynamic electromyography (EMG) is used to determine the timing of muscle activation and to crudely estimate the relative magnitude of muscle contraction during gait cycle. It is synchronized with kinematic and kinetic data, thus allowing inference about the muscular sources of force and motion abnormalities of prosthesis user (21).

CONCLUSION

Quantitative gait analysis is recognized as being useful for providing an objective assessment about amputee person gait and for documenting progress as a person undergoes rehabilitation. They can be beneficial for verifying visual observation, providing objective measurements that substantiate a subjective assessment and for identifying and addressing differences in a prosthetic user's gait from normal. However, at present, quantitative gait analysis does not appear to be particularly useful for assisting the prosthetist for diagnosing problems with the prosthesis. Because computerized 3-D gait analysis is complex and time-consuming, it may be reserved for the more difficult cases, or those who have persistent difficulty with the fit or alignment of their prosthesis. Clinical motion data need to be expressed in an automated, understandable and concise form for clinicians to identify and treat pathological human movement. Interpretation of clinical motion data has been confined to experienced clinicians familiar with the graphical output due in part to the difficulty in visualizing motion and biomechanical parameters. For the time being, it is important that we continue striving to effectively integrate these measurements with the experience and skill of the prosthetist and the subjective feedback of the prosthetic user.

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GUIDELINE DEVELOPMENT FOR PROSTHETIC PRESCRIPTION IN LOWER LIMB AMPUTATION

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In the year 2000, a Prosthetics and Orthotics Guideline Development Group within the Dutch Society of Physical and Rehabilitation Medicine (VRA) was commissioned by the Dutch College of Health Care Insurances (CvZ) and the Ministry of Health Care to develop a clinical guideline on prosthetic prescription in lower limb amputation. The aim of this Prosthesis Guideline Development project (Proguide) was to develop a guideline on a scientific basis.

In the Netherlands a prosthesis is commonly prescribed by a medical doctor in Physical and Rehabilitation Medicine (MD in P and RM) in collaboration with a Certified Prosthetist (CP) and sometimes based on the advice of a treating Physical Therapist (PT). Experience plays an important role in the prescription process, which implies that a clear evidence-based motivation for the choices made cannot always be given. This fact leads to unintended and undesirable local prescription variations as well as to possible overuse or underuse of prosthetic care and a lack of transparency for consumers and health insurance companies.

In this perspective, a first clinical guideline was developed in order to achieve more consistency and cost-effectiveness in daily clinical practice. The methodology used was based on the gathering of scientific evidence (from the literature) and opinion-based knowledge (from Delphi panels) to create a first basis. Because there appeared to exist considerable gaps in our formal clinical knowledge concerning the effects of different prosthetic components on human functioning, the evidence-based part necessarily made a smaller contribution to this first guideline than the expert opinions.

Fortunately, through observations in daily practice and interviews with professionals quite a lot of knowledge about the functioning of users of lower limb prosthesis became available. A wide range of prosthetic components was used for the three levels of amputation under investigation (trans-femoral, knee-disarticulation and trans-tibial). Because of the good agreement on several aspects of prosthetic prescription, some relevant criteria used by the majority of the professionals became explicit. For instance, the level of personal activity was mentioned by many as an important factor when prescribing a prosthesis to lower limb amputees.

The formal, clinical and technical knowledge so obtained was then integrated by way of a formal consensus procedure, for which the Modified Delphi Technique was used, developed by the RAND Corporation. With the structuring of the group communication process and the possibility to express personal judgment anonymously, the Delphi method appeared very useful. In the Netherlands this project was the first in which the three key disciplines in the field of lower limb amputation and prosthetics participated in such a group process. The reaction of the participants was enthusiastic with regard to design, procedure and the overall results of the round table session, which implies that the next phases in the guideline development process will receive sufficient support from the field.

After the Delphi procedure, the project team modified the formal evidence and the statements and opinions expressed into a first clinical guideline for prosthetic prescription. Besides the level of amputation, the level of activity forms the starting point from which choices can be made for various prosthetic components. Criteria regarding personal characteristics of the patients determine the essential steps in the prescription process. Individual adjustments can be made based on specific aspects related to clinical characteristics (e.g. skin condition, muscles strength, cardiopulmonary condition, joint mobility), daily life circumstances and, if applicable, employment situation.

The clinical use of a guideline ultimately depends on its applicability in daily practice as well as its usefulness in terms of effectiveness and control of costs. Therefore, the guideline development is continued with a project to follow up the described process of guideline development by conducting 2 studies. In the first (cohort) study, the applicability of the preliminary guideline will be evaluated from various perspectives (caregiver, patient, researcher) in order to further optimize the guideline. Several clinical factors (e.g. amputation level, and activity level) will be tested as possible determinants of applicability. After optimization of the guideline, a second (cost-effectiveness) study will be conducted to test whether use of the guideline actually leads to better functional outcome (both in terms of activity level and patient satisfaction) and/or better cost-effectiveness. The second phase will end with a plenary evaluation of the outcome of both proposed studies among expert profession-

als, which will result in a final trajectory for implementation and dissemination of the guideline.

RELEVANCE

In the Netherlands the incidence of major lower limb amputation is about 19 per 100.000 inhabitants. These include amputations from the transmetatarsal to the transpelvic level. In an amputee population in the north of the Netherlands, approximately 82% of the total number of lower limb amputations occurred as a result of vascular disease, 9% were traumatic amputations, and 9% had anoncological origin (period 991-1992). In the Netherlands, 86% of all lower extremity amputations are trans-femoral (TF) amputations (34%), knee disarticulations (KD) (10%) or trans-tibial (TT) amputations (42%). Of all lower limb amputees, approximately 50% are eventually fitted with a limb prosthesis.

There is a growing interest in clinical guidelines particularly regarding the provision of medical aids. An important reason is found in changes in the health care system in the near future. In the Netherlands there has been an increase in costs of medical aids in general of 12,5% yearly in the last 5 years. The costs of limb prostheses amount to 22 million euro last year. This is one of the reasons for the Dutch College of Health Care Insurances (CvZ) and the Ministry of Health Care to require more insight in prescription criteria and related costs of medical aids.

In general, the definition of a clinical guideline is as follows: systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances. This definition emphasizes the clinical guideline as a practical instrument for daily practice and, therefore, as a support in taking decisions in specific clinical situations both for professionals and patients. Two important objectives of clinical guidelines can be identified. Firstly, it can be considered as the reflection of a state of the art knowledge base in a clinical discipline. From this perspective, it can be the starting point for the collaboration of a number of disciplines, which are involved in a specific form of health care. Secondly, a guideline can serve as an instrument for external regulation, because it provides professional insight for third parties, such as health insurance companies and the government. From this perspective, it can serve as a tool to monitor effectiveness, costs and quality of care. In addition, with regard to a guideline for lower-limb prosthetic prescription, potential users will be offered more insight in the prescription process and the different prosthetic options.

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ASSESSMENT OF FUNCTIONALITY OF PROSTHETIC HANDS USING THE SOUTHAMPTON HAND ASSESSMENT PROCEDURE

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Abstract

There is increasing recognition of a need to measure the functional outcomes of treatment in all fields, including prosthetics. There are different aspects of the process of development and application of prostheses from the laboratory to the home. As part of this collective need different tests exist (or are being developed) which address some parts of this requirement. The Southampton Hand Assessment Procedure is one such tool.

INTRODUCTION ASSESSMENT

The lifecycle of a prosthesis can be divided into four broad areas, from Research through Development, to Clinical and Domestic application. In each area there is a different interest from the professionals, and each group has a different way of measuring success. There are three domains that are measured by these groups: Function, Activity and Participation, these categories are based on the World Health Organization International Classification on Functioning, Disability and Health (WHO ICF) (1). As the prosthesis moves from design to field use the different measures become more or less appropriate, and it is necessary to develop different tools to suite the different areas.

Southampton Hand Assessment Procedure (SHAP) was originally devised to quantitatively assess the functional range of prosthetic hand systems, fitting it within the first two areas of research and development and it is activity based (2,3). As it was developed it became clear that it was useful for injured, and healthy hands as well.

The tool was designed to be a more practical method for use in a busy clinic, thus it was made portable, simple to use and easy to interpret. It aimed to produces a metric that reflected the physical capabilities of the hand under study. The result was a test that requires only twenty minutes to complete and produces a simple numerical score out of one hundred, rating the overall hand function.

METHODS AND SUBJECTS

Methods

The test uses a form-board and self-timed tasks. The tasks are divided into two sections; the first are abstract objects of two different weights, designed to encourage the use of six standard grip patterns. This is then followed by 12 simulated Activities of Daily Living (ADLs). While not all grasps are possible for conventional prostheses this test was devised to allow for prostheses that do allow these grasps.

To perform the test the items are placed on the areas of the board as specified and the user starts the timer, performs the task and stops the timer. It is this time, compared against a normalised population, that leads to the measure.

The test combines aspects of the existing systems into a procedure that is fast enough to be completed in the short time span specified. Particularly important is the reproducibility of the tasks. The activities of daily living are mostly mono-manual, hence they test the ability to use the prosthesis in the dominant role. While it is true that this is not the usual role for a prosthesis, this is the simplest way to gauge the effectiveness of the device as a manipulator.

The resulting score is the combination of sub scores for each of the grips and are combined so that the overall score reflects the importance a particular grip has in daily living, and so the score indicates the use that grip is to a person. Validity tests have been undertaken with inter rater and other tests of reliability. SHAP can be used to measure different designs of hands as well as progress following treatment or injury.

The study described here looks at two experiments to measure the functional effectiveness of prostheses designs. The first compares a single hand design with different sizes as used by different wearers. The second compares multiple designs in more detail by using a single operator and repeated measures on different designs of hand and wrist.

Subjects

Experiment 1
A group of eight users with transradial loss using conventional prosthetic hands was tested. The hands were electrically driven with myoelectric controllers in conventional Voluntary Opening, Voluntary Closing format. All the mechanisms have an anthropomorphic form, set in a tips type grip. Each used a self-suspending socket over the olecranon. Three had powered wrists.

Experiment 2
The author was fitted with a self suspending socket over his left (non dominant) hand and performed the tests with Otto Bock, Motion Control and Touch Bionics handson a daily basis.

RESULTS

There was a measurable difference in the scores between the smaller and larger Otto Bock hands (significant at the 2% level): Large 68 (+/- 14.3), Small 28 (+/- 14.2), (paired t-test with unequal means). This result suggests that hand size is an important factor in the its functional capabilities.

The repeated measures show that although the Motion Control had passive wrist flexion as an option it does not effect the functional capabilities of the hand as measured with the SHAP score. Although the Touch Bionics hand has a weaker grip than the other prosthesis the range provided by the fully curling independent fingers mean that it can grasp more objects in a more natural and enclosing grip such that greater prehension force is not required.

DISCUSSION

The limited gape of a conventional prosthesis limits the functional capabilities more than the speed of prehension or the availability of wrist flexion. However when wrist flexion was used the body motions required to operate the hand were easier and required fewer compensatory motions, while it did not impact greatly on the overall scores.

CONCLUSION

The SHAP was designed to give simple assessment of the functional capabilities of the hand and as such can highlight where improvements can be made in the design and application of the devices.

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MEASUREMENTS AND EVALUATION OF HUMAN GRASPING

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Abstract:

In the paper methods and devices for measurement and evaluation of grasping in the rehabilitation environment are proposed. Investigation of grasping was divided into three phases: reaching to grasp an object, exerting force on the object, and changing the orientation of the grasped object. The original methods are computer based and provide quantitative evaluation of grasping. Reference pattern of grasping was obtained by measurements performed in healthy persons. Assessment of grasping force and training of grasping was performed in groups of patients with various etiologies.

INTRODUCTION

Grasping is such an everyday activity that it is difficult to imagine, why grasping would be an interesting object of research. Nevertheless, we can state that grasping is the most important human motor ability. Grasping food and bringing it close to the mouth certainly is a proof for this statement (1, 2). Another question arises, why grasping is of interest in engineering environment. The answer lies in development of ever more complex man-machine interfaces, multifingered robotic hands, and prosthetic or orthotic devices. Our aim is, however, to design devices and methods enabling assessment and quantitative evaluation of grasping abilities before and after various rehabilitative interventions in people with special needs.

Our studies of grasping are divided into three phases. In the first phase the fingers are approaching the object to be grasped. In the second phase the fingers are exerting forces onto the object, while in the last phase the position and orientation of the grasped object is changed by appropriate finger movements.

HAND APPROACHI NG PHASE

Preshaping of the fingers according to the shape of the object is characteristic for the approaching phase. Three objects were selected in experiments: thin plate, block, and cylinder. The objects were by the use of magnetic contact attached to the endpoint of a robotic manipulator. The task of the robot was to place the objects in different positions and orientations in the subject's workspace. Robot also randomly introduced perturbations of the object position or orientation. Five infrared markers were placed on the fingertips together with additional three markers attached to the dorsum of the hand. The preshaping of the fingers was evaluated by defining a pentagon connecting the five fingertips (3). Reaching and pointing hand movements were also studied by the help of haptic robot and virtual environment (4). In virtual environment, a labyrinth was created at the start of each test. By moving the end point of the haptic robot, the subject was able to move the pointer through the labyrinth and to feel the reactive forces of the wall. The subject's primary task was to pass the labyrinth as quickly as possible, with a few collisions with the walls as possible. The test was applied to subjects with various neurological diseases and also to subjects after amputation.

Figure 1: *A compact assessment system with two force measuring units in the shape of a cup and thin plate can be connected to a personal computer to accurately measure the dynamic grip force in cylindrical and lateral grip.*

GRASPING PHASE

An original tracking system for the assessment and training of grip force control was developed (5). The system consists

of two measuring objects enabling assessment of power and precision grip (Figure 1). It can be connected to a personal computer for visual feedback and data acquisition. The task requires the patient to track the target signal on screen by applying appropriate force to the grip-measuring device (Figure 2). The target signal is presented with blue ring moving vertically in the centre of the screen. The applied force is indicated with a red spot. When the grip force is applied, the red spot moves upwards. The aim of the task is to continuously track the position of the blue ring by dynamically adapting the grip force to the measuring unit. The complexity of the task is adjusted by selecting the shape of the target signal, e.g. ramp, sinus, rectangular shape, setting the level of the target force, and changing the dynamic parameters, e.g. frequency, force-rate. The results in healthy subjects showed significant differences in grip force control among different age groups. In a patient after Botulinum-Toxin treatment the method revealed noticeable effects of the therapy on patient's tracking performance. Training with the tracking system showed considerable improvements in the grip force control in 8 out of 10 stroke patients. The systems was tested also in a group of users of orthoses.

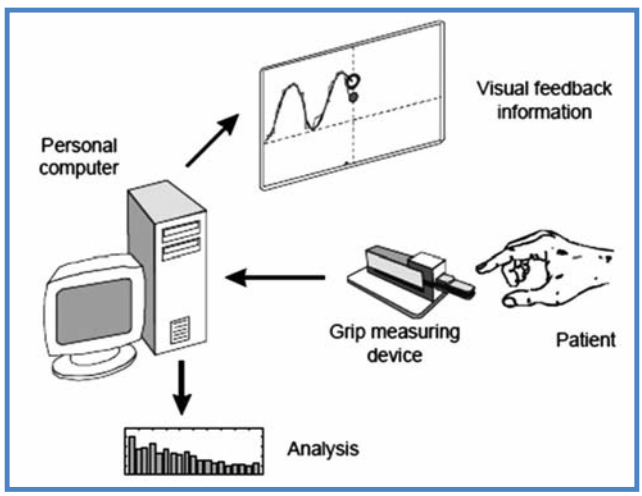

Figure 2: *Grip force control was assessed using the force tracking task where the patient applied the grip force according to the visual feedback from the computer screen.*

HAND DEXTERITY PHASE

An original assessment approach was developed with the aim to evaluate the grip dexterity (6). In this case the subject holds an object with the fingertips and changes its orientation. The movements of the fingers, wrist, and forearm were observed. The subject was sitting in front of computer screen, while holding a block with his fingertips. Six infrared markers were attached to the block. The position and orientation of the block was assessed by six OPTOTRAK cameras. The block was then displayed in the virtual environment within the same orientation as in the real world. In the same time a reference semi-transparent object was displayed on the screen in another orientation. The task of the subject was to align both objects. In further studies of hand dexterity a new isometric device for multi-fingered grasping in virtual environments was designed (7). The device was aimed to simultaneously assess forces applied by the thumb, index, and middle finger. A mathematical model of grasping, adopted from the analysis of multi-fingered robot hands, was applied to achieve interaction with virtual objects. The movements of virtual object corresponded dynamically to the forces and torques applied by the three fingers. The training tasks were designed to train patient's grip force coordination and dexterity through repetitive exercises.

CONCLUSION

Three original approaches to measure and evaluate human hand functionality are described in the paper. The simple device enabling assessment of forces during power and precision grasping was extremely well accepted in clinical environment, both from the side of patients and therapists. Several prototype devices were, therefore, built and distributed for further clinical evaluation to rehabilitation centres in Slovenia and also Australia and Romania. Slovenian producer of medical equipment is interested into production of the grasping force tracking system providing evaluation and training of grasping in patients with various etiologies.

In all three approaches computer measurements were introduced enabling quantitative estimation of human hand functionality. With some of the approaches described virtual reality was used. Virtual reality is a powerful tool providing the patients with repetitive practice, feedback information, and motivation to endure practice. Another advantage of virtual reality rehabilitative systems is the possibility of the adaptation of the training task to the capabilities of individual patient. In this way training in virtual environment can start at an earlier stage than training in real environment. Execution of skilled tasks rather than simple movements induces improved results of the training process.

Acknowledgements

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THE WILMER ORTHOSES FOR THE UPPER EXTREMITY

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Abstract

Orthoses may be instrumental in the treatment of different pathologies. The design of an orthosis should be based on sound mechanical analysis of the specific force patterns between the body and the orthosis. The WILMER shoulder orthosis effectively neutralizes a shoulder subluxation by creating a controlled misbalance between the forces acting on the forearm and those acting on the upper arm. The WILMER elbow orthosis enables patients with a paralysed elbow to actively flex their flail arm again. A purely mechanical spring mechanism compensates the gravity forces acting on the forearm of the patient. An automatic locking mechanism enables the patient to retain the flail arm in two positions.

INTRODUCTION

Sound biomechanical analysis should be at the basis of the management of functional impairment of the upper limb (1). Orthoses are among the many treatment options. Orthoses fulfill their task by the exertion of forces onto the anatomical structures. Depending on the upper limb segments involved, and depending on the functional requirements a specific pattern of forces between the orthosis and the body is needed. Each functional loss, in combination with personal wishes and demands, results in a different orthotic design. However, every orthosis needs to fulfill some basic requirements concerning cosmetics, comfort, and control (2). Two examples of orthotic management of the upper limb are elucidated below.

THE WILMER SHOULDER ORTHOSIS

Introduction

The WILMER shoulder orthosis is designed for patients who suffer from a complete paralysed arm as a result of a brachial plexus lesion or a hemiplegia. The basic functions of the orthosis are the neutralization of a shoulder subluxation and the suppression of oedema by horizontal positioning of the forearm. The biomechanics of this orthosis has been described previously (3). Here, the description is limited to the main features of the orthosis.

Methods

Because of cosmetics patients desire to wear the orthosis underneath their clothes. That means neither the mitella nor the hemisling can be used. This is not a pity, because both devices are unsuitable for the neutralization function, as can immediately be concluded from a mechanical analysis, Figure 1. Because the action line of the suspension force lies distally to the center of gravity of the bent arm no subluxation correcting force can exist. Displacement of the action line of the suspension force proximal to the center of gravity results in an attractive orthosis structure. The total system acts like a balanced arm, Figure 2. The weight of the forearm forces the upper arm upwards, thereby neutralizing a

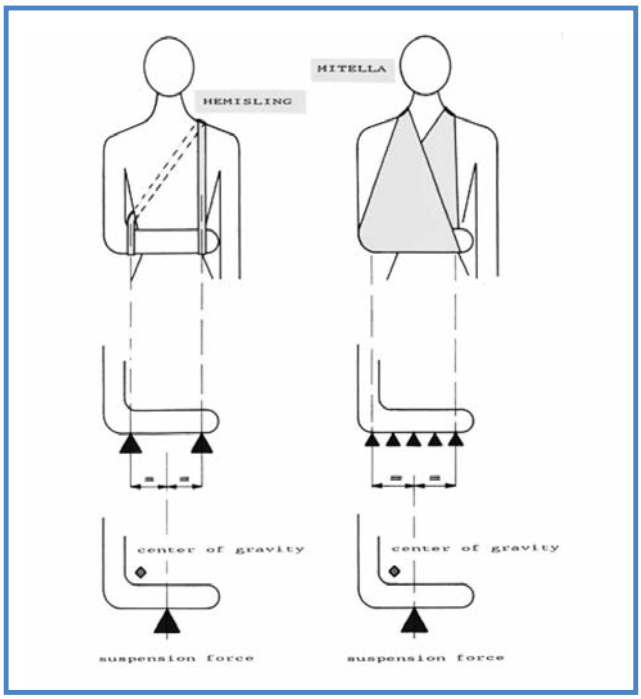

Figure 1: *The action line of the effective suspension force of a mitella or a hemisling lies distally to the centre of gravity of the bent arm. Therefore, no subluxation correcting force can exist.*

shoulder subluxation. The suspension point needed is created by a tension band that suspends the arm on the shoulder. A shoulder cap transmits the suspension force to the body. A chest strap keeps the shoulder cap in place. All components are situated near the limb and therefore the orthosis can be worn underneath the clothing without problems.

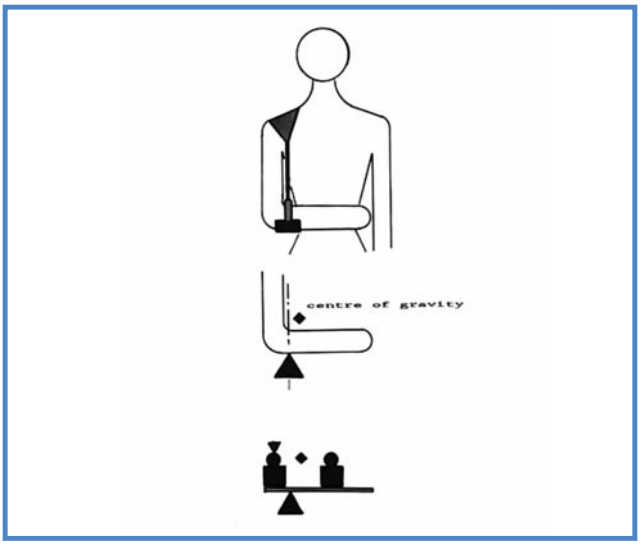

Figure 2: *Displacement of the action line of the suspension force proximal to the centre of gravity results in an attractive orthosis structure. The total system acts like a balanced arm.*

Results

The WILMER shoulder orthosis, Figure 3, offers an effective neutralization of a shoulder subluxation. Because of the horizontal position of the forearm oedema is suppressed and pain is reduced. Wearing the orthosis reduces arm sway, therewith reducing the risk of injuries. The orthosis allows for passive exo/endo rotation of the humerus. The WILMER shoulder orthosis is comfortable to wear, easy to don and doff, and invisible to wear, underneath the clothing; which gives a cosmetic appearance. The total mass of the orthosis is 200 g.

Discussion

The WILMER shoulder orthosis is the only device known that effectively neutralizes a shoulder subluxation. Many other subluxation orthoses use a humeral cuff to support the mass of the patient's arm. These systems are not capable of neutralizing the subluxation for a prolonged period of time. The humeral cuff supports the arm by friction forces on the skin only. Skin reacts to friction by creeping in a direction opposite to the friction force thereby trying to restore the normal skin position. As a consequence, the initial neutralizing action of the orthosis is lost.

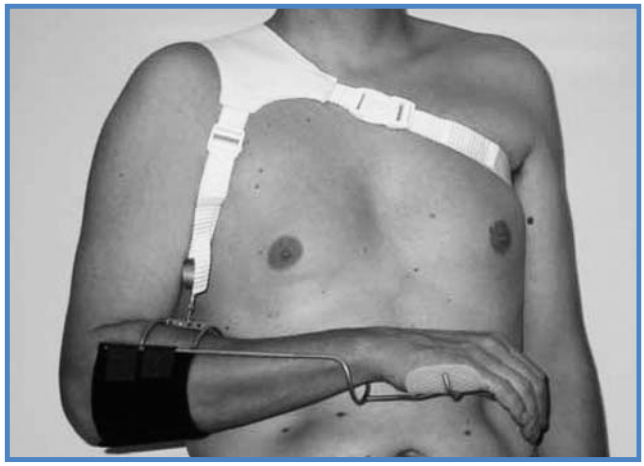

Figure 3: *The WILMER shoulder orthosis. The arm is suspended from the shoulder. The weight of the forearm forces the upper arm upwards, thus neutralizing a shoulder subluxation.*

THE WILMER ELBOW ORTHOSIS

Introduction

The WILMER elbow orthosis is a dynamic orthosis designed for patients with a paralysed elbow due to a brachial plexus injury or due to hemiplegia. A paralysed elbow can be brought into flexion by shoulder abduction angles over 90°. However abduction angles that great are not acceptable both functionally and cosmetically.

Methods

By adding an orthosis to the paralysed arm a decreased abduction angle necessary for full elbow flexion results. A spring mechanism in the orthosis almost fully compensates gravity forces acting on the forearm. This way the elbow is kept extended at very small abduction angles whereas an abduction angle of approximately 30° initiates full elbow flexion. The WILMER elbow orthosis, Figure 4, is a unilaterally construction with two hinged frame bars made from stainless steel tubing. A force analysis of the orthosis shows a one sided hinge to be free from torsion moments during normal operation. Also in the locked position a one sided hinged orthosis is only loaded in the rotation plane of the hinge.

Moreover, one-sided hinged orthoses benefit cosmetics by their unilateral construction, and favour the comfort of wearing by a reduced weight and easy donning and doffing.

The orthosis is fitted to the patient's arm by two fittings on either side of the elbow joint. This way the orthosis only loads the skin with normal forces, not with shear forces. The fittings themselves are made from perforated plastic

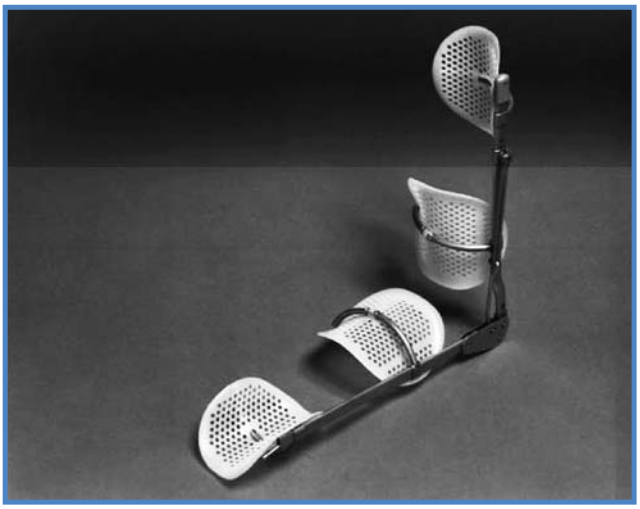

***Figure 4**: The WILMER elbow orthosis*

sheet material. In this way perspiration is not hampered. The fittings are supported only in their centre so they can automatically adapt to the shape of the arm of the patient.

A locking mechanism is added to the orthosis to enable the patient to retain the flail arm in the flexed position independent of the abduction/anteflexion angle. In this locked position the arm + orthosis is suitable to lift and carry objects. A second locking position at the near-extended arm enables pushing or clamping of objects, and facilitates easy donning and doffing of the orthosis. The locking mechanism operates automatically and is controlled by the patient with his or her handicapped side. This locking mechanism can restrain some activities, like driving a car. Therefore, the locking mechanism can be switched off by pulling a knob located at the wrist-region.

Results

The WILMER elbow orthosis actually restores some elbow function. The automatic locking mechanism enables manipulation of the environment, and facilitates easy donning and doffing. The orthosis is comfortable to wear because of the body adaptive perforated fitting areas, and because of the low mass. A complete elbow orthosis weighs approximately 150 g. The WILMER elbow orthosis is invisible to wear underneath the clothing at the medial side of the arm, and therefore offers a cosmetic appearance.

Discussion

The WILMER elbow orthosis is the only device known that facilitates active elbow flexion in a purely mechanical fashion.

CONCLUSION

Basic biomechanical principles and a good understanding of the inevitable force patterns have resulted in the design of attractive and effective orthoses for the upper limb. The WILMER shoulder orthoses is the only orthosis known that neutralizes a shoulder subluxation. The WILMER elbow orthosis enables someone with a flail arm to actively flex and extend the elbow again, whereas the locking mechanism of the orthosis offers several functional advantages for the wearer.

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OUTCOME MEASUREMENT OF ADULT UPPER LIMB AMPUTEES

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Abstract

Fifty-five subjects after unilateral upper limb amputation were assessed with OPUS Upper Extremity Functional Status (a questionnaire specifically developed for upper limb amputees) and ABILHAND (a generic measure for subjects with upper limb impairments). Results were analyzed according to the Rasch model. Both scales had some weaknesses, needed rating-scale modification, and had too few difficult and too many easy activities for most of our subjects. Combining both into one scale would produce a better targeting of item difficulty to subject ability.

INTRODUCTION

The last years have seen a very rapid development in the field of upper limb prosthetic components and care. Several new myoelectric prosthetics such as hands, wrists, elbows and also a myoelectric shoulder have been developed. With target muscle reinnervation it is now possible to have multiple control sites (1), allowing the clinician to combine several myoelectric components in subjects with high or bilateral amputations. Most of these components and procedures are expensive, hence the need for objective evaluation of their effectiveness.

There are several modes for measuring outcome in subjects after an upper limb amputation, e.g. degree of hand function, amputee's level of functioning, quality of life and also satisfaction with prosthesis. At all levels, it is possible to use generic or pathology-specific outcome measures. The measure used must demonstrate sound psychometric properties.

In recent years, there has been a growing trend to use the Rasch model to facilitate the development and validation of outcome instruments (2). Rasch analysis provides psychometric information that is not obtainable through classical test theory (3, 4), including: 1) the functioning of rating scale categories; 2) the validity of a measure by evaluating the fit of items to the latent trait; and 3) the consistency of item difficulty with the expectations of the construct (and hence a description of the range and hierarchical relationship of the variable). In fact, Rasch analysis has been recommended as a method for assessing scale properties in addition to classical psychometric criteria for reviewing and assessing surveys and questionnaires for disability outcome research (5).

The purpose of this study was to evaluate and compare two outcome measures, the OPUS Upper Extremity Functional Status (OPUS-UEFS, a questionnaire specifically developed for upper limb amputees) and ABILHAND (a generic measure developed for subjects with upper limb impairments).

METHODS AND SUBJECTS

Methods

Clinical data (age, age at time of amputation, cause of amputation, time since amputation and fitting with the first prosthesis, dominance before amputation, types of prosthesis used) were collected via structured interview. Subjects were also interviewed with ABILHAND (46 items, 5-point rating scale) (6) and OPUS-UEFS (23 items, 5-point rating scale) (7). Results were analyzed by WINSTEPS software (8). The following aspects underwent Rasch analysis: 1) the functioning of rating scale categories; 2) the validity of a measure by evaluating the fit of items to the latent trait; and 3) the consistency of item difficulty with the expectations of the construct (and hence a description of the range and hierarchical relationship of the variable).

Subjects

Fifty-five adults, 42 (76.4%) men and 13 (23.6%) women who had had an upper limb amputation and had completed rehabilitation at the Institute for Rehabilitation in Ljubljana at least one year prior were included in our study. At the time of testing subjects had a mean age of 55 years (s.d. 17.4 years, range 19-85) and the amputation had occurred on average 31

years before testing (s.d. 17.2 years, range 1-61). Thirty-seven subjects had trans-radial, 9 trans-humeral and 2 partial hand amputation, 4 wrist and 3 shoulder disarticulation. At the time of testing 44 subjects wore passive, 7 body-powered and 2 myoelectric prostheses.

RESULTS

The rating scale diagnostics showed that some levels of the rating categories did not comply with the criteria for category functioning. The criteria were met by combining levels 1 ("very difficult") and 2 ("slightly difficult") of OPUS-UEFS, and category 3 ("slightly difficult") and 4 ("very difficult") of ABILHAND into a single category. After this rating-scale modification, 12 of the 46 ABILHAND items resulted redundant ("overfit"), 8 did not behave according to the Rasch model ("misfit") and 8 showed a marked dependency of the measure on study group characteristics such as age, sex, level of amputation and dominance (differential item functioning, DIF). Two of the 23 OPUS-UEFS items misfitted and none overfitted. Among the remaining items, 7 were the same in both questionnaires.

DISCUSSION

The purpose of this study was to evaluate and compare two outcome measures, the OPUS-UEFS and ABILHAND. Both misfitting items from the OPUS-UEFS were the same as in our previous study (7). Most of the overfitting items are very easy items, usually performed by one (the dominant) hand only and probably too easy for our subjects. On the other hand, most misfitting items are the hardest ones to perform, usually done by both hands. Because we included only amputees several years after amputation, some of them had developed compensatory strategies for performing these activities in an easy way or avoid doing them.

The main advantage in using a general outcome measure for upper limb impairments is its ability to permit comparisons between subjects with different upper limb problems (i.e. amputees, stroke patients, patients with rheumatoid arthritis and others). For instance, half of the ABILHAND items that had no fitting problems in our population are the same as described for stroke patients (9) and the order of difficulty is similar. On the other hand, as shown by the items that demonstrated DIF in ABILHAND, a specific measure could be more appropriate to provide insight on the effect of the prosthetic device on the subject's functional status.

After combining the two measures into a new one, to test if its metric properties were satisfactory we performed preliminary analysis which resulted in a Rasch model that covered the study population better than ABILHAND or OPUS-UEFS alone.

CONCLUSION

Both scales have some weaknesses, in particular not enough very hard activities and too many easy activities for most of our subjects. Promising results, in terms of a better agreement between subject abilities and item difficulty, were obtained by combining both scales into a new one. Further studies are needed to give more reliable psychometric information on the new scale.

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EVIDENCE ON TREATMENT OF IDIOPATHIC SCOLIOSIS

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INTRODUCTION

The aim of the lecture is to find criteria for a successful treatment of idiopathic scoliosis with TLSO. First, the diagnoses "idiopathic scoliosis" has to be narrowed. On the other hand limitations of bracing have to be discussed.

METHOD

234 patients with an idiopathic scoliosis (Cobb angle 20°-50°) were evaluated. Measurements were taken on standing radiographs (ap) and were taken before therapy, six months later and at least one year after weaning of the brace. Compliance was judged with a compliance score and two groups with good and bad compliance were formed.

RESULTS

Patient with good compliance (n-188) and also good initial correction (n-136), a continuous correction of about 7° Cobb angle was evident. Patient with good compliance but bad initial correction (n-45) can only expect a stop of progression. Patient with bad compliance (n-47) have shown progression of curvature with high variation (32.°±6.° to 37.°±9.°). The result is highly influenced by primary correction and compliance. The result at the end of therapy depends on the Cobb angle at the begin of therapy.

DISCUSSION

Patient with good initial correction and good compliance can expect a continuous reduction of the curvature.

The reason of a bad initial correction in the brace has to be multifactorial: rigidity of the curvature, maturity, rotation or lack of brace effectiveness. In patient were only bad initial correction can be reached the influence of compliance to the final outcome is low. A stop of bracing has to be discussed. Patient with a good initial correction but bad compliance have to be motivated for therapy.

CONCLUSION

The results depends on the Cobb angle at the begin of therapy, brace correction and compliance. But a higher Cobb angle at begin of therapy cannot be compensated by compliance.

THE USE OF ANKLE-FOOT ORTHOSES FOLLOWING STROKE

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Abstract:

This presentation will review the principles governing prescription of ankle-foot orthoses for patients following stroke. Normal gait biomechanics and the pathological biomechanics of stroke gait will be reviewed, and the biomechanical principles underpinning lower limb orthotic intervention will be presented. Important details of orthosis specification will be discussed, including the most appropriate angle of plantar/dorsiflexion in the orthosis. Common errors in orthotic provision will be addressed, including inappropriate use of mechanical ankle joints, and failure to accommodate shortening of the gastrocnemius. The critical issue of "fine-tuning" the orthosis (adjusting the final angle of tibial inclination) in order to optimise kinetics and kinematics in the critical late stance phase will also be discussed. Early results of recent research on the ability of an ankle-foot orthosis to improve the kinetics and kinematics of the hip joint will be presented. Clinical examples will be used to illustrate these concepts.

INTRODUCTION

Prescribing the correct ankle-foot orthosis (AFO) following stroke is problematic to many clinicians. The range of available options is extensive, and some of the published research is confusing, often providing inadequate detail about the design characteristics of the AFO being studied. This makes it difficult to prescribe with confidence. This presentation will review the prescription recommendations contained in the final report of the consensus conference on the orthotic management of stroke patients organised by the International Society for Prosthetics and Orthotics (1), before going on to discuss some of the finer points of AFO design. An approach based on an understanding of the biomechanical features of normal gait, an ability to comprehensively identify the critical elements of the pathological gait of the patient, and a recognition of the biomechanical requirements of the orthosis, will be presented as a prerequisite to informed prescription.

GAIT OF STROKE PATIENTS

All too frequently the rationale for prescribing an AFO post-stroke is to address the problem of a "dropped foot", but it should be obvious that many stroke patients face significantly greater challenges to their mobility than simple swing phase equinus. While it is true that in the early stages of recovery the foot and ankle are indeed often flaccid, leading to difficulty clearing the toes during swing phase, over time the presentation commonly changes to one in which the foot and ankle posture into a more typical position of persistent plantarflexion and supination. Many of the problems encountered in hemiplegic gait are directly related to the abnormal stance phase biomechanical situation that this creates. Logically therefore, an important objective of any orthotic intervention should be to attempt to "normalise" the stance phase biomechanical environment, as much as possible.

An AFO can potentially have much greater influence on stance than on swing (2). The gait of many stroke patients is adversely affected by stance phase plantarflexion, caused by increased tone, spasticity or shortening in the plantarflexor muscle group. The biomechanical consequence of this stance phase plantarflexion is anterior displacement of the point of origin of the ground reaction force (GRF), with the consequence that an excessive external extension moment is generated at the knee throughout stance phase, leading to knee hyperextension. This abnormal GRF alignment also creates an equally problematic external flexion moment at the hip (causing flexion) at a stage in gait when an external extension moment is normal. Correct application of an AFO manipulates and realigns the GRF close to the centres of the knee and the hip throughout stance, thereby improving the knee extension moment and, importantly, the hip flexion moment (3,4). In an ideal situation the orthosis helps to create an extension moment at both joints in mid-late stance, which is a biomechanically desirable condition. Close alignment of the GRF to the proximal joints also reduces the demand on the neuromuscular system.

ANKLE ANGLE OF AFO

A number of authors have reported on the importance of the angle of dorsiflexion in an AFO if hyperextension of the knee is to be controlled (5-7). This suggests that dorsiflexion is necessary to normalise the bending moments about the knee, to control hyperextension, and to ensure effective forward progression of the body over the affected limb. However, this is rather an over-simplification. In truth it is the angle

of inclination of the tibia relative to the ground in stance that is the important factor, rather than the angle of dorsiflexion per se. If an orthosis must hold the ankle in plantarflexion, for example in the presence of a contracture, the angle of the tibia can still be inclined by adjusting the heel height of the footwear and by using heel wedges. Some degree of tibial inclination is normal in mid-stance (8). At end stance, both the tibia and the femur should be inclined (9). This is necessary if the GRF is to be aligned in front of the knee and behind the hip, creating the desired external extension moments at both joints. Simultaneous extension moments at the knee and the hip passively stabilise both joints, and improve the ability of the limb to support body weight in late stance (10).

Following a stroke, gastrocnemius shortening is common. Dorsiflexing beyond the position achievable with the knee extended will result in the gastrocnemius contracture limiting knee extension in late stance, and will actually prevent the creation of the desired hip and knee extension moments. The limiting factor to dorsiflexing the foot in the AFO must always be the length of the gastrocnemius. Thereafter, wedging should be utilised to align, or "fine tune" the orthosis, which is as important to optimising gait as is the alignment of a prosthesis. Fine adjustment of the angle of tibial inclination in a solid AFO has been demonstrated to be of great clinical significance in the management of cerebral palsy (9,10), There is emerging evidence that the same may be true in the management of stroke (3,4).

It is tempting to think that gait with an orthosis which has a moving ankle must be superior to a design in which the ankle is fixed, but this is not necessarily so (11). Ankle joints should only be considered in the presence of adequate gastrocnemius length (1). There is no evidence that gastroc-nemius length can be increased by allowing free dorsiflexion in the orthosis. In fact, the only way that dorsiflexion can occur in the presence of a short gastrocnemius is for the knee to go into early flexion, in which case the desired inclina-tions of the tibia and the femur are lost. In order that the gastrocnemius can be passively stretched by extension of the knee in late stance, an orthosis that blocks dorsiflexion is required.

CONCLUSION

Although the use of AFOs in the rehabilitation of patients with stroke has long been a recognised treatment option, there remains considerable disagreement regarding what constitutes best practice. This problem is exacerbated by the fact that the existing scientific evidence for the effectiveness of AFOs is generally at low levels. There is a clear need for high level research to further investigate the benefits of orthotic treatment. Additionally, future research must include explicit detail of the design and biomechanical features of the AFO being studied to enable the reader to faithfully reproduce the intervention[4]. Adopting an analytical and biomechanically sound approach to identifying the functional deficit facing the patient remains an essential prerequisite to the selection of an appropriate orthosis. AFOs should be individually designed and custom-made by a trained orthotist following thorough assessment, identification of biomechanical deficit and the setting of clear functional outcomes. Optimally designed AFOs can exert their influence on the knee and the hip, as well as the foot and ankle.

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FES OF LOWER EXTREMITIES - CRITICAL REVIEW

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Abstract

The review demonstrates benefits of surface functional electrical stimulation for patients with upper motor neuron lesion, i.e. after stroke, with cerebral palsy, and with complete and incomplete spinal cord injury. The article is based on larger study, published recently.

INTRODUCTION

This review article is based on recently published invited review study (1). Functional electrical stimulation (FES) is a rehabilitative technology that uses electrical currents applied to the peripheral nerves. In this way FES provides restoration of movement or function, such as walking by a person with complete or incomplete spinal cord injury, stroke or cerebral palsy. FES is performed in a series of rectangular monophasic or biphasic (symmetrical or asymmetrical) electric pulses described by the following parameters: amplitude or intensity of pulses, frequency or pulse repetition rate, duration of single pulse, and duration of a pulse train (2). A surface stimulation electrode is a terminal through which electrical current passes into the underlaying tissue (3).

Four properties of surface stimulation electrodes and electrodes positioning are exerting an essential influence upon the effectiveness of electrical stimulation: electrode size, polarity of electrodes, resistance, and distance between the electrodes.

The design criteria for surface stimulation electrodes are as follows: physical comfort to the skin, electrical surface area greater than four square centimeters preventing skin irritation, use of hypoallergenic materials, flexibility to follow body surface, ease of attachment and ability to remain in position for the duration of at least one active day, reusable, low cost, reliable means of connection to stimulator, resistant to medical solvents and electrode gels, low and stable electrical resistance. The necessary electrical stimulator consists of an input circuit, pulse generator, output stage, and power supply. The current source of stimulation pulses provides a constant current irrespective of the resistance of the skin and the tissue between the electrodes. In the case of the voltage output stage the skin resistance is lower than that between the electrodes. The voltage source of stimulation pulses provides a constant voltage independently of the skin and tissue resistance. A power supply provides the energy necessary for the operation of particular electronic circuits (low voltage) and the electrical stimulation itself (high voltage). Electrical stimulator is usually battery powered. At the output of the stimulator stimulation pulses with an amplitude of more than 100 V are required. A high voltage for the output stage is obtained from low battery voltage by means of a voltage converter.

Stimulation frequency has noticeable influence on fatigue of the neuromuscular system. An electrically stimulated muscle fatigues more quickly than in the case of voluntary contraction. The main reason is the reversed recruitment order. In a voluntary contraction of a normally innervated muscle, the slow fibers are recruited first, and as increased muscle force is required, the fast fibers are recruited. Slow fibers are, therefore, activated frequently, while fast fibers are employed only infrequently, during a burst of intense activity. When applying electrical stimulation, fibers with a greater diameter respond earlier. These are motoneurons innervating fast muscles. The normal order of recruitment order is, therefore, inverted resulting in an increased fatiguing of electrically stimulated muscle.

WALKING AFTER STROKE

In 1961 Liberson started to use electrical stimulation for prevention of foot-drop in hemiplegic patients (4). The idea was further developed by Lojze Vodovnik who after Moe and Post (5) named the new method functional electrical stimulation - FES and defined it as follows: The purpose of FES is to provoke contraction of muscles deprived of nervous control, in order to obtain a useful functional movement (6-8).This distinguishes FES from a purely therapeutic electrical stimulation which is used predominantly to improve muscle strength, wound healing, to reduce pain, spasticity, and joint contractures. The prerequisite for FES is preserved excitability of the lower motoneuron and muscle that is able to contract. In Ljubljana at the beginning (in 1970) FES was planned mainly as an orthotic device for stroke patients but in later years the therapeutic use became more important in comparison to the orthotic one. Namely, the candidates for

gait stimulators were only selected after successful therapeutic program.

Interest for the clinical use of FES has recently increased because of its orthotic as well as possible therapeutic or carryover effect of FES. Systematic review of eight studies on the orthotic effect of FES on the improvement of walking in stroke patients was published in 2003 (9) and a positive effect on walking speed was suggested in six studies where walking speed was measured. The over-all improvement in walking speed was 0,13 m/s (0,07 - 0,2) or 38% (22,18 - 53,8%). The authors conclude that surface stimulators are useful devices for gait training in acute patients at rehabilitation centers. The advantage of further use of stimulator at home is that patients can practice as much as they want. However, good instruction in proper electrode placement is needed from physiotherapist. As for therapeutic effect of FES, it was noted already by Liberson (4) that some patients retained the ability for foot dorsiflexion for varying lengths of time after stimulation was stopped. Also other studies report on this phenomenon (10-12) which consists of increased voluntary movement and reduced spasticity but samples were small and few used convincing methodology (9).

An extensive review of development of drop foot stimulators is given by an international group of researchers (13). Three hard-wired single channel drop foot stimulators from Ljubljana are described. The first developed was the PO-8 (14) (1966), which was approved for use by the U.S. Board for Food and Medicines (the forerunner of today's FDA). FEPA-10 (1970) featured a large stimulation amplitude control knob, easily manipulated by patients (Fig. 7). MICRO-FES developed in the late 1970s was significantly smaller and lighter than FEPA-10 (65 g versus 190 g) (15,16).

The Odstock drop foot stimulator was described in 1997(17) with several clinically useful features like controlling the stimulation of the hemiplegic foot either by a heel switch worn on the hemiplegic or nonhemiplegic side. Miniature potentiometers allowed adjustment of both the rate at which stimulus was ramped up at toe-off and the rate at which stimulus was ramped down at heel strike. To asses the amount of use, a subject makes of the stimulator outside the clinic, recording of the time of stimulation was added (18).

WALKING OF CEREBRAL PALSY (CP) CHILDREN

The use of FES in children, mostly CP, reveals certain specific features that are absent in the case of adults. The position of electrodes is often atypical, the switch position on the foot is different from that common in adult patients. The differences are in the beginning of stimulation, mode of stimulation control, its duration, and the way the child carries the stimulator. The switch position should therefore be adapted to the site of the first contact of shoe at the beginning of the stance phase.

There have been few reports on the use of FES applied during walking on gait in spastic cerebral palsy. First results from Ljubljana on functional electrical stimulation (FES) applied to children were published already years ago (19). Since then it is routinely used in the unit for rehabilitation of children of the Institute for Rehabilitation, Ljubljana, Slovenia. From other centres than Ljubljana, positive experience and guidelines on FES use for children with cerebral palsy were published in 1997 (20-22).In Ljubljana most children with hemiplegia used a one-channel electrical stimulator and some with diplegia used a two-channel stimulator. Fifty percent of them used the electrical stimulator regularly in the home environment, at least 30 minutes daily. The parameters of stimulation, used in children are: frequency 25 - 40 Hz, impulse width 0,5 ms, while stimulation amplitude is individually adjusted. The most widely accepted approach to apply FES in children is the peroneal nerve stimulation so as to obtain functional movement of dorsiflexion and moderate eversion of the foot in the swing phase of the gait and thus correct equinovarus position of the foot in spastic hemi or diparesis. By means of surface electrodes, the peroneal nerve is stimulated in the popliteal region. Beside functional movement of foot dorsiflexion, other effects are achieved.

Kinesiological analysis of gait with and without FES showed that more normal movements in knee and hip joint are present when using FES. The gait shows greater symmetry and the basic parameters of gait are closer to normal. The position of the foot in dorsal flexion at the end of the swing phase enables full foot support instead of equinous position and tiptoe walking. With proprioceptive and biofeedback mechanisms activation, changes in sensory-motor organization are achieved with prolonged effects on posture and gait patterns. Effects of FES are better in hemiplegic than in diplegic children. Botulinum toxin therapy of spastic plantar flexors of the foot, facilitating the effect of peroneal FES in hemiplegic children (23, 24), has been recommended by research team from Ljubljana.

WALKING AFTER COMPLETE SCI

The Ljubljana FES walking system consists of two small two-channel stimulators attached to each leg. Only three electrodes are applied to single leg in order to produce knee extension and flexion response. As both activities never occur simultaneously, the distal electrode placed over knee extensor represents the common electrode for both stimulation channels (25).

The Ljubljana FES system was before 1989 delivered to 50 complete SCI patients (26).The energy efficiency of FES assisted walking in completely paralyzed SCI persons was

rather low. Considerable body weight was specially, during the leg or crutch transfer, supported by the arms. Four-channel FES gait pattern was also for about ten times slower than normal walking. However, FES walking exercise was found as an effective mechanism to improve fitness in completely paralyzed SCI persons providing health benefits similar to regular exercise in able-bodied individuals.

Using the same principles as Ljubljana FES system and adding two channels of stimulation to both hip extensors, the FDA approved Parastep surface stimulation system was developed (7).

WALKING WITH INCOMPLETE SCI

The first reports on application of FES to incomplete SCI patients go back to late eighties and early nineties of the past century (27, 28). The therapeutic electrical stimulation program was started immediately when the patients entered the rehabilitation center (27). The program consisted of cyclic stimulation of partially paralyzed knee extensor muscles, by alternate stimulation trains of 4 s and pauses of 4 s. The daily stimulation session lasted for one half hour. The training program lasted for three months. By applying a two-channel stimulator the patients could perform a smooth and aesthetic walking pattern. Here, the knee extensors were stimulated during the stance phase and the peroneal nerve of the ipsilateral extremity was excited to provoke the flexion withdrawal response during the swing phase of walking. In many cases stimulation of only peroneal nerve, resulting in simultaneous hip and knee flexion and ankle dorsiflexion, was found sufficient. The adequate FES control was accomplished by the use of hand switch built into a handle of a crutch. The therapeutic effects resulting from an FES gait program in incomplete SCI patients were studied also by Scottish researchers (28). Forty subjects (31 with incomplete spinal cord injury and 9 with cerebral damage) were studied in a multicenter trial across Canada for an average time of one year (29). Changes in maximal walking speed of incomplete SCI subjects with and without FES were studied by Ladouceur and Barbeau (30). The aim of another study performed by Canadian researchers was to quantify the effect of long-term FES assisted walking on the ankle joint of spastic incomplete SCI subjects (31).

A comparison of the effects of FES with that of an ankle-foot orthosis (AFO) for assisting foot clearance, gait speed, and endurance, was made by another Canadian research group (32).

In the period 1983-2000 57 peroneal stimulators were given to incomplete spinal cord injured persons in Ljubljana Institute of Rehabilitation for home use. 35 were tetraparetic and 22 paraparetic patients. A questionnaire evaluating the home use of FES and its influence on the quality of life was sent to the SCI persons. 32 patients used FES for walking and the rest for muscle strengthening only. 9 patients were able to walk outdoors, while 24 used FES only at home (25).

CONCLUSIONS

In the comprehensive review of functional and therapeutic applications of neuromuscular electrical stimulation, the authors33 focused also on transcutaneous peroneal nerve stimulation to treat ankle dorsiflexion weakness. They claim that despite demonstrated effectiveness, the method is not routinely prescribed in the USA for drop foot treatment in hemiplegia. However, they report on recent FDA approval of three surface peroneal nerve stimulators i.e. the Odstock dropped foot stimulator and the wireless NESS L300, which both use a heel switch to trigger ankle dorsiflexion. The third approved stimulator, the Walk Aide, uses a tilt sensor embedded into the stimulator attached to the shank to trigger the ankle dorsiflexion. More clinical prescription and usage of these devices is expected since the approval.

In feasibility study (34) the authors implanted percutaneous intramuscular electrodes into the gastrocnemius and tibialis anterior muscles of affected limbs. The results suggested that percutaneous FES might immediately improve the ankle kinematics in children with CP. However, the authors are aware of the invasive nature of implanting percutaneous electrodes, the risk of potential infection, and the lack of commercially available stimulators, the reasons which prevent the use of percutaneous FES in clinical settings.

It is clear now that electrical stimulation has in completely paralyzed SCI persons only the value of a general fitness exercising. In this respect combination of indoor or outdoor bicycle and FES can be more interesting for persons with complete paraplegia and in the same time also safer. In this view it is also not difficult to realize that implanted stimulation of extremities of SCI subjects is rather obsolete.

Surface FES in incompletely paralyzed patients is predominantly used for therapeutic purposes. It can be efficiently used together with treadmill and body weight support. In this way FES is competing with robotic exoskeletons. As FES is considerably less expensive and simpler to use, the expectations for broader future use of FES are realistic.

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SYMPOSIUM: BONE ANCHORED AMPUTATION PROSTHESES USING THE METHOD OF BRÅNEMARK OSSEOINTEGRATION - 18 YEARS OF EXPERIENCE

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The number of problems related to suspension and comfort of socket prostheses has led to a desire to attach prostheses directly to the residual skeleton. Since 1990 we have performed such treatment using the method of osseointegration (1, 2). The concept of osseointegration was first described by Professor P-I Brånemark and has been in successful clinical use for dental applications for more than 40 years (3, 4). For individuals with amputations the treatment includes two-surgery sessions and prosthetic rehabilitation. At the first surgery a titanium implant (fixture) is inserted in the residual bone and left unloaded for about six months (1, 2). At the second surgery a titanium rod (abutment) is inserted into the distal end of the fixture and is then penetrating the skin. Prosthetic suspension is obtained by connecting the osseointegrated prosthesis (OI-prosthesis) to the abutment with an attachment device. For patients with transfemoral or transhumera1 amputations the total treatment period is about 12 months (5). For patients with transradial and thumb amputations the treatment period is shorter.

On the upper extremity a variety of prostheses are built; i.e. cosmetic, myoelectric, bodypowered and hybrids. The patients indicate improved functionality, free range of motion in the proximal joints, better comfort and improved sensibility due to the osseoperception (6).On the lower extremity the focus is on transfemoral amputations. The prosthesis needs to have an attachment device with a safety function and a great variety of prosthetic knee and foot components can be used. The patients express great benefits of not having a prosthetic socket (7-9); i.e. to be able to work more freely with the hip and stump muscles, to be able to better feel what surface they walk on (10, 11) and better sitting comfort (9).

Most of the patients have a transfemoral amputation for reason other than dysvascular disease. During the first period of years (1990-1996) the implants were custom-made and about 45 % of the patients had severe complications with loosening, mechanical failures and/or deep infections. However, most of these complications could be handled and 85 % of the patients could use the OI-prosthesis. During the following years the treatment procedure was refined and since year 1999 a standardized treatment concept is followed. Today a total of about 120 patients have received the treatment in Sweden. Currently the success rate is better than 90 % at 2-years follow-up since the protocol was introduced.

In 1999 a prospective clinical investigation, named OPRA, was started (Osseointegrated Prosthesis for the Rehabilitation of Amputees). The inclusion criteria are to have a transfemoral amputation with problems with socket prostheses, to have completed maturation of the skeleton and normal skeletal anatomy and to be below the age of 70. Exclusion criteria are severe peripheral vascular, to undergo treatment with drugs that could affect the treatment negatively and pregnancy. The study protocol includes a wide range of assessments performed preoperatively and until 2 years postoperatively i.e. x-rays, registration of complications and assessment of gait and quality of life. The study is ongoing and includes a total of 55 implants on 51 patients (4 treated bilaterally). A primary report from the study includes the first 18 patients that have passed 2-years follow-up (7). 17/18 (8 male/10 female, mean age 45 years, amputation cause; 12 trauma, 5 tumour, 1 arterial embolus, mean time since amputation 15 years) used the OI-prosthesis at follow-up. One could not use the prosthesis due to pain and subsequent loosening of the implant. The results show statistically significantly improved general health related quality of life (HRQL), measured by SF-36, and condition-specific HRQL showing increased prosthetic use, improved prosthetic mobility and less problems as compared to the preoperative situation.

Development of a new treatment concept of this type is a tedious and time-consuming process, which has to be carefully monitored and controlled. However, this treatment is substantially improving quality of life for individuals with amputations. Thus, OI-prostheses represent a very promis-

ing development in the rehabilitation of individuals with limb loss.

Information: *www.sahlgrenska.se/su/osseointegration*

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OUTCOME MEASURES IN LOWER LIMB PROSTHETICS

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"Patient - based outcome measure" is a shorthand term referring to the array of questionnaires, interview schedules and other related methods of assessing healthy, illness and benefits of health care interventions from the patient's perspective.

In rehabilitation, the use of outcome measures is increasingly important, driven primarily by the need for evidence-based practice.

Specifically in the field of amputee and prosthetic rehabilitation there has been a parallel increase in the use of outcome measures, however there are a multitude of measures in current use and there is no agreed "gold standard" measure in this field.

An evidence-based approach to selecting outcome measures involves making judgements about the quality of the validity and reliability studies, interpreting the findings and deciding whether they are appropriate to one's specific practice1.
This Symposium will provide a description of the basic requirements of an outcome measure and will provide advice on how to evaluate and select the most appropriate measure.

The results of a recent systematic review of the literature on this subject from 1995-2005 will be presented and details of the measures of mobility, function and quality of life recommended by this review will be provided 2.

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MAJOR AMPUTATIONS OF THE LOWER EXTREMITY DURING 25 YEAR. A STUDY ON 430 PATIENTS FROM SIX COHORTS IN THE URBAN CITY OF MALMÖ, SWEDEN.

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Abstract

This descriptive report shows the characteristics of patients of six annual cohorts with major amputations from the city of Malmö, Sweden from 1979-2004.
During 25 years the population in our city has increased especially the proportion of over 80 years of age. Changes found among the amputated patients were: The incidence of major amputation decreased. Additionally, when we compare back ground data from the patients and results from a follow-up one year postoperatively every fifth year from 1979 to 2004, we can conclude that we have fewer bilateral amputations but more vascular referrals, more nonwalkers during the 1990's, more vascular surgery before the amputation in 1984-94 and a higher proportion of transtibial amputations (TT) during 1984-99. The age-differences are non-significant except among men between 1979-1994/04.
Among postoperative changes we can notice that the mean number of days in hospital has degreased but fewer patients now can be discharged back home. Fewer patients got a prosthetics and were able to walk during the 1990's and the proportion of TT was lower in the 1980's and 90's. The mortality within one month and year after the amputation has reduced during 25 years.

INTRODUCTION

Limb amputation represents one of the oldest and most serious surgical operations (1). Major leg amputation is sometimes unavoidable but the first aim is to preserve the patient limb. For this purpose many efforts has been made during the past quarter of century in our society. This includes health information and better diabetes care, vascular surgery, treatment of cardiovascular disease, infections, cessation of smoking (2, 3). This report shows changes during 25 years regarding patients with major amputation in the city of Malmö, Sweden.

METHODS AND SUBJECTS

Methods

This descriptive study of 430 patients from six annual cohorts with major amputations was collected and followed-up after one year postoperatively. All major amputations from the selected years were included. The medical records were analyzed and the patients were interviewed by one and the same investigator repeated the study every fifth year - 1979, 1984, 1989, 1994, 1999 and 2004. All patients alive one year after the operation, were examined as part of a routine follow-up.

Subjects

Included were only major amputations caused by lower limb ischemia from the population of the urban city of Malmö, Sweden. Excluded were major amputations caused by tumour or trauma. Statistics: Chi square and Student's tests.

RESULTS

The number of major leg amputation were 100 in 1979, 89 in 1984, 80 in 1989, 53 in 1994, 57 in 199 and 48 in year 2004. The mean age of the men and women are from 71 to 77 and 78 to 82. Significant changes only for men between 1979 and 1999/04 .

During 25 years the annual number of major amputations at our hospital has more than halved. This means a decrease of the crude incidence to 18 per 100 thousand in 2004. A simultaneous increase of the population with 28 thousands inhabitants has occurred in our city and the proportion of +80 years has more than doubled up to 6 %. Other significant difference compared to 1979 was the increase of the proportion of vascular referrals and surgery, fewer bilateral amputations. Temporary, during the 1990's, more patients were

non-ambulant patients before the operation and the quota TT/TF was lower. Only smaller or non-significant changes could be seen regarding the proportion of men, residence, living alone, previous hip fractures, diabetes mellitus, acute ischemic disease, dementia and Parkinsonism. The mean age for men and women were 74 and 80 years respectively during our 25 years with no significant changes except for men between 1979 and 1994/04. In 2004 the mean age of all the patients was 80+/-12 (51-95) years.

Postoperative data gave significant lower mean number of days in hospital but instead a decrease in the proportion of patients that could return straight back home. The mortality within one month and one year was significantly decreasing, particularly among those with a TT. During the 1990's we notice a temporary lower proportion of the patients who got a prosthetics and were able to walk. Among the patients treated with a TT we found no significant differences regarding the walking capacity at follow-up, nor regarding higher reamputation/re-operations.10/37 TT were re-amputated on the femur in 2004.

DISCUSSION

The data chosen in 1979 are used in this comparative study. Even if the age-differences are small some of the results can be influenced by age. This study on few patients gives decreasing number of amputations for each year which makes it harder to compare the cohorts especially if you want to compare men and women.

Decreasing incidence of major amputation has been described before (5) and our figures are in line with others (4, 5) Our patients are frail and have low survival rate as have been found by others (6, 7). The mean age in this report is high as well as the proportion of primary TT compared to others (5, 7). This could partly explain the higher re-operation rate in Malmö. Comparing this report with others can be deceptive because of different inclusion criteria. Also the social status of the population can make a difference (8). The population in the city of Malmö is not in highly rank regarding prosperity in Sweden but it was even worse in the 1990's.

CONCLUSION

From the city of Malmö it is clear that we have a significant decrease in the incidence of amputation when six annual cohorts of major amputations where followed during 25 years. The characteristics of the patients were otherwise similar even if the postoperative mortality has decreased. The preventive measurement from our health care system, in order to avoid major amputations, seems to have been successful. During the 1990's, the patients in our city, temporary could have been composed of a group with more delicate health. We can see some clinical data showing the crude impact and that these patient groups have had on our hospital and how this has developed during 25 years and some indications of how we have treated the patients.

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OUR EXPERIENCES WITH THE BELOW KNEE AMPUTATION

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Abstract

Objective: The aim of this analysis was to evaluate the characteristics and outcome in patients undergoing lower limb amputation in University Medical Centre Ljubljana between January 1st 1996 and December 31st 2002. Patients and methods: Among 771 patients with lower limb amputation we focused on 172 (22.3%) patients with below knee amputation. The most common underlying pathologies indicating amputation were diabetes mellitus complicated by vascular occlusive disease and infection. Results and discussion: Postoperative complications occurred in 24% of cases. The majority suffered from infections that required wound revision or reamputation. Among below knee amputees there were 102 (59.3%) of patients with indication for prosthesis and were sent to Institute for Rehabilitation, Republic of Slovenia.

INTRODUCTION

Major amputation is a commonly performed procedure that is indicated in patients with failed attempts at revascularization, comorbidity or anatomic factors precluding revascularization efforts, and extensive tissue loss or infection (1).

The transtibial level is the most proximal level at which near-normal function can be expected for most patients. Preserving the knee joint allows transtibial amputees to consume much less energy then transfemoral amputees and contributes to more efficient ambulation with prosthesis (2).

The below-the-knee amputation (BKA) is typically performed about 15 cm below the knee. A longer muscle flap made up of the thick muscles of the back of the calf is attached to the remaining part of the tibia or to a shorter muscle flap that makes up the front of the calf. This soft tissue is important because it provides padding for the remaining part of the limb at the site where it attaches to the prosthesis. The remaining part of the limb is known as the residual limb or stump. It can have different shapes, but it is somewhat bulbous initially due to postsurgery swelling. In time, it may resemble cylinder or a cone. The length of the residual limb is very important. If it is too short or too long, it may be difficult to fit it with prosthesis (3).

Because BKA is a common surgical procedure we attempted to gain a better understanding of the patient population that required BKA, including co-morbid diseases, revascularisation history, indications for amputation, and postoperative complications.

METHODS AND SUBJECTS

Retrospective analysis was conducted using data from medical records of patients who underwent BKA in University Medical Centre Ljubljana at the Department for surgical infections and Department for Traumatology, between January 1st 1996 and December 31st 2002. Medical records were reviewed for basic demographic data, underlying pathologies indicating amputation and postoperative complication. Descriptive statistics were obtained for basic demographic characteristics. The main outcome measure was early operative outcome (operative mortality, wound complications and need for revision amputation).

RESULTS

In our sample women were on average roughly 8 years older than man, and the difference was statistically robust. The distributions of patients by age group, indications and comorbid conditions are presented in Table 1.

Postoperative complications including wound infection, bleeding and dehiscence occurred in 23.1% of patients (Table 2). Secondary operative procedure was necessary in 24.4% of patients. There was cardiac arrest in 2 patients (1.2%), and no cerebrovascular insults, pulmonary embolism or deep vein thrombosis in our group of patients.

Among 172 amputees there were 102 of patients with indication for prosthesis and were sent to Institute for Rehabilitation, Republic of Slovenia. Among the remaining 70 patients, there were 40 (23.2%) using wheelchair, 14 (8.1%) were immobile and 16 (9.3%) were using crutches.

Table 1: *Demographic data of patients undergoing lower extremity amputation*

	Total, n=172	Male, n=108	Female, n=64
Mean age (SD) [years]	69.1 (13.0)	66.2 (13.9)	73.9 (9.5)
Age group [n (%)]:			
21 - 40	7 (4.0%)	6 (55.5%)	1 (1.6%)
41 - 60	26 (15.1%)	24 (22.2%)	2 (3.1%)
61 - 80	118 (68.6%)	68 (62.9%)	50 (78.1%)
> 80	30 (17.4%)	16 (14.8)	14 (21.8)
Indication for amputation [n (%)]:			
Vascular occlusive disease	161 (93.6%)	98 (90.7%)	63 (98.4%)
Infection	154 (89.5%)	94 (87.0%)	60 (93.7%)
Trauma	7 (4.0%)	7 (6.5%)	0
Tumour	1 (0.6%)	1 (0.9%)	0
Comorbid conditions [n (%)]:			
Diabetes mellitus	114 (66.2%)	67 (62.0%)	47 (73.4%)
Cardiovascular disease	117 (68.0%)	74 (68.5%)	43 (67.2%)
Lung diseases	5 (2.9%)	4 (3.7%)	1 (1.6%)
Neurologic diseases	27 (15.7%)	17 (15.7%)	10 (15,6%)
Malignancy	7 (4.0%)	5 (4.6%)	2 (3.1%)

Table 2: *Postoperative complications and secondary operative procedures after BKA*

	Total, n=172	Male, n=108	Female, n=64
Postoperative complications			
Infection	31 (18.0%)	17 (15.7%)	14 (21.9%)
Bleeding	2 (1.1%)	1 (0.9%)	1 (1.6%)
Dehiscence	7 (4.0%)	6 (5.5%)	1 (1.6%)
Operative mortality	0	0	0
Postoperative mortality	3 (1.7%)	1(0.9%)	2 (3.1%)
Secondary operative procedure			
Reamputation	32 (18.6%)	20 (18.5%)	12 (18.7%)
Revision	10 (5.8%)	7 (6.5%)	3 (4.7%)

DISCUSSION

The majority (68.6%) of the patients were older than 60 years. Many patients had multiple medical co-morbidities. Vascular occlusive disease mostly caused by Diabetes mellitus was the most common underlying pathology. BKA is associated with higher wound complication and revision rate as above knee amputation (1, 4). In our group of patients, postoperative complications occurred in 23.1%, which was comparable to the findings of other authors. The latter was also true for the need for secondary operative procedure, which was 24.4% (1, 4).

Preserving the knee is also important for subsequent prosthesis use. In our group of patients, 59.3% of patients were candidates to use prosthesis.

CONCLUSION

In our institution, the majority of BKA are performed in geriatric patients with vascular occlusive disease. BKA is associated with high level of revision and reamputation rate, which is particularly distressing for both, patient and the surgeon.

We recommend this type of operation, since high quality of life can be achieved despite frequent correction rate of previous below knee amputation.

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KNEE DISARTICULATION - THE METHOD OF CHOICE IN RELATION TO FEMORAL TRANSCONDYLAR AMPUTATION

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Abstract

Knee disarticulation as the method of choice in amputation surgery is still a rarely used method, primarily due to the operative technique itself and secondly due to poor understanding of prosthetic replacement possibilities. Unpopularity of knee amputation over many years was caused by bad experience with primary wound healing and the resulting stump of poor quality with regard to its function. Over the last years, a significant progress has been made with regard to materials and highly sophisticated technology and consequently the industry of orthopeadic aids. In the end knee disarticulation proves to be superior due to the possibilities of prosthetic replacement and the advantages are: 1. a long and strong stump with a tip that can endure full-weight bearing and is suitable for fitting of a knee disarticulation prosthesis, 2. the energy expenditure during walking is equal to walking with below-knee prosthesis, 3. normal function of the upper leg muscles. In our experience, knee disarticulation using the Baumagrtner tehnique and the application of knee disarticulation prosthesis yields very good results.

INTRODUCTION

The aim of this paper is to show that knee disarticulation according to Baumgartner has its place in daily practice of amputation surgery and that knee disarticulation prosthesis has proved fully functional. We have been using this operative method and knee disarticulation prosthesis since 1990. However, we have introduced minor modifications that have yielded good results with application of disarticulation prosthesis for the knee.

The majority of surgeons still give priority to femoral transcondylar amputation and high proximal amputation of the lower leg over the method of knee disarticulation. The application of the aforementioned methods is surgically more demanding and associated with a higher risk of complications, which is the very reason of unpopularity.

Knee disarticulation as an operative method in amputation surgery owes its unpopularity to the complicated technique (Gritti-Stokes, Challander) but also to the possibility of various complications in the treatment: inflammation and skin necrosis, soft-tissue necrosis, infection in the resected portions of the femoral stump or associated pains. It has often been the case that reamputation (femoral transcondylar) is necessary (1). The created stump was often unsatisfactory for prosthetic fitting. Mazet and Hennessy described amputation through the knee joint with sagittal resection of the femoral condyle and positioning of the patella between sites of condylar resection. Vaucher and Blanch (1982) recommended the method of minimal resection of the lateral ends of the femoral condyles, which can cause complications such as skin and soft-tissue infection, hematoma, etc. Duerksen and colleagues (1990) described a new technique of knee disarticulation.

Disarticulation of the knee and not transcondylar amputation of the femur is recommended for high traumatic amputation of the lower leg, crush injury, complex injuries and tumors of the lower leg.

METHODS AND SUBJECTS

Baumgartner describes the method of knee disarticulation as a surgically simple procedure that creates a functionally satisfactory stump with regard to further prosthetic fitting. The simplicity of the technique is reflected in every aspect - skin, cartilage, bone, muscles. First, a skin incision is performed in two directions form the outer side of the medial and lateral condyle using an anterior long semicircular incision at 3-5 cm distally below the tibial tuberosity and posteriorly at the level of the sagittal line along the midline of the popliteal fossa. Then, a skin flap is raised and the knee joint exposed. The exposed collateral ligaments and hamstring tendons are

resected . The patellar ligament is cut off at the patellar tip. The patella is now placed in the position of "patella alta", which additionally increases the contact and weight-bearing surface of the stump. A transverse wide capsulotomy is done to expose the knee joint with menisci and ACLs that are resected. The knee joint is flexed, the notch is exposed, the PCL is removed and the femoral condyle surface is left intact. Nerves and blood vessels in the popliteal fossa are exposed, ligated and transsected. Intact cartilage and femoral condyles are covered with the anterior skin flap which is sutured tension-free to the posterior skin flap in the popliteal fossa. A free drain is placed below the fascia along the entire scar length. The drain is removed after two days and sutures after 14 days.

Synovitis at the incision level on lateral wound margins is a possible complication, in which case a suture is released.

Three patients are presented, in whom knee disarticulation has been performed:

a) 61-year-old patient fell under a motor excavator and his right lower leg was injured - a distal third of the lower leg was crushed. Primary amputation at the level of the middle third of the lower leg was performed. The wound was left open and local therapy instituted. Due to complications in terms of bone protrusion on the fibular and tibial stumps, musculo-cutaneous defect and impossibility of wound closure, reamputation at the proximal third level was indicated. It was also left open but complications occurred and transcondylar amputation of the femur was advised by a trauma surgeon. All advantages and disadvantages of knee disarticulation and disarticulation prosthesis as compared to transcondylar amputation of the femur and above-knee prosthesis were explained to the patient. The patient chose knee disarticulation, and after completed wound healing the patient was admitted to the Institute for Rehabilitation and Orthopaedic Aids rehabilitation and fitted with a disarticulation prosthesis. After completed prosthetic rehabilitation the patient was able to use the prosthesis during the whole day, walk independently, use a walking cane for longer walks and work on the land.
b) 36-year-old patient sustained a traumatic amputation of the right foot, of the distal third of the lower leg, and a femoral fracture due to a mine explosion during the Croatian homeland war. Transtibial amputation was performed at the level of the proximal third and the right femur was treated by internal fixation according to the AO method. After several months of treatment, the stump was in flexion contracture greater than 30 degrees. Prosthetic fitting was no possible so that the surgeon recommended transcondylar amputation of the femur. Advantages of knee disarticulation over transcondylar amputation of the femur as well as advantages of disarticulation knee prosthesis over upper-leg prosthesis were explained to the patient. The patient chose knee disarticulation. In the postoperative course synovitis occurred on the lateral side of the stump so that two sutures were removed, antibiotic therapy instituted and the healing was protracted for two weeks. After completed healing of the stump, prosthetic rehabilitation was begun at the Institute fo Rehabilitation and Orthopaedic Aids. Following rehabilitation the patient was able to use the prosthesis for all daily activities and to walk unassisted.
c) 45-year old patient was injured in a traffic-related accident as a car driver and sustained an open fracture of the right lower leg. Operative treatment of this complex fracture was attempted but due to infection appearing in the postoperative course amputation wasindicated. The surgeon recommended transcondylar amputation of the femur. After examination advantages of knee disarticulation over transcondylar amputation were explained to the patient as well as the advantages of a disarticulation knee prosthesis over an above-knee prosthesis. Knee disarticulation was performed and prosthetic rehabilitation was begun at the Institute fo Rehabilitation and Orthopaedic Aids. After rehabilitation the patient wore the prosthesis during the entire day, used a walking cane for longer walks and worked actively.

RESULTS

Our experience in the application of the knee disarticulation technique in the period of 17 years includes not only the operative treatment but also prosthetics, i.e. application of a special disarticulation prosthesis for the knee. We have implemented minor modifications to the original Baumgartner method, which yielded good results. Our good experience and recommendation are in these indicationes: trauma, tumors, lower-leg infections, circulatory problems in diabetics.

DISCUSSION

Knee disarticulation as well as of the disarticulation prosthesis for the knee clearly shows the position of this technique in relation to transcondylar amputation of the femur. Transcondylar amputation of the femur is not functionally better than transfemoral amputation since the above-knee prosthesis is also fitted to the femoral transcondylar stump. With regard to application it is more demanding than disarticulation prosthesis of the knee. Energy consumption during walk with disarticulation prosthesis is increased by 40% and with the above-knee prosthesis by 70 - 80%. According to American authors, knee disarticulation is described as a simple, safe operative procedure, which has advantages in the prosthesis application but which is not accepted by American surgeons and is not widely applied (2). Some authors recommend the Mazet and Hennessy method as well as the Burgess method, where reduced resection of the distal femur is performed in such a way that a distal portion of the

cartilage can be spared and the medial, lateral and posterior prominence of the condyles is resected marginally 1,5 cm of the distal condylar portion is resected in order to obtain a wider surface of the central knee portion and then the preserved ACL is sutured to the patellar ligament. For this method and also the Bowker method it is significant that due to cartilage removal a large bone surface is created, which increases the risk for bleeding and consequently associated complications. Thus, the end-bearing of the distal stump portion is significantly reduced. In the prosthetic sense, a disarticulation stump of the knee is obtained and it can accept only an above-knee prosthesis with weight-bearing tuberosity of the ischial bone. This is the very reason for application of the Mazet and Hennessy and Burgess disarticulation methods also for palliative indications where no prosthesis will be applied because patients will use wheel chairs. However, according to the ISPO Consensus Conference in 1990 knee disarticulation has absolutely its place in the practice as an amputation technique. It can be recommended in younger and elderly patients for the following indications: trauma, tumors, lower-leg infections, circulatory problems in diabetics.

CONCLUSION

In our opinion, knee disarticulation is the method of choice as compared to transcondylar amputation of the femur regardless of etiology. First, due to the simplicity of the operative procedure itself and second due to good quality of the stump and the possibility to apply disarticulation prosthesis also in young and elderly patients. Technological progress and the resulting new developments in the prosthetics of the lower extremities have opened new possibilities in the choice of amputation methods applied in the lower extremity surgery and consequently in the choice of the amputation level. This is very important for the quality of life of amputees.

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EARLY OUTPATIENT PROSTHETIC FITTING/REHABILITATION AS AN ALTERNATIVE FOR LOWER LIMB AMPUTEES IN SLOVENIA

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Abstract

The model of outpatient prosthetic fitting/rehabilitation as an alternative to classic stationary model is presented in this article. Increasing number of lower limb amputees in elderly initiated the idea of outpatient prosthetic fitting/rehabilitation as a complementary method to classic stationary rehabilitation in the National Rehabilitation Institute in Ljubljana. The model consisted of delayed immediate prosthetic fitting with Pneumatic Walking Aid during the hospital stay, prosthetic rehabilitation in our outpatient unit, followed by fitting the temporary prosthesis by the mobile prosthetic team from the National Rehabilitation Institute, continuing prosthetic rehabilitation in our outpatient unit and final application of permanent prosthesis by the mobile prosthetic team. Prospective study of outpatient prosthetic fitting/rehabilitation in 2004, including 66 lower limb amputees proved, that outpatient model of prosthetic fitting and rehabilitation in selected population could be as effective as the classical stationary model and thus represents a possible alternative.

INTRODUCTION

Increasing number of elderly patients with critical lower limb ischemia present a challenge for alternative and **patients friendly** prosthetic rehabilitation.

Every kind of walking is better than a wheelchair. Our elderly do not accept to be left in a wheelchair, they want to walk! Only 40 to 50 steps make them able to cover their flats by themselves. Elderly feel and function better at home and therefore quite a lot of them would prefer the outpatient model of prosthetic rehabilitation.

METHODS AND SUBJECTS

In General Hospital Celje immediate prosthetic fitting with Pneumatic Walking Aid (PWA) was introduced in 1991 and routinely used since. It was included into our outpatient model. After leaving the hospital, these patients continued prosthetic rehabilitation on the outpatient basis once or twice weekly in our outpatient unit, proceeding with strength exercises for upper and lower extremities, mobility exercises for the residual limb, learning walking with crutches and with PWA.

When the residual limbs were prepared for temporary prosthesis, the patients at risk and those, who haven't got the possibility to attend outpatient rehabilitation regularly, were sent to our National Rehabilitation Institute in Ljubljana for stationary rehabilitation and prosthetic fitting.

Those, who were willing and able to attend our outpatient programme, were presented to the mobile prosthetic team from the National Rehabilitation Institute, consisting of a skilled physiatrist and two orthopaedic engineers, who visited our hospital twice a month and managed 10 to 12 patients per visit.

Measurements and moulds for temporary prosthesis have been made and prostheses were ready for further testing in 12 days in average.

The temporary prostheses, being tested and fitted, the patients continued their rehabilitation program in our outpatient unit once a week, using their prostheses increasingly throughout the day.

When residual limb was prepared, permanent prosthesis was tested, adding final adaptations and aesthetic touch and finishing the procedure.

RESULTS

Prospective study on outpatient prosthetic fitting/rehabilitation was carried out from 16.01.2003 to 07.01.2004. The study included 66 patients, which fulfilled the testing conditions.

50 (76%) were males and 16 (24%) females in average age of 66 years, 36 of them were smokers. Critical ishemia was the

cause for amputation in 64 cases, 24 of them were diabetics, two amputations resulted from trauma only.

There were 19 transfemoral, 39 transtibial amputations and only one knee diarticulation, 7 patients were bilateral amputees.

After the rehabilitation, 68 prostheses have been applied. All patients but one, have been walking without assistance with or without crutches.

We have had only one serious complication. An undisciplined diabetic patient, heavy smoker and bilateral trans femoral amputee, broke his right arm and landed in a wheel chair.

DISCUSSION AND CONCLUSION

The majority of lower limb amputees are elderly. They function and feel better in well known domestic surroundings, therefore they prefer to stay at home. The prospective study proved, that outpatient prosthetic fitting/rehabilitation in selected population is effective, therefore the model of early outpatient prosthetic fitting and rehabilitation should become the method of choice, giving the patients, who are willing and have the possibilities to attend the outpatient activities, the possibility to be adequately rehabilitated at home.

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THE IMPORTANCE OF IMMEDIATE PROSTHETIC FITTING ON AMPUTEE REHABILITATION

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Abstract

This study is done with the aim of investigating the importance of immediate prosthetic fitting technique (IPF) on the amputee rehabilitation. A total of 26 patients participated in the study. In the group who were provided with immediate prostheses, there were 11 patients, while there were 15 patients who were provided with classical prosthetic application. They were all assessed for general physiotherapy assessments, functional state, ambulation activities, gait, quality of life, prosthetic satisfaction and prosthetic training period. There were significant differences between the groups when the anthropometric values, data of weight bearing, gait, quality of life, phantom sense, pain and prosthetic training were compared. It can be stated that the quality of life of the amputees will be improved by the early ambulation facility in immediate prostheses fitting technique. It can be concluded that by the IPF technique the amputees can therefore reintegrate to normal living in a shorter period.

INTRODUCTION

The aim of lower limb amputee rehabilitation using immediate prosthetic fitting (IPF) is to prevent the complications of inactivity, shaping the stump as soon as possible, early transition to definite prostheses and provide reintegration to normal living (1, 2).

The main reason that prevents functional prosthetic usage after lower limb amputation is the stump-socket fitting problems. The stump can be shaped in 3-6 months by using conventional methods such as bandaging and socks produced for edema. This period can be prolonged due to amputation cause, age, or inappropriate physiotherapy applications (1, 2).

This study is carried out to investigate the role of IPF technique on the rehabilitation of lower limb amputees.

METHODS AND MATERIALS

Subjects

26 patients were included in the study whose ages varied between 21-55 years and amputated because of trauma, cancer and diabetes mellitus. Cases were divided into two groups. In the first group (IPF group) there were 11 patients (8 trans-tibial, 3 transfemoral), while there were 15 cases (11 trans-tibial, 4 trans-femoral) in the second group (conventional).

Methods

All the amputees were given physiotherapy-rehabilitation program including strengthening, stretching, breathing, weight bearing, weight shifting and balancing activities, dynamic exercises for stump, pre gait exercises, gait training indoors and outdoors, functional activity training and activities of daily living. In conventional group, the patients were given also bandaging.

Physical characteristics of the amputees, muscles strength, range of motion, anthropometric measurements, phantom limb sense and pain, weight bearing through the amputated limb, ambulation activities, gait analysis, quality of life, prosthetic satisfaction and prosthetic training period were evaluated.

RESULTS

Physical characteristics of the amputees were shown in Table 1.

In the IPF group it was seen that there was no difference between the edema of the two sides due to the anthropometric measurements of the stump ($p>0.05$).

In the classic prosthetic application group, it was observed that there was an important difference between the intact and amputated side edema and edema has been still continuening ($p>0.05$).

Table 1: *Physical characteristics of the amputees*

Characteristics	Group I (n=11) X±SD	Group II (n=15) X±SD
Age (Year)	36.13±15.99	35.33±12.15
	n (%)	n (%)
Sex		
Women	2(18)	3(20)
Men	9(82)	12(80)
Amputation Cause		
Trauma	6 (55)	7 (47)
Diabetes Mellitus	2 (18)	5 (33)
Cancer	3 (27)	3 (20)
Amputation Level		
Trans-tibial	8 (73)	11 (73)
Trans-femoral	3 (27)	4 (27)

Table 2: *Comparison of the gait parameters and weight bearing*

	Group I (n=11) X ± SD	Group II (n=15) X ± SD	p
Stride lenght	109.34±18.17	105.86±19.18	*
Amputated side step lenght	57.83±9.79	57.72±9.49	
Intact side step lenght	51.64±9.32	48.29±11.09	*
Step width	11.48±2.54	12.08±2.22	
Cadance	96.40±7.06	93.72±5.70	*
Velocity	87.95±16.66	82.85±16.92	*
Weight bearing on amputated side	43.58±4.05	38.96 ±4.04	*

*p<0.05

When the patients were evaluated for their prosthetic treatment period, it was observed that there was a significant difference between the two groups (p<0.05).

The prosthetic treatment period is the period beginning training with the Immediate Prostheses and continuening with the transition to definite prosthesis training with definite prostheses until the discharge from the prosthetic department. This period was found to be 38.60±5.57 days in the IPF group while it was 106.20±11.87 days in classical group.

It was also determined that significant differences was found to be between the two groups in the intact side step length, stride length, gait speed and cadence (p<0.05).

When the weight bearing capacity was evaluated, an important difference was found to be in favour of the IPF group (p<0.05) (Table 2).

Due to the results achieved from the study an obvious diminish was existed in phantom pain and sense in the group who received IPF (p<0.05).

Also a significant difference was determined in the first group from the view point of quality of life (p<0.05).

DISCUSSION

IPF is an effective way in shaping the stump, coping with the disabilities and preventing the postoperative complications after amputation (2, 3).

Above mentioned issues all lead amputees to reintegrate normal living in a shorter period of time. Amputee can walk functionally and experience phantom limb sense and pain lesser (3, 4).

It can be concluded that the patient selection is a very important factor to be successful in the IPF technique. It may be difficult to utilize this technique in cancer and vascular problems. In our study, our patients were amputated because of cancer and diabetes mellitus. We noticed that they could adapt to this technique and fitted very well with IPF. They received better results when compared with the patients of classical application.

CONCLUSION

It can be concluded that IPF technique is an effective way of amputee rehabilitation which leads to reintegrate normal living in a shorter period of time and improve the quality of life.

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FROM AMPUTATION TO REINTEGRATION

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Abstract

The article discusses the program of rehabilitation and reintegration of patients with lower-limb amputation, who had undergone amputation at the Medical Clinical Center Maribor and were then, in regard to their functional state, referred to rehabilitation at the Institute for Rehabilitation, Republic of Slovenia. We retrospectively followed 58 patients. In our research 88% of included patients were fitted with prostheses and were able to walk acceptable distance. The functional state of the patients at discharge was based on gait tests and the improved assessment of motor abilities on the Functional Independence Measure (FIM).
The follow up of amputee patients is important part of complete rehabilitation program. Their reintegration has to be followed and carefully stimulated by rehabilitation team.

INTRODUCTION

Most lower-limb amputations result from impaired peripheral arterial blood flow and consequential chronic critical ischemia. In general, the patients are elderly, they suffer from numerous comorbidities and frequently live in inadequate social conditions.

The goal of amputee's rehabilitation is to help patient return to the highest level of function, while improving the overall quality of life - physically, emotionally, and socially (1-3).

In our retrospective study patients who had lower limb amputation and concluded early rehabilitation program in Medical Clinical Centre Maribor, were then referred to complex rehabilitation program at the Institute for Rehabilitation, Republic of Slovenia.

The aim of our study was to find out how amputee patients finishing rehabilitation program were able to walk with prosthesis and return to active life.

METHODS AND SUBJECTS

Methods

After early rehabilitation in Maribor a group of amputee patients was included in complex rehabilitation program at the Institute for Rehabilitation in Ljubljana. The rehabilitation team, the physicians - PRM specialist, specialist in internal medicine, medical nurses, physiotherapist, occupational therapist, prosthetic engineer, social worker, psychologist and vocational counsellor according to patients needs help the patient to adapt to a new life-style.

The activity or disability level was regularly followed by the rehabilitation team using motor Functional Independence Measure (motor FIM) and walking tests.

Subjects

115 lower-limb amputations were performed on 105 patients (aged from 17 to 95 years) in Medical Clinical Centre Maribor between May 1st 2006 and April 29th 2007.

67 of them were referred to Rehabilitation Institute in Ljubljana for rehabilitation, 9 did not respond. So 58 amputee patients (aged from 17 to 87 years) were admitted to rehabilitation. The causes of lower-limb amputation were: in 29 patients (50%) complications of diabetes, in 22 patients (38%) peripheral arterial disease, in 4 patients (7%) injury, in 2 (3%) osteomyelitis and in 1 patient (2%) carcinoma. The level of amputation: 64% trans-tibial (TT), 26% trans-femoral (TF), 3% bilateral TT, 3% bilateral TF and 3% bilateral, TT and TF amputation.

RESULTS

51 amputee patients (88%) were fitted with prosthesis. In 7 patients (12%), prosthetic fitting was not performed due to their weak physical condition.

The average motor FIM at admission was 68 (from 21 to 84), at discharge 74 (from 30 to 84), it increased in average for 6 (from 0 to 21).

Walking tests were performed in 44 patients with appropriate physical condition. Walking speed was assessed as the time

needed to walk 10 meters with prosthesis.On average, the subjects needed 34 seconds to walk 10 meters (from 7 to 85 seconds). Walking endurance was assessed as the distance covered with prosthesis in 6 minutes. In that time, the subjects walked 132 meters on average (from 20 to 340m).

52 patients (90%) returned home, to their previous social environment, 6 patients (10%) were discharged into nursing home. The average period from the amputation to admission on rehabilitation was 112 days (from 40 to 348). The average period from admission to discharge from the Institute was 28 days.

DISCUSSION

The functional level of amputee patients depends on the interaction between physical, mental, psychological and social factors (4-6).

We agree FIM score is not useful in predicting successful prosthetic rehabilitation in lower extremity amputee patients (7). The motor subscore acompagnes the use of prosthesis.

We compared some demographic characteristics of our group with the analysis of the amputees in Croatia (8). The most common diseases that resulted in amputation were: diabetes mellitus and obstructive vascular diseases, trauma, osteomyelitis and tumors.

Average period from the amputation to admission for rehabilitation program was 112 days (from 40 to 348) in Slovenia and over 190 days in Croatia.

The average period from admission to discharge from the Institute was 28 days in Slovenia and about 40 days in Croatia.

CONCLUSION

In amputee patients with normal stump healing the admission to the complex rehabilitation program should be done as soon as possible. Its goal is to help patient return to the highest level of function, while improving the overall quality of life - physically, emotionally, and socially.

The functional state of the patients at discharge from the rehabilitation program in our Institute was based on gait tests and the improved assessment of motor abilities on the Functional Independence Measure (FIM). After finishing the rehabilitation program most of the amputee patients observed in our study returned to their homes and their further reintegration will be followed-up at their regular outpatient controls.

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THE WILMER PASSIVE HAND PROSTHESIS FOR TODDLERS

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Abstract

The WILMER Passive Hand Prosthesis is developed for children aged one through five years. This harnessless hand prosthesis aims primarily at giving the child two arms of equal length. The hand features an easy to control passive prehension function. The movements of the fingers are mechanically coupled to the movements of the thumb. By pressing an object against the fingertips, the hand opens. By slightly tilting the object, it can be grasped. The hand prosthesis can be mounted in a passive friction wrist rotation prosthesis, available in different outer diameters. Clinical tests showed the hand mechanism to be very robust and reliable. For the age group mentioned this hand prosthesis is one of the very few available with a prehensile function.

INTRODUCTION

For young children, 1 - 5 years of age, with (unilateral) upper limb deficiencies at forearm or upper arm level, the parents sometimes opt for a prosthesis. The reasons can include cosmetics, i.e. the wish to look as complete as possible, or the idea that the use of a prosthesis is beneficial for the development of the child. As an alternative for the myoelectric prosthesis, which is often judged as too heavy, especially for the very young child, we have developed a mechanical, low mass hand prosthesis, Figure 1.

Figure 1: *A young girl wearing a WILMER Passive Hand Prosthesis*

METHODS AND SUBJECTS

As point of departure for the design of the hand mechanism, the desire to keep the mechanism as simple as possible was chosen. The hand is of a passive nature. This implies that the other hand is needed to open the prosthesis. This can be seen as a drawback, however, the sound hand is most often already utilized to hold the object and to present it to the prosthetic hand. The advantage is that no harness is needed to operate the hand, as is usually the case in an active mechanical hand prosthesis.

The working principle of the hand is simple, Figure 2. The movement of the fingers is mechanically coupled to the movement of the thumb by a four-bar linkage. An elastic band acts as a closing spring and provides the desired pinch force. By pressing an object against the fingertips the hand opens. Now an object can be tilted in between the thumb and the fingers of the prosthesis. By releasing the fingers, the hand is closed by the spring and the object is clamped between the thumb and the fingers.

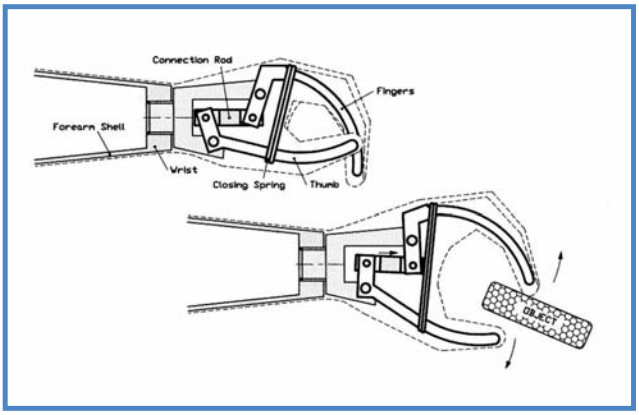

Figure 2: *The mechanism of the WILMER Passive Hand Prosthesis comprises a four-bar linkage. This linkage encompasses the thumb, the fingers, a connection rod, and the hand frame.*

To achieve a natural looking operation of the hand mechanism, the plane of movement of the thumb is placed at a 45-degree angle with respect to the plane of movement of the fingers. This implies the need for a spatial four-bar mechanism with an additional degree of freedom. Instead of adding a rotation option along the long axis of the connection rod, some play in the bearings of the connection rod is allowed. This method is preferred as it keeps the mechanism simple.

To couple the hand mechanism to the forearm shell a very simple friction wrist was designed that allows for passive pro- and supination. The amount of friction can be easily adjusted by turning a setscrew.

Through our collaboration with several rehabilitation centers in The Netherlands the WILMER passive hand prosthesis is supplied to children in the target age group for clinical testing. Over the years almost one hundred of these hands were provided.

RESULTS

The parts of the hand mechanism, and those of the wrist, have been manufactured and the mechanism has been assembled, Figure 3. The operation is as expected.

Figure 3: *The assembled WILMER Passive Hand Prosthesis mounted in the WILMER Friction Wrist*

The technical specifications include a maximum opening width between the thumb and the index finger of 35 mm, an overall length from the wrist to the nail surface of the middle finger of 72 mm, and a total mass of 78 g (without the cosmetic glove). The passive friction wrist is available in two different diameters: 30 mm and 38 mm, with a mass of 12 g and 20 g respectively. The overall length of the wrist is 13 mm for both diameters.

Some foam material and a cosmetic glove cover the hand mechanism to shape a natural appearance, Figure 4.

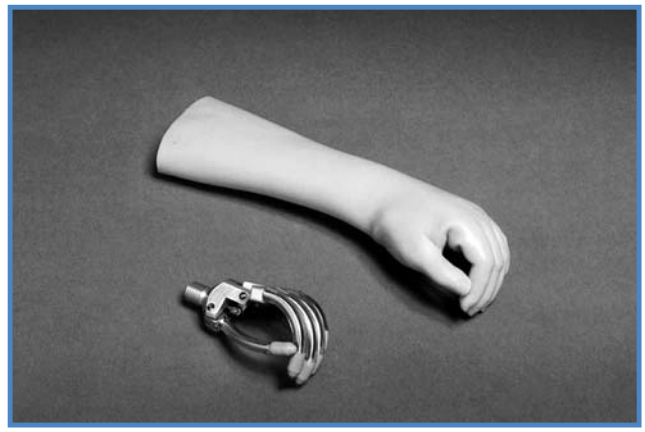

Figure 4: The hand mechanism is covered by a foam moulding and a cosmetic glove to ensure a natural appearance

Although a thorough outcome study still has to be performed to determine the functional benefits of this prosthesis, the clinical experience indicates no major problems in the technical properties of the device. The hand mechanism proved to be very robust and reliable. It proved to be insensitive to sand, water and dirt. Repairs are seldom necessary and usually can be attributed to excessive loads, like falls, resulting in deformed fingers or loosened adhesive bonds. Moreover, no special care is needed except for occasional cleaning of excessive debris/sand.

The children and their parents report the hand provides a limited grasping function but excellent cosmetic support for two-armed activities. The prosthesis restores equal arm lengths. The absence of a harness is cherished and especially beneficial for small children, as they do not understand why they need a harness. The hand is used for many different activities like riding a tricycle, and play activities like building blocks, swinging, turning head over heel, etc. Parents report a positive effect on the child's development.

DISCUSSION

The WILMER passive hand prosthesis utilizes a simple four-bar linkage mechanism and is operated in a very simple passive fashion. Therewith the overall mass of the hand is kept very low. The hand offers mainly a support function to the child, which proved very useful for riding a tricycle or in play activities requiring two handed support tasks. Compared to the only known other passive hand prosthesis for children, the L'iL E-Z hand (1), marketed by TRS Inc., USA, the WILMER Passive Hand Prosthesis provides a more easy grasp of an object as a result of the coupled motion of the thumb and the fingers. In the L'iL E-Z hand grasping is more difficult as only the thumb can be moved. As a result, the other hand is occupied by keeping the thumb open and is not available to present the object to the prosthesis. In the WILMER Passive Hand prosthesis the object is pressed against the fingertips to open the hand. Once open, the object

can be tilted in between the fingers and the thumb. Moreover, the WILMER Passive Hand Prosthesis is cosmetically superior, mainly because of the cosmetic glove used.

CONCLUSION

The WILMER Passive Hand Prosthesis is developed for children aged one through five years. This hand prosthesis gives the child two arms of equal length, and an easy to control passive prehension function without the need for a control harness. The hand features a low mass construction, which proved to be very reliable in the clinical tests. The WILMER Passive Hand Prosthesis stands out in functionality and in cosmetics as compared to other passive hand prostheses on the market.

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TOUCH BIONICS PRESENTATION: I-LIMB HAND

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Touch Bionics is the UK-based award winning company focusing on the supply of electrically powered Upper Limb Prostheses (ULP). Touch Bionics grew out of a programme of work conducted at the Princess Margaret Rose Hospital in Edinburgh from 1963; starting with comprehensive research into developing prosthetic solutions for children affected by Thalidomide. By 2003 the company was spun out from the NHS. An initial SMART award from Scottish Enterprise got the company going, and was later funded by private investors.

Touch Bionics developed the i-LIMB™ System – **world's first commercially available bionic arm**. The Touch Bionics i-LIMB™ Hand offers users a step-change in functionality and performance, enabling patients to do more with their prosthetic hand. The i-LIMB Hand and partial hand has individually articulating fingers, a rotating thumb and a range of grip patterns. All these features are combined in a hand that is more anatomically correct than any other hand currently available on the market, which allows for increased functionality and improved cosmesis.

In another industry first, Touch Bionics' finger technology has been adapted for patients who have a partial hand requirement, due to either congenitally missing fingers or fingers lost through an accident. Partial hand is an area of prosthetics that has been without a satisfactory powered solution for patients. ProDigits are the key point of innovation from Touch Bionics.

I will cover the following aspects during the presentation:
- History of Touch Bionics leading to development of i-LIMB Hand
- Introduction to i-LIMB Hand
- Patient selection
- Patient videos using i-LIMB Hand
- Cosmesis options
- ProDigits- Partial hand Solution
- Conclusion and Question and answers

OUR EXPERIENCE IN OCCUPATIONAL THERAPY WITH CHILDREN WITH CONGENITAL UNILATERAL UPPER EXTREMITIES AMPUTATION

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Abstract

The most common congenital upper -extremities deficiency is a unilateral, short, below elbow deficiency, with absence of the forearm, wrist and hand. In this article seven children, age of five months to nine years, were analyzed during two years using human occupation theory and purposeful activities. Four children were fitted with a cosmetic prostheses and three with a myoelectric prostheses. Duration of prosthetic training was usually five to ten days, for about one hour. At the end of training process all of the children used prostheses independently all day long.

INTRODUCTION

The most common congenital upper -extremities deficiency is a unilateral, short, below elbow deficiency, with absence of the forearm, wrist and hand. At the age of five to six months (an age when a child begins to sit and needs arms for prop support) infant with a congenital limb deficiency was fitted with cosmetic prosthesis for upper extremities. Fitting at this age accustoms a child to the presence of the prosthesis and encourages bimanual activity. Five years old children were fitted with a myoelectric prostheses wich were financed by the health insurance. The type of prosthesis depended on age, quality of the stump as well as children and parents' wishes and activities. Occupational therapy treatment was accomodated to child's age and included activities specific for the stage of development.

METHODS AND SUBJECTS

In this article seven children, age of five months to nine years, were analyzed during two years using human occupation theory and purposeful activities. Four children were fitted with a cosmetic prostheses and three were fitted with a myoelectric prostheses. At the time of the first fitting children were five to six months old. They were assessed by a doctor, a prosthetist and an occupational therapist. The functions that were assessed by the use of projective techniques included: motor skills, cognitive skills, task skills, interaction skills, orientation, motivation, mood, reality orientation, level of activity, self - image and independence. Duration of prosthetic training was usually five to ten days, for about one hour. On the first day of prosthetic training a child wears the prosthesis for a short period of time, usually not longer than 30 minutes, and then progresses learning to put on and take off the prosthesis. Training with cosmetic prosthesis at the age of five to six months included incorporating prosthesis into activities of rolling, initially from prone to supine and then reverse followed by the hand to hand transfers while in independent sitting position. In this stage of training with cosmetic prosthesis the most important is to incorporate prosthesis into body image by creating engrams in central nerve system.

The second day began with the training of functional activities and play skills through interactive games. Training of self care activities on the third day included dressing and eating procedures, wich started with spoon feeding. Children used prosthesis along with dominant hand as assistance and fixation. Writing and drawing, pencil sharpening, using dial phone, fastening buttons, tying shoeslaces and using zippers were training activities on the fourth day and were adapted to developmental stage. On the last day we repeated performance of all activities of daily living. Training with myoelectric prosthesis included the same activities only performed in different way. All three children from this article used cosmetic prosthesis before myoelectric one. The first and most important stage in training with myoelectric prosthesis is to learn the appropriate muscle motions and contractions needed to operate the device precisely. Opening and closing the hand and rarely pronation and supination if the stump is long enough. Change of weight is also a new moment that must be included in the preparations of training with myoelectric prosthesis.

The first follow up visit was scheduled approximately four weeks after discharge and than at longer intervals, every six months.

RESULTS

On the first day of prosthetic training children were usually wearing the prostheses for 30 minutes. On the fifth to tenth day children fitted with cosmetic prostheses were incorporating and using prosthesis for about two hours and were puting it on independently. Children fitted with myoelectric prostheses were using them in gross and fine motor tasks for about six hours. Three days were enough for children fitted with myoelectric prostheses to learn how to coordinate and move myoelectric hand successfully. The feeling of heaviness disappeared after five days. On the tenth day all children had good balance, coordination, posture and mobility in following activities: controlled lowering with support activity (six months), high kneel to half kneel with hands up activity (eighteen to thirty months) and toe walking (three to four years) and heel walking activity (four to five years). Six month later all children were using prostheses successfully all day long. A year later five out of seven children were involved in sports, recreation and creative activities.

DISCUSSION

The attitude of our Institute is that the functional use training is necessary and very important stage of the prosthetic process and requires the best possible collaboration and communication of therapist, children and parents and should last at least seven to ten days. The therapist's ability to motivate children and parents as well as explain the importance of training is crucial for successful cooperation.

CONSLUSIONS

The amputees' potential is limitless. It does not solely depend upon the quality of the prosthesis, medical care or therapy. All these areas ideally work in close harmony with one another. Motivation of parents and children is the most important for reintegration. It is the responsibility of all rehabilitation professionals involved to create environment that will encourage and enhance this process.

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GROUP OCCUPATIONAL THERAPY IN CHILDREN AFTER AN UPPER LIMB AMPUTATION

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Abstract

An occupational therapist is an important member of a rehabilitation team of children after amputation of an upper limb who teaches children to be independent with and without prosthesis. That can be done individually or in groups. At the Institute for Rehabilitation, Republic of Slovenia, two types of group activities are used, cooking and picnics. A questionnaire on the satisfaction with the group activities was sent to all the children and parents visiting our outpatient clinic. All the children and parents who answered our questionnaire were satisfied with both group activities. It can be concluded that both cooking and picnicking are appropriate group activities that may be used in rehabilitation of children after upper limb amputation. Cooking is better for prosthetic training while picnics are more social events.

INTRODUCTION

The main rehabilitation goal in children after an upper limb amputation is for them to become independent with and without prosthesis, productive, and to have satisfying lives. An important member of a rehabilitation team treating these children is an occupational therapist who has to teach children how to actively use their prosthesis for play, at school and at other age-appropriate activities, such as bathing, getting dressed, brushing their teeth, and feeding themselves (1), as well as for sport and other hobbies.

Occupation therapy is usually performed individually, but sometimes it can be organized in a group. Individual therapy is more appropriate immediately after the first fitting and after fitting with a new system when the child has to concentrate and follow the instructions. That can be done easier when the child is alone with the therapist and family members only. Later, at follow-ups, group activities can be added, where children and parents meet and see that they are in the same boat as many other parents and children. There are ten different types of groups commonly used in occupational therapy (2): exercise, cooking, tasks, activities of daily living, arts and crafts, self -expression, feelings-oriented discussion, reality-oriented discussion, sensorimotor or sensory integration and educational activities.

At Institute for Rehabilitation in Ljubljana, at the outpatient clinic for rehabilitation of children after an upper limb amputation, cooking and organized picnics are used, where different outdoor games are played.

The aim of the present study was to find out the children's and parent's opinion about the mentioned group activities.

METHODS AND SUBJECTS

A questionnaire on cooking and picnics were prepared and sent to all (n=24) the children visiting our outpatient clinic for rehabilitation of children after an upper limb amputation.

RESULTS

Twelve correctly filled in questionnaires were returned, 8 from girls and 4 from boys. The children were 14 years old on average. Ten had trans-radial amputation, 1 partial hand amputation and one trans-humeral amputation. One amputation resulted from an injury, all the others were congenital deficiencies. Two children did not use a prosthesis, 2 used cosmetic and eight myoelectric prostheses.

Ten children were included into cooking activities at least once. Five believed that cooking was a meaningful and seven that it was a very meaningful activity. The two children with a cosmetic prosthesis said that it was not useful, whereas six myoelectric users said that it was partially useful and two that it was very useful for cooking (Table 1). The latter two also used it regularly for cooking at home.

Five children also participated at picnicking at least once. They all believed that it was well organised and most of them would attend it again.

DISCUSSION

Most children and their parents who answered our questionnaire had been included into group activities at least once and

Table 1: *Children's opinion about the usefulness of prosthesis for cooking and the meaningfulness of cooking*

How useful is prosthesis for cooking?	Cooking is		Together
	Meaningful	Very meaningful	
Not useful	1	1	2
Partially useful	3	3	6
Very useful	0	2	2
Total	4	6	10

all were satisfied with those activities. About half of those who did not answer the questionnaire had not participated at any picnic and many of them were already 18 years old or older. The other half of those who did not answer were younger and were not included into cooking. Most of them had participated at picnics at least once, but they were too young to participate very actively in most group games. Their parents seemed to have decided to participate in picnics mainly to meet other parents.

A group can offer a structure and shape within which we can observe a child and his or her characteristics, find the degree of the child's development, his or her psychic and social abilities, how the child responds to peers, how he or she sees himself or herself and the others, how he or she receives and deals with a large quantity of information and how he or she plans and finds solutions to problems. The two group activities used in this study are very different. Cooking is not appropriate for very young children, but is done with prosthesis and many activities, such as opening different packages (butter, flour, sugar), steering in a bowl, beating/smashing an egg, rolling paste, peeling fruits and many others have to be done bimanually. Children are taught how to use their prosthesis and they can observe other children while doing the same activity.

On the other hand, picnics were organised on a playground. The children went down a slide, used swings, climbed on a jungle gym, played with sand and balls and skipped rope. There was some food served so that they had to open an ice cream, a juice or peel some fruit, but many performed most of those activities without prosthesis. The picnics served more as a social event for spending some time with other children and their parents as well as with rehabilitation team members in an informal setting.

CONCLUSION

It can be concluded that both cooking and picnics are appropriate group activities that may be used in rehabilitation of children after un upper limb amputation. Cooking is better for prosthetic training whereas picnic is more of a social event. All the children and parents who answered our questionnaire were satisfied with both group activities.

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COMPREHENSIVE APPROACH IN HABILITATION OF CHILDREN WITH CONGENITAL BILATERAL DEFICIENCY OF UPPER LIMBS - A CASE REPORT

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Abstract

The incidence of congenital upper-limb deficiencies is very low. Children with upper-limb deficiencies must be referred to a multidisciplinary clinic early in life in order to achieve good functional independence. Management of children with bilateral limb deficiency differs from those with unilateral deficiency. Our aim is to present a comprehensive approach in habilitation of a child with congenital bilateral deficiency of upper limbs. We believe that this boy was fitted early enough to establish good wearing patterns. We also believe that early fitting may prevent secondary physical disabilities during growth, such as scoliosis, and will also enhance bilateral functional skills.

INTRODUCTION

The incidence of congenital upper-limb deficiencies for United States, Canada and the UK is estimated to be 1:9400 live births (1). An 11-year total population study of Western Australia, that examined the prevalence and epidemiology of congenital upper limb anomalies, found the prevalence of babies born with upper limb anomalies to be 1 in 506 (2). Bilateral upper limb deficiency is very rare condition. By our knowledge there are no precise data on incidence available. In last eight years there were two such cases in Slovenia, one of them is going to be presented in this article.

To the knowledge of a nowadays, children with limb deficiencies must be referred to a multidisciplinary clinic within the first four months of life. The aim is a detailed assessment, evaluation and early fitting of prosthesis for unilateral upper limb deficiency (3). Kuyper et al. are reporting that only 3% of children with bilateral upper limb deficiency are fitted with prosthesis (4). "De Hoogstraat" rehabilitation centre uses a restrained prosthesis prescription policy, depending on the type of deficiency and the expected functional benefits.

An early fitting of unilateral limb deficiency is important for amputations as well as for congenital malformations (4). In the unilateral upper-limb amputee it allows the opportunity to develop bimanual skills into the body image and into useful prehensile activities at an earlier age. Early fitting may also contribute ultimately to better prosthetic tolerance and wearing patterns and may prevent an asymmetrical posture and spinal curvature (5-12).

On the other hand, management of bilateral upper limb deficiency is usually different. Lento describes infants and children with congenital bilateral upper-limb deficiencies, who generally develop a remarkable ability to adapt to their situation. They do not have a distorted sense of body form that may occur if the limb or limbs were amputated later in life. Therefore, many may not feel the need for any type of prosthesis even for cosmetic reasons. Many prefer to rely on their lower limbs in place of an upper limb(s) to perform typical activities of daily living such as bathing, dressing and feeding (12).

But there might be also some long-term problems of lower limbs use. A retrospective study performed to determine the incidence of spinal abnormalities in patients with skeletal defects of the upper extremities showed that there was a 100% incidence of scoliosis among patients with bilateral amelia. The results of bracing were poor, due to patient rejection of the brace (13).

We believe also that using of feet might not be always a socially accepted choice in different settings.

Aim: We want to present a comprehensive approach in habilitation of a child with congenital bilateral deficiency of upper limbs.

METHODS AND SUBJECTS

A boy was born after uneventful pregnancy, 8 days before the term, with bilateral amelia of upper limbs. Radiologically there were a short humerus, ulna, radius and 2 metacarpal

bones present on the left side and aplasia of humerus, short radius and ulna, two metacarpal bones and phalangeal bones for two fingers on the right side.

He was referred to our Institute at the age of 8 months. A team of specialist of physical and rehabilitation medicine, occupational therapist and prosthetic engineer conducted a detailed functional assessment. Clinically there were two short fingers on the right side coming out of shoulder, and a 10 cm long arm with two longer fingers on the left side. Neurologically there were no signs of abnormality. Motor development was slightly delayed: he just started to roll from prone to supine, was able to transfer to sitting position with help and needed some support to maintain sitting position. To support the motor development he was referred to physiotherapy. He was encouraged to use his feet in different activities.

At the age of 15 months he was still not able to transfer independently to sitting and standing position. He was using his feet to handle different objects. Four months later he was able to walk independently, but was dependant in most of daily life activities. Some adjusted eating tools for left upper limb fingers were provided.

At the age of three and half years first prosthesis was prescribed. He got a body-powered prosthesis for exarticulation of right upper limb, with Omni wrist for shoulder joint, orthotic elbow and voluntary closing children's hook (a crocodile) for some other activities. For most of daily life activities he was using his feet or he got help form parents or accompanying person. He was able to hold spoon with two longer fingers on his left side, but had problems when feeding himself. He was also able to hold a pencil, but not firmly enough to draw. At the same time he was able to draw and play very successfully by using his feet.

We decided to refer him into a two weeks in-hospital training program for training the use of different assistive devices, slowly strengthening the grip on left side and use of prosthesis on right side. At the time of precise evaluation we tried to find an important goal with the boy, to motivate him for prosthetic wearing. We found out he was very keen on playing some computer games, but was having problems, since he could use just left upper arm fingers. We prepared some adjusted tool to hold it with prosthesis while playing. We also organized a meeting with his teachers from a kindergarten, so we could transfer our knowledge and help them to provide a stimulating environment for a boy.

RESULTS

At the beginning he used prosthesis only for bike riding and occasionally for some other activities, such as carrying basket during picking up chestnut. For most of daily life activities he was using his feet or he got help form parents or accompanying person.

He was able to hold spoon with two longer fingers on his left side, but had problems when feeding himself. He was also able to hold a pencil, but not firmly enough to draw. At the same time he was able to draw and play very successfully by using his feet. We found out he was very keen on playing some computer games, but was having problems, since he could use just left upper arm fingers. We prepared some adjusted tool to hold it with prosthesis while playing.

We organized also a meeting with his teachers from a kindergarten, so we could transfer our knowledge and help them to provide a stimulating environment for a boy.

At the age of four years he is able to hold all different objects, which are not to big or heavy, with fingers on the left side. He gained some muscular power and dexterity. He is able to eat and draw by using adjusted tools for holding spoon and pencil. He is also able to use some adjusted tool for his right side to type on a computer. He is able to ride a bicycle by using prosthesis. He is also motivated to use it during some other activities, but predominantly while playing on a computer. He still uses his feet for some activities. His spine is developing without any serious pathology.

Functional skills level evaluated by Pediatric Evaluation of Disability inventory (PEDI, 14) are comparable to normal development in the mobility and social skills domains. He is having lower functional level score in the self-care domain. Results are on 14,8 percentile. Similar are results in caregiver assistance scales.

DISCUSSION

Our aim was to present a case of comprehensive approach in habilitation of children with congenital bilateral deficiency of upper limbs. We didn't follow the premises of early fitting, which are reported to contribute ultimately to better prosthetic tolerance and wearing patterns and may prevent an asymmetrical posture and spinal curvature (5-12). As Lento was describing infants and children with congenital bilateral upper-limb deficiencies, who generally develop a remarkable ability to adapt to their situation, we can confirm it stands also for a presented boy. He is a happy child, interested in a many different activities and only motivated for a prosthesis wearing when it offers him a help in activities of his interest.

Due to a good mobility of both fingers on left side, we planed to improve their strength and dexterity and to use them as a dominant hand. Both fingers on the right side are much smaller, so we tried to fit prosthesis on a non-dominant side. To make prosthesis as light as possible we decided to use body-powered system. In one year he become less dependent

on his feet, more frequently he draw with hands and also use them better at some other activities, which are normally performed with hands.

If we are taking into account the goals that a school-aged child should achieve are (11), we can say that the development of functional activities of this boy are going quite well. He is able to hold objects with the prosthetic limb without breaking or dropping them, to operate the terminal device reliably, but still needs an assistance to don and doff the prosthesis and to dress. Parents are encouraging use of the prosthesis in some of activities.

We hope that he will gain further in the field of functional abilities. However we can not predict how it will be in the adolescence. Function and wear may occasionally be far less important than appearance in that time, especially to the adolescent with an upper-limb deficiency.

CONCLUSION

We believe that this boy was fitted early enough to establish good wearing patterns and he would not discard prostheses once he will be old enough to make his own decisions. We also believe that early fitting may prevent secondary physical disabilities during growth, such as scoliosis, and will also enhance bilateral functional skills.

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THE ASSESSMENT OF CAPACITY FOR MYOELECTRIC CONTROL: CONSTRUCT VALIDITY AND RATING SCALE STRUCTURE

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Abstract:

The Assessment of Capacity for Myoelectric Control (ACMC), an observational-based instrument for measuring the overall prosthetic ability, was validated previously with repeated measures. The purpose of this study was to evaluate the ACMC construct again with a larger sample of single measures. The 4-point rating scale structure and its use were also evaluated. Data from 96 ACMC assessments (males 58, females 38, mean age 11) was analysed using the Rasch measurement model. The results showed that the hierarchy of item difficulty was consistent with the clinical expectation. The construct was proven to be unidimensional. Two items demonstrated misfit but did not degrade the total measurement and hence item removal was not necessary. The rating scale usefully differentiated the clients based on their abilities and the categories were being used expectedly. Further research is needed to examine the task influence and other aspects of validity and reliability of ACMC.

INTRODUCTION

The ACMC is a 30-item observational-based assessment designed to assess the overall prosthetic ability in daily tasks. The client's performance is rated on a 4-point rating scale (1). The purpose of this study was to evaluate the ACMC construct again with a larger sample of single measures since the previous study was validated with repeated measures. The 4-point rating scale structure and its use were also evaluated in this study. Specific questions were asked: Does a larger sample provide a wider range of prosthetic ability than the first validity study? Is the hierarchy of item difficulty consistent with clinical expectation? Do all the items work together to measure a single 'prosthetic control' dimension? Do all the items function as expected? Is the 4-point rating scale appropriately constructed to differentiate between prosthetic users of different abilities? Have the four categories been used in the expected manner?

METHODS AND SUBJECTS

Methods

The ACMC assessments were collected between September 2000 and December 2004 by six raters. The tasks chosen during the assessments included play activities and different daily tasks. The assessments were analysed using the Rasch rating scale model. This model was chosen because it allows an analysis at the item and category level (2).

Subjects

Ninety-six upper-extremity prosthetic users participated in this study (males 58, females 38, congenital deficiency 83, amputation 13, age range 02-57, mean age 11, median 8). The sample consisted of persons with different prosthetic levels and various length of experience in prosthetic use.

RESULTS

The overall result confirmed the construct validity of ACMC with a larger sample. The results showed that a wider range of prosthetic ability existed in this sample. The hierarchy of item difficulty was consistent with the clinical expectation and the construct was proven to measure only 'prosthetic control'. Two items functioned unexpectedly (misfit) but did not degrade the total measurement and hence item removal was not necessary. The rating scale was sufficient to differentiate different prosthetic abilities and the 4 categories were being used expectedly.

DISCUSSION

The consistency of item hierarchy with clinical expectation and the unidimensionality of ACMC confirmed the construct validity. The item misfit could be due to the difficulty of the tasks. In the development of another Rasch derived test, the

originators found that persons' measures were dependent on the task performed during the assessments (3). Thus, it is reasonable to assume that the control of prosthetic grip is easier in some tasks than in others. Therefore, further research is needed to test if the ACMC items are functioning in a similar way independent of the choice of tasks. No removal or addition of category is needed since the 4 categories are sufficient. The raters had used the categories as expected. This implies that the definitions of the categories are well understood.

CONCLUSION

The construct validity of ACMC and good quality of the rating scale were demonstrated in the present study. This implies that ACMC can be a useful instrument in the field of prosthetic rehabilitation.

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USE AND SUPPORT OF RAPID PROTOTYPING IN PRODUCING PROSTHESES AND EPITHESES

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Abstract

By introducing new technologies our intention was to find a most optimal technological possibility for improving the quality of the outlook of protheses' after a partial hand amputation (either fingers or the hand), and in manufacturing of epitheses. In the field of CAD technology we have tested some different scanners by means of which the models of fingers, palms and parts of the face were digitized. We have checked also usability of some computer programs for 3D-shapes. Various procedures of RP technology, which is to be classified among CAM technologies, have been examined with manufacturing of moulds or tools for manufacturing of an aesthetic prosthesis of a finger, the hand, and of maxilofacial protheses - epitheses. This technology provides the patients with the highest life like quality of prosthetic design.

INTRODUCTION

The development of modern technologies is being transferred from other various branches of industry into orthopaedical techniques as well as it is transferred into the field of orthotics as prosthetics.

In recent years the Computer-Aided Design - Computer-Aided Manufacturing (CAD-CAM) technology has become established. The Computer Aided Design technology made it possible to construct a product by means of a computer program. By implying the Computer Aided Manufacturing program the computer made model of the constructed product can be produced by use of a multi-axial processing machine or by using some recent laser technology procedures which are classified among RP-Rapid Prototyping Technology. The first successful trials of implying this technology in the field of medicine go back to 1992 (1). Quite soon the technology has found its way in the field of dental medicine. Coward et al. were the first to publish the results of implementing the Rapid Prototyping Technology into the field of manufacturing of maxillofacial prostheses, in the case of an auricular epithesis (2). The first publications on how this technology was implemented in the field of prosthetics dates into 2002 (3), when a part of a robotic hand and prosthetic socket for the lower limb prosthesis (4) were manufactured. Didrick (5) was the first to mention the manufacturing of an aesthetic finger prosthesis and in our Institute for Rehabilitation we have tested this technology in manufacturing of a prosthesis in case of a partial hand amputation. At present it is used also in manufacturing of epitheses.

In order to reproduce the closest match to the original fingers and hand the only way was to capture the shape of its counterpart on the healthy hand.

At the Institute for Rehabilitation the manufacturing of silicone hand prostheses was based on the shape of similar PVC cosmetic gloves or on the model of a similar hand of a third person. None of the above mentioned methods has enabled manufacturing of prostheses that would closely resemble the patient's healthy hand.

Manufacturing of epitheses takes a lot of time as manual modelling of the firstmodel is necessary to make it mirror the healthy part of the face. Accordingly, the Institute together with the partners wanted to develop a high resolution CAD-CAM technology for protheses manufacturing, where the shape is mirroring the patient's healthy part of the body.

METHODS AND SUBJECTS

Prostheses and epitheses production can be divided into the following steps:

3D Digitizing (capturing of the physical shape)
During the development phase, three laser- or optical scanners were tested while preparing a digitized 3D-model of a hand, stump and a part of the face. The following scanners were tested: the Freescanner CAPOD CAD-CAM System, the Zscanner 700, and the 3D-optical scanner ATOS II 400.

CAD Modelling (modifications on the computer model)
The 3D digital model of the healthy hand was corrected and adjusted to the digital model of the stump by means of internally developed software ATOS 6.0.0.3 and Tebis CAD. The processing and correction of the digitized model of epitheses has been performed by means of the program, called Geomagic.

Computer Aided Model or Mould Manufacturing
In the production of a master-model and tool, three technologies for fast manufacturing of first models and tools were tested: the DMLS (Direct Metal Laser Sintering), the SLS (Select Laser Sintering) and the 3D print technology.

Moulding and Finalization of Prostheses or Epitheses
In the production of prostheses after a partial amputation of the palm various colour shades of medicinal silicone were dosed into the tool. The mould was inserted into a power press so as to assure a contact between silicone and all the parts of the tool. The tool has been put onto a hot stove where silicone vulcanization was achieved by heating it to an adequate temperature. After vulcanization was completed the tool was cooled, demounted and used to finalize the prosthesis.

RESULTS 3D

Digitizing (capturing of the physical shape)

The highest quality of scanning was achieved by ATOS II 400, produced by German company GOM: it provided digital models with visible skin details.

With the Freescanner CAPOD CAD-CAM system the perception of skin details was not possible and it did not register the narrow passages between fingers and the palm. The device is considered to be suitable for digitizing of the nose only where requirements are not that high.

The Zscanner 700 proved to be precise enough to enable scanning of ear models. In finger- or hand scanning it did not register all the skin details.

CAD Modelling (modifications, made on the computer model)

ATOS program enables model mirroring, adjusting of the stump and the mirroring model of the healthy hand, as well as ajdusting the models into the coordinate system. The program Tebis CAD was used with some more pretentious modelling, as for instance widening or broadening of pixel points net in a digitized model, for controlling the difference in volumes of the two models, providing the control of thickness, change of flexion in finger joints, and correction of skin details. With correction and mirroring of the model in an auricular or orbital epithesis the Geomagic computer program was implemented: it enabled model mirroring, adjusting the model as to its volume, providing defect corrections on the model, etc.

Computer Aided Model or Mould Manufacturing

The highest level of appearance of skin details in the hand prostheses tool was achieved by the DMLS technology (Direct Metal Laser Sintering) with 0.04 mm accuracy. In the testing of the SLS (Select Laser Sintering) technology and the print technology, the accuracy was 0.1 mm. After the tools check the most accurate surface was found to be the one produced by the DMLS technology. Silicone was poured into the tools and after the vulcanization the quality of test prostheses was found to depend on the appearance of skin prints. The highest quality of the tool surface was achieved by the DMLS technology and the lowest by the 3D print technology. The latter produced a rougher surface of the prostheses test model despite the satisfactory appearance of the skin prints. The appearance of skin prints achieved by the SLS was not essentially lower than the one achieved by the DMLS technology. The SLS technology was selected for tool manufacturing of the hand prostheses due to its accessible costs.

Moulding and Finalization of the Prostheses or Epitheses

The procedure of finalization of the prostheses has been performed in accordance with the established technological ways.

DISCUSSION

The final appearance of a prosthesis depends greatly on its shape. In most centres for manufacturing silicone hand prostheses the procedures of manual modelling (6, 7) are used nowadays. The quality of such prostheses depends on the prosthetist's artistic skills. By using the CAD-CAM high resolution technology, the highest-quality prosthetic design can be achieved even when a prosthetist lacks artistic skills. The same procedure is mentioned by Didrick (5), by whom this technology has been applied in the procedure of manufacturing of finger prostheses. There was not possible to make a comparison of experience other authors had made in the field of implying the CAD-CAM technology in prostheses manufacturing after partial amputation of the hand since in the medicine articles' base it was not possible to find any evidence on the use of this technology with colleagues abroad.

Due to existing licence contracts or partnership enterprises eventual comparisons between individual computer programs have not been performed.

DMLS technology may offer the greatest precision yet due to the heavy weight of the tool and the high price it is less suitable.

As to its quality and price the print technology proved to be the most favorable solution in manufacturing a prototype of auricular or orbital epitheses. The material which this technology is based on is quite brittle. Accordingly, it may enable grinding but it cannot achieve the necessary tenacity which is inavoidable for the manufacturing of the tool.

During the development phase, the CAD-CAM technology processes were defined to enable the production of silicone prostheses after partial hand amputations, which in their form mirror the patient's healthy hand.

As to manufacturing of epitheses it has been stated that the technological procedure is an adequate one and qualitative enough to ensure manufacturing of an epithesis prototype, improving the similarity of the model with the healthy part of the face, and saving the time of forming; however, we implemented the procedure only for the manufacturing of the prototype and not for the tool itself.

Some more experiences in implementing this new technology could be evidented in some expert articles on epitheses manufacturing.

Already in 1997 the preliminary report on use of CAD-CAM technology for manufacturing of face prostheses has been published by Chen LH et al. (8) Further it was Sykes who confirmed the advantages of this technology since he used it in epitheses shaping and -manufacturing (9).

Some further authors (10-14) tended to publish their experiences on epitheses manufacturing by implying the CAD-CAM or Rapid Prototyping technology, respectively. All authors report of benefit of the said technology which is said to be precise and time-saving for the prosthetics.

CONCLUSION

Our experiences in using the CAD-CAM high resolution technology have shown that such technology enables computer-based manufacturing of a prosthesis which in its form mirrors the healthy hand. This technology provides the patients with the highest quality of lifelike prosthetic design.

New technology customizes the final product to such measures that it significantly contributes to successful post-traumatic rehabilitation of a patient from personal, psychological, aesthetical and practical aspects. The results were very promising and eventually proved that the approach, with further improvements, will provide final products with better quality, providing a ground for better and faster rehabilitation of patients.

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COMPARISON OF GRIP STRENGTH IN PERSONS WITH CARPAL TUNNEL SYNDROME USING READY-MADE FABRIC AND CUSTOM-MADE ORTHOSES

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Abstract

The aim of the study was to find out whether custom-made wrist orthoses, which hold the wrist in a neutral position, offer better improvement of hand function than ready-made fabric orthoses with 30° dorsal flexion wrist position. The main points of interest were the comparisons between the strength of cylindrical, lateral and pinch grips. The results did not show any statistically important differences. To compare an influence of different orthoses on reducing of other symptoms of carpal tunnel syndrome or applicability in work activities can be further questions for our investigation.

NTRODUCTION

Carpal tunnel syndrome is a very frequent diagnosis in our every day practice. The prevalence of carpal tunnel syndrome symptoms in Sweden is 14.4%. Together with EMG confirmed diagnosis 4.9% (Atroshi et al., 1999). In Slovenia, there has been no similar research. Arnež (1999) compares the outcomes of the Swedish research and reports that the prevalence of the carpal tunnel syndrome in Slovene general population could be approximately from 200 000 to 288 000 persons. He estimates that in Slovenia there are from 40 000 to 57 000 persons with clinically and electro physiologically confirmed carpal tunnel syndrome.

The treatment of the carpal tunnel syndrome can be conservative or surgical. The conservative management of the carpal tunnel syndrome includes treatment with no steroid anti-inflammatory medications, treatment with steroid injections and orthotic treatment. When there is no success or in the case of the acute carpal tunnel syndrome with strong pains, surgical intervention is r ecommended (1).

Orthotic treatment improves the symptoms of carpal tunnel syndrome (2-5), but there has been no study on the influence of orthosis and its shape on the hand function.

The aim of the study was to find out whether custom-made wrist orthoses, which hold the wrist in a neutral position, offer better improvement of hand function than ready-made fabric orthoses with 30° dorsal flexion wrist position. The main points of interest were comparisons between the strength of cylindrical, lateral and pinch grips.

METHODS AND SUBJECTS

Methods

The grip strengths were measured with Grip force tracing system (6). The subjects were given custom-made orthoses from thermoplastic material. They were lent one of the three sizes (L, M and S) of ready-made fabric wrist orthoses (Sporlastic Manu-Hit).

Firstly, grip strengths of the unaffected hand were measured (cylindrical, lateral in pinch grips). The affected hand was first measured with the ready-made fabric orthoses with the wrist in 30° dorsal flexion, then with custom-made orthoses with the wrist in neutral position and finally without orthoses.

Subjects

The study included all the persons with EMG confirmed carpal tunnel syndrome treated at the outpatient` clinics at the Institute for Rehabilitation, Republic of Slovenia, from January 2007 to January 2008, who were willing to participate.

RESULTS

In the period from January 2007 to January 2008, 16 persons were treated. Three of them refused to participate in the study. The study group included 12 women and 1 man, 12 were right-handed and 1 was left-handed. In 11 subjects, the

dominant side was affected. The average age in the study group was 48.5 years.

The results did not show any statistically important differences. The compared means of grip forces did not deviate much between"custom made","fabric-ready"and "withoutorthoses"inthethree types of grip (Figure 1). The compared means of grip forces (between groups of different grips) show that the forces of cylindrical grip were the lowest with the custom-made orthoses, followed by without orthoses and the highest were with fabric- ready orthoses. The results in lateral grip and pinch grip forces were similar.

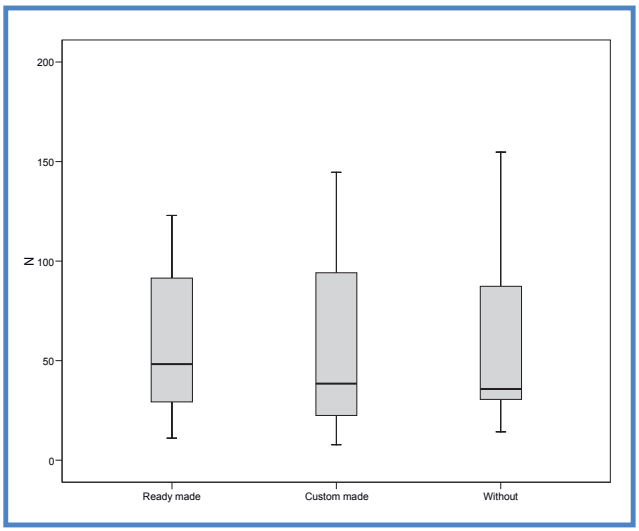

Figure 1: *Compared Means of grip forces between custom made, fabric-ready and without orthosis*

DISCUSION

In persons with carpal tunnel syndrome, wrist orthoses are prescribed with the aim of reducing acroparesthesias, accompanying pain and unreliability of grip as they support the wrist joint and restrict its motion while leaving the fingers and thumb free to move. Our rehabilitation team suggests that patients with carpal tunnel syndrome wear wrist orthoses in neutral position. The angle of wrist position varies considerably in literature, from 10° of flexion (7) to 30° of extension (7). Pressure studies comparing mild angles of deviation to neutral and carpal tunnel pressure (7) have suggested that the wrist angle that produced the lowest pressure is within 2 to 3° of flexion and 1 to 2° of ulnar deviation. In Slovenia, patients receive ready-made fabric or custom made wrist orthoses, depending on the severity of symptoms and the patients' profession. The users are usually suggested to wear the orthoses at night and in the case when they have symptoms while performing work activities also during the day if they can work with the orthoses.

Our hypothesis was that custom-made orthoses enabled better fixation and position of the wrist in persons with carpal tunnel syndrome, caused higher strength of cylindrical, lateral and pinch grips and improved hand function. The findings indicated that there were no differences between the orthoses, or in the case of cylindrical grips even showed positive effects of ready-made fabric orthoses. That result can be annotated to difficulties in gripping the device for measuring the strength of the cylindrical grip with custom-made orthoses which are rigid and slippery on the palm region.

None of the known ready-made fabric orthoses, assure neutral position of the wrist or suit to the person'shand. They are also not useful orstrong enough for every day work. According tovalid legislation in Slovenia, a nurse or even a merchant can provide commercially available orthoses to a person with carpal tunnel syndrome. However, we believe that they do not have sufficient and appropriate knowledge and that this problem needs to be addressed.

CONCLUSION

The study did not confirm the hypothesis, but it will be further developed. In addition, the future studies can compare the influence of different types of orthoses on reducing the other symptoms of the carpal tunnel syndrome or their applicability in work activities.

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FLATFOOT - IS IT A MEDICAL PROBLEM?

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Abstract

Flatfoot (pes planus, planovalgus) in children is a common condition. Nevertheless, it needs evaluation in order to separate „physiological" from pathological patients. Authors deal with the diagnostic possibilities in outpatient practice and in the orthopaedic department of a university hospital - the only one for children in Slovakia. The methods of conservative and surgery therapies are discussed. Despite the fact that the exact incidence of flatfoot is unknown, numbers of operation interventions in patients urge the need for cooperation with a specialized provider of custom made plantar orthoses. Authors describe the cooperation with a market leading provider of custom made plantar orthoses in Slovakia covering approximately 65% of the market. The experience draws upon an application of 26,597 pairs of custom made orthopaedic insoles in 2007. The variations of conservative treatment of flatfoot in children and adults are discussed. The range of orthotic devices in post-operative treatment is presented.

SURGICAL AND ORTHOTIC TREATMENT OF DIABETIC FOOT ULCER

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INTRODUCTION

The most common complication on diabetic neuropathic foot is the evolution of trophic ulcers. Deformity of the foot construction, development of pathological pressure points, severe neuropathy and chronic local irritation all play together an important role in the evolution of the ulcer. Its treatment should aim at an even pressure distribution on the plantar surface of the foot and the relief of the ulcer.

METHODS AND SUBJECTS

If deep wounds develop under the transversal arch affecting the MTP joint, the toe and the concerned part should be remove as well as open wound treatment. Decrease of the longitudinal arch leads to development trophic ulcer on the middle part of the plantar surface. Under the wound a bony bump can often be observed with a severe destruction of the bones and joints of the foot and an extreme deformation of the bony arch.

CONCLUSION

With the sugical removal of the bony protrusions the plantar pressure over the concerned area in stance and walk phase is alleviated therefore can result in the recovery of the wound. Naturally, a well-built total contact foot-orthoses and the use of orthopeadic shoes is always indispensable after surgery.

SCREENING EVALUATION OF DIABETIC FOOT CHANGES

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In clinical evaluation of the diabetic foot, the basic issue is evaluation of the vascularisation stage, presence of infection and involvement of different anatomic structures. When we consider a vascularisation stage, we observe presence or absence of vascularisation. The vascularisation is generally insufficient in diabetic foot cases but it is of utmost importance to note an absence of circulation at certain part of a foot.

Infection is the second key parameter which is determined by clinical examination as present or absent, and clinical signs of infection are differentiated as a chronic or acute infection.

The third parameter are involved anatomic structures and that is divided into four stages starting from the surface and going towards the bones. In the first stage a change is present only at skin level. The second stage - skin and subcutaneous tissue are involved. The third stage - more superficial structures, tendons and fascia. The fourth stage - superficial structures and articulations or bone.

The abovementioned clinical parameters indicate the clinical entities which can be seen in the diabetic foot such as clavus, trophic ulcer, cellulitis, phlegmona, abscess, septic arthritis and gangrene. Different qualities of clinical parameters very specifically indicate clinical parameters so it is possible to demonstrate this relation as an algorithm or as a table (Table 1).

The above mentioned way of thinking is very useful in clinical practice while evaluating foot state, follow up, understanding of foot changes in diabetic patients and in education. The demonstrated criteria are very significant not only in a surgical treatment but in non-operative treatment as well. It is equally useful in physical treatment since the situation of progression of changes is possible, which can easily be seen, based on simple clinical parameters.

These criteria are very useful as a screening method. According to the mentioned parameters, besides clinical examination, it is not necessary to use additional diagnostic procedures.

Table 1: *Elements for evaluation of diabetic foot changes*

Changes on foot	Vascularisation		Infection			Structures involved			
	insufficient	absent	chronic	acute	none	skin	subcutan tissue	+fascia, tendons	+articul bone
Clavus	+		+ –		+	+	+ –		
Trophic ulcer	+		+	+	+	+	+		
Cellulite	+			+	+	+			
Phlegmona	+			+	+	+	+	+	
Abscess	+	+			+	+	+	+	
Gangrene	+	+	+	+	+	+	++		

IN-SHOE PRESSURE MEASUREMENT

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Abstract

Patients with foot problems are frequent visitors of outpatient clinics specializing in physical medicine and rehabilitation. Specialists in PMR may rely on their clinical examination or use additional assessment methods, such as in-shoe plantar measurements. For the purpose of the present study the F-Scan was used on 430 patients. In most patients, plantar pressure were satisfactorily reduced with new orthopaedic shoes. The authors believe that in-shoe plantar pressure measurement is much more important at the time of the fitting of new shoes when it objectively demonstrates the results. When pressures are not distributed well, additional adaptations can be made to decrease them.

INTRODUCTION

Patients with foot problems are frequent visitors of outpatient clinics specializing in physical medicine and rehabilitation. Specialists may rely on their clinical examination or use additional assessment methods. The clinical exam is very effective in accurate evaluation of anatomical abnormalities, however, it is not as effective in evaluation of functional abnormalities (1). Functional abnormalities are especially difficult to evaluate under loading conditions, particularly in shoes. In the western world people seldom walk barefoot, so it is important for clinicians to assess the processes inside the shoes. Various platforms may be used for barefoot-walking assessment, while insoles with measurement sensors are needed for in-shoe measurement .

In-shoe plantar pressure can be measured with a variety of instruments, including force-sensing resistors or FSRs, piezoelectric sensors (in hydrocells) and capacitive transducers, as well as by critical light deflection (2). These instruments can be used as discrete sensors or they create a matrix of multiple sensors.

In discrete measurements, the sensors are positioned at specific anatomical locations only, whereas at matrix measurements, the sensors are organized in rows and columns and are located under the whole sole. Each method has its advantages and disadvantages and it is important for clinicians to beawareofthesystem'smeasurementproperties.

The aim of the study was to find out whether in-shoe plantar pressure measurement was necessary before prescription or whether it was more important at the fitting of new shoes.

METHODS AND SUBJECTS

Methods

In-shoe plantar pressures were measured by the F-Scan system (Tekscan, Boston, MA). The system consists of 0.18mm-thick sensor insoles, which have pressure-sensitive, resistive, and conductive silver-based inks arranged in 60 columns and 21 rows embedded in Mylar coating. The columns and rows intersect, creating a "cell". There are 960 cells in each insole. The resistance et each cell is proportional to the pressure applied on its surface. These insoles are connected to cuff units (preamplifiers), which are attached to the lower leg with a Velcro strap. A 9.25m cable attaches the sensor and cuff unit to computer. The data were collected at 50 Hz. The F-scan has excellent resolution and provides reliable measures of relative pressure values (3, 4).

In all the patients, the measurements were performed twice, at their first visit before prescription and after the fitting of the new shoes.

Subjects

The study included all the patients who were examined at the Institute for Rehabilitation, Republic of Slovenia, at the outpatient clinic for foot problems, from January 1st 2003 to March 31st 2005, and for whom their phyisician believed that they needed in-shoe pressure measurement at examination or at fitting.

RESULTS

430 patients, 51.4% percent of them were women, were included into the study. They were 58 years old on average (sd 18 years, from 18 -90 years). They had from one to four different diagnoses. 70.9% had orthopaedic problems, 13.5% diabetes, 6.0% rheumatoid arthritis, 10.1% paresis and different neurological diseases. 52.8% were measured at the examination only, 15.1% at the fitting only and 32.1% at the examination and at the fitting (Figure 1).

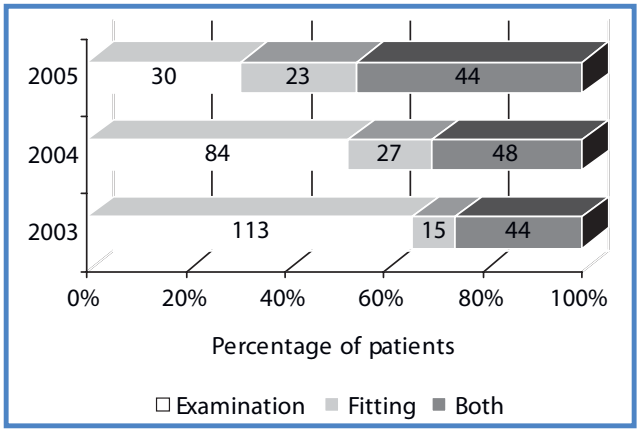

Figure 1: *Percentage of patients, examined in different years, measured at examination only, at fitting only or at examination and fitting*

Table 1 presents the characteristics of prescribed orthopaedic shoes for patients with different diagnoses.

Table 1: *Characteristics of prescribed shoes for patients with different diagnoses*

	Orthopaedic impairments	Diabetes	Rheumatoid arthritis	Neurological problems
High shoes	38.6	53.4	42.3	75.0
Custom-made insole	23.6	56.8	19.6	75.0
Lateral wedge	10.8	17.2	12.5	37.5
Medial wedge	7.5	6.8	3.8	37.5
Arch supports	70.8	41.3	61.5	25.0
Elevation	11.8	6.8	0	25.0
Soft material	56.0	68.0	61.0	50.0

Shoe adaptations successfully decreased excessive plantar pressures in 72.8 % of patients (Figure 2).

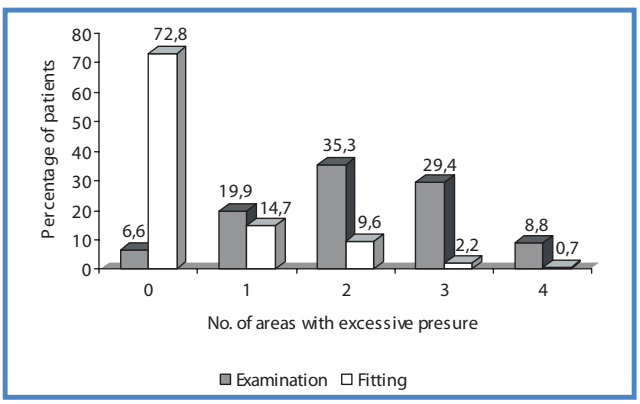

Figure 2: *Percentage of patients with excessive plantar pressures at examination and at fitting*

DISCUSSION

The study found a high level of agreement between medical diagnosis and prescribed characteristics of orthopaedic shoes.

The results do not clearly demonstrate how often diagnosis and prescription were actually based on in-shoe plantar measurements and how often on clinical examination only.

However, Figure 1 shows that in the first year in over 60% of the subjects plantar pressures were measured at the examination only, whereas in the last year only in one third of the patients pressures were still measured at the examination only while in over half of them they were measured at both, the examination and the fitting. It seems that we had realised that the measurements were not needed so much for diagnosis and prescription, but more for the evaluation of new shoes. That is in agreement with Ahroni (4) who states that high in-shoe pressure in diabetic subjects can be predicted in part from readily available clinical characteristics.

Additionaly, the study found that with new shoes elevated plantar pressures was satisfactorily reduced in over 70% of the subjects (Figure 2). Only 12.5% of the subjects still had excessive plantar pressures in more than one area and 14.7% in one area only. At the examination only 6.6% of the patients did not have excessive plantar pressures, while 73.5% had excessive plantar pressures in more than one area. The measurements objectively demonstrated the reduction of pressures and additional adjustments were made to reduce them in those patients who still had excessive pressures.

CONCLUSION

In-shoe measurement of plantar pressures may be helpful at examination, but it is much more important at the time of the fitting of new shoes when it objectively demonstrates the result. When the pressures are not distributed well, additional adaptations can be made to decrease them.

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MBT SHOES DECREASE PLANTAR PRESSURE IN THE DIABETIC FEET

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Abstract

Increased plantar pressure plays an important role in the development of diabetic neuropathic foot ulceration. Masai Barefoot Technique (MBT) shoes decrease walking speed and increase the center of pressure excursions. We tested MBT shoes in 7 patients with diabetes mellitus. Plantar pressures during walking were measured in the patient's regular shoes and in MBT shoes at baseline and six months later with F-scan (Tekscan Inc.). Immediately after fitting, MBT shoes decreased plantar pressures under the 3rd and 4th metatarsal head on both feet and under 5th metatarsal head on the right foot (all $p<0.05$). A substantial, but statistically insignificant, decrease was observed also under 2nd metatarsal head on both sides and 5th on the left. One patient developed pressure ulcer. After six months, slight insignificant increase in plantar pressures was observed at all measurement points. MBT shoes can reduce plantar pressures in some areas on the diabetic foot.

INTRODUCTION

Foot ulceration affects up to 15 % of patients with diabetes mellitus at some point in their lives (1). If not treated properly it can deteriorate to gangrene and amputation of the affected extremity. Foot deformity and improper footwear cause increased plantar pressures which play an important role in the development of diabetic neuropathic foot ulceration (2). Plantar pressures, except on the lateral forefoot, increase at faster walking (3) and are decreased by rocker soles (4). Masai Barefoot Technique (MBT) shoes (Figure 1) decrease walking speed (5) and increase the center of pressure excursions (6). We sought to investigate whether MBT shoes can decrease plantar pressures in diabetic patients.

Figure 1: *MBT shoes*

METHODS AND SUBJECTS

Methods

Plantar pressures were recorded at baseline and six months later. Two measurements were done each time: in the patient's regular shoes and in MBT shoes.

Plantar pressures were measured during walking at the patients' most comfortable speed with F-scan (Tekscan Inc., Figure 2). *F-Scan*® is a measurement system that captures dynamic in-shoe pressure information revealing interaction between foot and footwear. It provides bipedal plantar pressures and force measurement using paper-thin sensors placed inside the shoe. Unlike traditional visual observation of foot function and gait, *F-Scan* quantifies contact pressure distribution and timing.

Figure 2: *F-scan*

The patients also filled in the Foot Function Index (FFI, 7) for walking in ordinary and MBT shoes.

The data were analysed by SPSS 14.0 for Windows. Descriptive statistics and paired t-test were used.

Subjects

7 type 2 diabetic patients (3 men, 4 women) of average age 53 years (20 - 77) with foot deformity and loss of protective sensation (unable to feel the standardized 10-g Semmes-Weinstein monofilament) entered the study. All study subjects had palpable pulses of pedal arteries. The patients with open foot ulceration were not recruited.

The patients were supplied one free pair of MBT shoes and clearly instructed about the potential balance problems.

The study was approved by the Ethics Committee, Medical Faculty, University of Ljubljana, Slovenia.

RESULTS

Immediately after the fitting, the MBT shoes decreased plantar pressures under the third and the fourth metatarsal head on both feet and under the fifth metatarsal head on the right foot (Figure 3). A substantial decrease was observed also under the second metatarsal head on both sides and the fifth on the left, but was not significant ($0.1 < p < .05$).

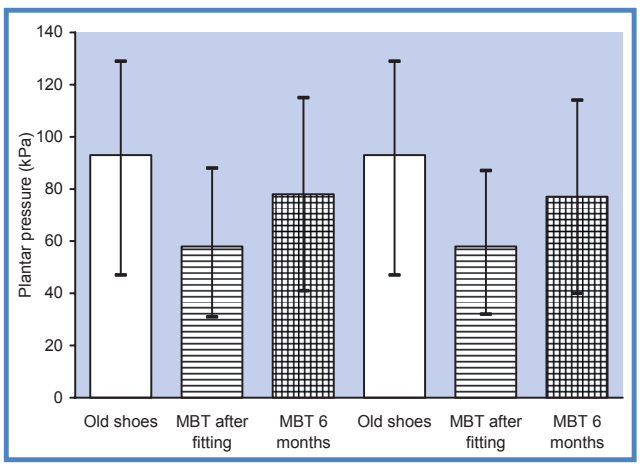

Figure 3: *Plantar pressures*

The patients wore the MBT shoes on average for 5 days per week (from 2 to 7 days), 2 hours per day (from 1 to 4 hours). Except for one patient, all had problems at the beginning, assessed with 5 points on the VAS scale on average. Four patients had additional balance problems assessed from 2 to 9 on the VAS. In one patient, the MBT shoes decreased the pain, in two patients the pain remained the same and in four the pain increased from 1 to 5 points on the VAS. One patient developed a superficial foot ulceration which healed in one week.

After six months, a slight, insignificant increase in plantar pressures was observed at all the measurement points and no difference in the FFI with ordinary or MBT shoes.

DISCUSSION

In spite of the initial problems and no significant change in the FFI, the MBT shoes decreased plantar pressures under the second, third and fourth metatarsal heads. Except for the big toe, in all the measured areas plantar pressures were decreased in the MBT shoes. The pressures might have increased under other areas, or were lowered by slower walking, which was observed clinically but was not measured. All the findings are in concordance with other studies (3-5).

CONCLUSION

MBT shoes were found to decrease plantar pressures under some areas in all the included subjects. However, careful evaluation is required to determine that the pressures under the other areas are not excessive.

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PLANTAR PRESSURES IN RELATION TO FOREFOOT PAIN IN RHEUMATOID ARTHRITIS PATIENTS

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Abstract

The aim of the study was to compare pressures under painful and non-painful areas of the forefoot. 60 rheumatoid arthritis patients (57 female, 3 male) with forefoot pain were included in the study. Plantar pressure measurement was performed with F-Scan system. Pressures under metatarsophalangeal joints were analysed. Metatarsophalangeal joint tenderness was assessed using a two-finger pressure technique. Pressures under painful joints were statistically significantly higher than under non-painful joints.

INTRODUCTION

Foot involvement occurs in 90% of people with rheumatoid arthritis (RA). The forefoot is most commonly affected, especially the metatarsophalangeal (MTP) joints. Inflammation of those joints can lead to pain, deformities, decreased joint mobility and stiffness, causing increased stress on the adjacent joints. Bony deformities and soft tissue atrophy change normal plantar pressure distribution. Increased pressure under the forefoot results in forefoot pain in RA patients.

METHODS AND SUBJECTS

Methods

Plantar pressures were recorded using the F-Scan system, version 5.0 (Tekscan Inc). The F-Scan allows the measurement of pressure due to vertical component of ground reaction force on foot during walking. Because they have been found to lose accuracy with prolonged use (1), new pair of sensor insoles was used for each patient. The sensors were cut to fit the shoes and calibrated using body mass as the applied force. Since the data are influenced by the temperature of the insole (2), the patients were given a warm-up period. Recording was performed while the patients walked along an open corridor at their normal walking speed. At least five left and right steps were recorded. The system software (Timing Analysis Module - TAM) was used to analyze pressures under MTP. The first and the last step were excluded from the analysis and the average peak pressures were computed from the remaining steps. A high reliability of the system has recently been proven in RA patients at our Institute (3).

MTP joint tenderness was assessed using a two-finger pressure technique. Results were analyzed using the SPSS 14.0.2 software. The average plantar pressures at painful and non-painful MTP joints for all the patients were compared for each foot using paired-samples t-test.

Subjects

60 RA patients (57 female, 3 male), average age 58.28 (SD 10.42, 35 - 84 years), were included in the study. Average duration of RA was 11.08 years (SD 8.78, 1 - 40 years). The disease activity at the time of investigation, assessed by DAS28, was mild to moderate (4.13, SD 0.69, 2.2 - 5.1). All the subjects signed an informed consent. The study was approved by the State Committee for Medical Ethics.

RESULTS

The average plantar pressures at painful MTP joints on both legs were higher (left median 196 kPa, interquartile range 92.5 kPa, right median 180 kPa, interquartile range 79.5 kPa) than at non-painful MTP joints (left median 156 kPa, interquartile range 107.5 kPa right median 140.5 kPa, interquartile range 79.5 kPa). The differences were statistically significant for the left ($p = 0.028$) and the right ($p = 0.005$) foot.

DISCUSSION

The study demonstrated that the average peak plantar pressures in RA patients were significantly higher at the painful than at the non-painful forefoot areas. Previous studies have confirmed the relationship between forefoot pressure and walking pain (4, 5). However, pain in those studies was assessed with a questionnaire (Foot Function Index), whereas in our study a clinical test was used. On the basis

of our results we may presume that with reducing excessive plantar pressures, foot pain could be extenuated.

CONCLUSION

Plantar pressures in RA patients are significantly higher at painful than at non-painful foot areas.

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MEASUREMENTS FOR ORTHOPAEDIC SHOES: A STUDY ON ACCURACY AND AGREEMENT OF PROFESSIONALS AND STUDENTS

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Abstract

We aimed at comparing foot measurements of final-year Prosthetics & Orthotics students (ten; having knowledge, but lacking experience), skilled technicians (two; lacking formal education on foot anatomy and disorders, but having lots of experience) and the measures provided by a foot scanner. Both feet of four healthy adult volunteers were measured. Agreement with scanner and within-group agreement were statistically analysed. In general, agreement within both groups was very high, whereby technicians were more synchronised among themselves than students. We also found that technicians appropriately determined EU shoe size as two to three sizes larger than the foot length, which is measured by the scanner and was erroneously reported by the students. Therefore, efforts should be made within undergraduate orthotics and prosthetics education to familiarise the students with practical procedures and requirements of orthopaedic measurements.

INTRODUCTION

Many people, especially elderly, have foot problems. These impact their activities, such as walking and consequently also participation (1). Foot disorders can affect all the more proximal joints of the lower limb (2). There are several reasons for foot problems, such as diabetes, rheumatoid arthritis and different injuries, but also inappropriate shoes. Inappropriate shoes cause foot ulcers in up to 20% of patients with diabetes (3). Over 70% of elderly patients admitted to a general rehabilitation unit have been found to have inappropriate shoes (3).

Many patients with foot problems get orthopaedic shoes. It is important that the measurement is performed by a skilled person who also has appropriate knowledge of foot anatomy and deformities.

The aim of the present study was to compare foot measurements of final-year Prosthetics & Orthotics (P&O) students (having knowledge, but lacking experience), skilled technicians (lacking formal education on foot anatomy and disorders, but having 10 years of experience) and the measures provided by a scanner.

METHODS AND SUBJECTS

Methods

The measurements were performed by two skilled technicians from the Institute for Rehabilitation, Republic of Slovenia, Ljubljana, and ten P&O students from the University College of Health Studies. They were all instructed to perform the measurements for the purpose of producing orthopaedic shoes. Additionally, the subjects' feet were measured by a foot scanner (UCS Inc., Vrhnika, Slovenia), which only measured the dimensions A, B, C and F (see below and figure 1).

Six dimensions were measured (Figure 1):
A. circumference at metatarsal heads (in cm);
B. circumference at midfoot (in cm);
C. circumference at hindfoot (in cm);
D. ankle circumference at malleolar level (in cm);
E. shank circumference at 15 cm (in cm);
F. EU shoe size.

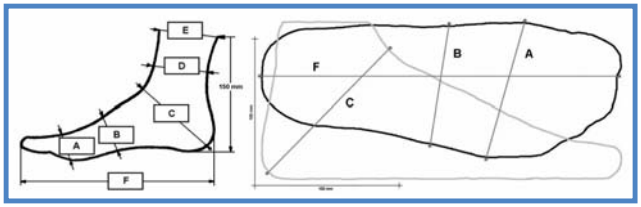

Figure 1: *Foot measures (left) and sample output from the foot scanner (right)*

Mean deviation (MD) was used to assess agreement of the measurers with the scanner measurements. Coefficient of variation (i.e., standard deviation divided by the mean, expressed in %) was used to assess agreement within the two groups of measurers. Intraclass correlation (ICC, using

absolute agreement definition with two-way random effects model) was used to assess overall agreement among the measurers (4). Bland-Altman plots (5) were used to further explore agreement and accuracy of the measurers.

Subjects

Four adult volunteers were measured (three male and one female), aged 28-59 years. All were healthy and none had any foot impairment or deformity. Both feet of each subject were measured.

RESULTS

Descriptive statistics summarising the measurements, agreement with scanner and agreement among each group of measurers are reported in Table 1. Mean CV over all dimensions for the technicians was 1.1% and 1.2% for left and right foot, respectively (and 1.1% over both feet), while for students it was 2.4% and 2.2% (2.3 % overall). Selected bland-Altman plots comparing the technicians and the students against the scanner (Figure 2) illustrate good agreement regarding circumference at hindfoot (top panels) and downward bias of the students and the scanner with respect to the technicians (bottom panels).

Table 1: *Descriptive statistics summarising the measurements, agreement with scanner and agreement among each group of measurers (MD = mean deviation; CV = coefficient of variation; NA=not available).*

Subject	Dimension	Technicians						Students						Scanner	
		Left Foot			Right Foot			Left Foot			Right Foot			Left	Right
		Mean (Range)	MD	CV	Mean (Range)	MD	CV	Mean (Range)	MD	CV	Mean (Range)	MD	CV	Foot	Foot
1	A	27.0 (27.0-27.0)	1.10	0%	27.3 (27.0-27.5)	0.85	1%	24.7 (23.0-28.5)	-1.25	6%	24.4 (23.5-26.0)	-2.05	3%	25.9	26.4
	B	25.8 (25.5-26.0)	-1.85	1%	26.0 (26.0-26.0)	-1.40	0%	26.3 (25.0-27.5)	-1.35	3%	26.2 (25.5-27.5)	-1.23	2%	27.6	27.4
	C	37.5 (38.0-37.0)	0.20	2%	37.0 (37.5-36.5)	0.20	2%	37.1 (36.0-38.0)	-0.25	2%	36.7 (36.0-37.0)	-0.15	1%	37.3	36.8
	D	24.5 (24.0-25.0)	NA	3%	24.5 (24.0-25.0)	NA	3%	28.2 (26.0-30.0)	NA	4%	28.1 (26.0-30.0)	NA	4%	NA	NA
	E	25.0 (24.5-25.5)	NA	3%	25.0 (24.5-25.5)	NA	3%	25.5 (25.0-27.0)	NA	3%	25.6 (25.0-26.5)	NA	3%	NA	NA
	F	45.0 (45.0-45.0)	2.50	0%	45.0 (45.0-45.0)	3.00	0%	43.2 (42.0-44.0)	0.65	1%	42.7 (42.0-43.5)	0.65	1%	42.5	42.0
2	A	23.0 (23.0-23.0)	-0.40	0%	23.3 (23.0-23.5)	-0.15	2%	22.9 (22.0-24.5)	-0.55	3%	22.9 (22.0-23.5)	-0.50	2%	23.4	23.4
	B	22.5 (22.0-23.0)	-1.40	3%	22.5 (22.0-23.0)	-0.70	3%	23.2 (22.0-24.5)	-0.70	3%	23.3 (22.5-24.5)	0.05	3%	23.9	23.2
	C	32.8 (33.0-32.5)	1.05	1%	32.8 (33.0-32.5)	2.25	1%	32.0 (31.0-34.0)	0.30	3%	31.9 (31.0-33.0)	1.37	2%	31.7	31.7
	D	22.5 (22.0-23.0)	NA	3%	21.8 (21.5-22.0)	NA	2%	23.6 (22.0-25.0)	NA	4%	23.7 (22.0-25.0)	NA	4%	NA	NA
	E	23.0 (23.0-23.0)	NA	0%	22.8 (23.0-22.5)	NA	2%	23.2 (22.5-24.0)	NA	2%	23.1 (22.0-24.0)	NA	3%	NA	NA
	F	39.3 (39.0-39.5)	2.25	1%	39.3 (39.0-39.5)	1.75	1%	38.0 (37.5-39.0)	1.00	1%	38.0 (37.5-38.5)	0.50	1%	37.0	37.5
3	A	28.0 (28.0-28.0)	0.50	0%	27.3 (27.5-27.0)	0.05	1%	26.2 (25.0-27.5)	-1.30	3%	26.2 (24.5-28.0)	-1.05	4%	27.5	27.2
	B	28.8 (28.5-29.0)	-1.65	1%	28.8 (28.5-29.0)	-0.85	1%	28.7 (27.0-30.0)	-1.75	3%	29.2 (28.0-30.5)	-0.45	3%	30.4	29.6
	C	39.5 (40.0-39.0)	0.10	2%	39.0 (39.5-38.5)	0.10	2%	39.3 (39.0-40.0)	-0.15	1%	38.9 (38.0-40.0)	0.00	2%	39.4	38.9
	D	27.0 (27.0-27.0)	NA	0%	27.0 (27.0-27.0)	NA	0%	29.4 (28.0-31.0)	NA	3%	29.6 (28.5-31.0)	NA	2%	NA	NA
	E	28.0 (28.0-28.0)	NA	0%	28.3 (28.5-28.0)	NA	1%	29.1 (27.0-39.0)	NA	12%	28.1 (27.0-29.0)	NA	2%	NA	NA
	F	45.3 (45.5-45.0)	3.25	1%	45.3 (45.5-45.0)	2.75	1%	42.7 (41.5-44.0)	0.70	2%	42.6 (41.0-43.5)	0.05	2%	42.0	42.5
4	A	29.5 (29.0-30.0)	0.70	2%	28.3 (28.5-28.0)	0.25	1%	27.6 (27.0-29.0)	-1.20	2%	27.3 (26.0-29.0)	0.75	4%	28.8	28.0
	B	28.8 (28.5-29.0)	-1.95	1%	28.8 (28.5-29.0)	-1.35	1%	29.2 (28.5-30.5)	-1.50	2%	29.4 (29.0-30.0)	-0.75	1%	30.7	30.1
	C	39.3 (39.5-39.0)	-1.25	1%	39.3 (39.5-39.0)	-0.25	1%	38.8 (38.0-39.0)	-1.75	1%	38.4 (37.0-40.0)	-1.10	2%	40.5	39.5
	D	28.8 (28.0-29.5)	NA	4%	28.3 (27.5-29.0)	NA	4%	29.9 (28.0-32.0)	NA	4%	29.8 (28.0-33.0)	NA	5%	NA	NA
	E	28.8 (28.5-29.0)	NA	1%	28.0 (28.0-28.0)	NA	0%	30.1 (28.5-39.5)	NA	11%	28.1 (27.0-29.0)	NA	3%	NA	NA
	F	45.8 (45.5-46.0)	2.25	1%	45.8 (45.5-46.0)	2.25	1%	42.9 (42.0-44.0)	-0.60	2%	43.3 (42.5-44.5)	-0.25	2%	43.5	43.5
Overall Mean	A	26.9 (23.0-30.0)	0.48	0.6%	26.5 (23.0-28.5)	0.25	1.3%	25.3 (22.0-29.0)	-1.08	3.8%	25.2 (22.0-29.0)	-1.09	3.2%	26.4	26.3
	B	26.4 (22.0-29.0)	-1.71	1.7%	26.5 (22.0-29.0)	-1.08	1.4%	26.8 (22.0-30.5)	-1.33	2.6%	27.0 (22.5-30.5)	-0.60	2.2%	28.2	27.6
	C	37.3 (32.5-40.0)	0.03	1.4%	37.0 (32.5-39.5)	0.58	1.4%	36.8 (31.0-40.0)	-0.46	1.6%	36.5 (31.0-40.0)	0.03	1.8%	37.2	36.4
	D	25.7 (22.0-29.5)	NA	2.4%	25.4 (21.5-29.0)	NA	2.1%	27.8 (22.0-32.0)	NA	3.9%	27.8 (22.0-33.0)	NA	4.1%	NA	NA
	E	26.2 (23.0-29.0)	NA	1.0%	26.0 (22.5-28.5)	NA	1.4%	26.9 (22.5-39.5)	NA	7.1%	26.2 (22.0-29.0)	NA	2.7%	NA	NA
	F	43.8 (39.0-46.0)	2.56	0.6%	43.8 (39.0-46.0)	2.44	0.6%	41.7 (37.5-44.0)	0.44	1.7%	41.6 (37.5-44.5)	0.24	1.3%	41.3	41.4

In general, agreement within both groups was very high (ICC computed over all dimensions was 0.996 and 0.975 for technicians and students, respectively, and 0.972 for the pooled sample).

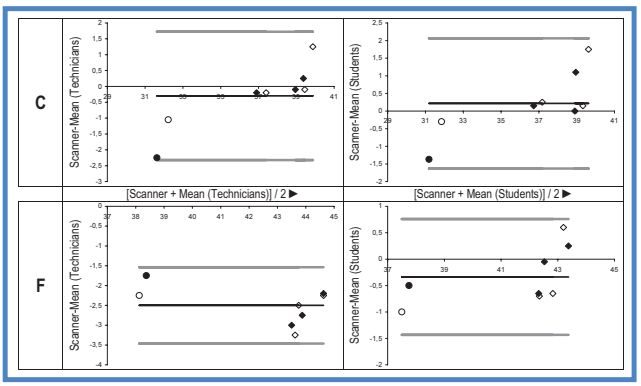

Figure 2: *Bland-Altman plots for comparing technicians (left panels) and students (right panels) with scanner (thin black line = mean difference, thick grey lines = mean difference ± 2SD; circles = female, diamonds = male subjects; open symbols = left, filled symbols = right foot)*

DISCUSSION

It is encouraging that in general, agreement within both groups was very high. As expected, the technicians were more synchronised among themselves than were the students. Students' measurements tended to follow the foot scanner "mechanically" on all dimensions, which is not desirable for the purposes of producing orthopaedic shoes, especially regarding shoe size. The technicians appropriately determined EU shoe size as two to three sizes larger than the foot length, which is measured by the scanner and was also erroneously reported by the students.

CONCLUSION

In undergraduate orthotics and prosthetics education, attention should be paid on practical experience. In particular, the students should be familiarised with the procedures and requirements of actual orthopaedic shoe measurements.

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TRANSLATION AND LINGUISTIC VALIDATION OF THE SWEDISH VERSION OF ORTHOTICS AND PROSTHETICS USERS' SURVEY

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Abstract

There is a lack of Swedish instruments assessing outcome of orthotic and prosthetic services. The North American derived Orthotics and Prosthetics Users' Survey (OPUS) consists of five questionnaires assessing common rehabilitation goals. It was translated to Swedish and validated linguistically. Thirty-nine persons answered the questionnaires and were systematically debriefed. In most cases the items were understood as intended. Words and expressions were changed if misunderstood or interpreted in different ways. The resulting Swedish version of OPUS showed acceptable linguistic validity. A study on construct validity and test-retest reliability is in process.

INTRODUCTION

Historically, Orthotic and Prosthetic (O&P) services in Sweden have been based on hands-on experience rather than science. Self-report instruments could be used to systematically evaluate the practice, but most of them are developed in English speaking countries and cannot be used in Sweden without translation and validation. Moreover, the only instruments available in Swedish are limited to the smaller group in O&P practice, namely prosthetic clients.

The Orthotics and Prosthetics Users´ Survey (OPUS) was developed and validated in the USA to assess the outcome in both prosthetic and orthotic users (1). The OPUS consists of five questionnaires assessing i) health related quality of life, ii) satisfaction with device, iii) satisfaction with services, iv) upper extremity function, and v) lower extremity function. If translated, OPUS could be a useful tool for studying the outcome of O&P services in Sweden. Still, validity problems can arise by using direct translations. Therefore, translations' validity must be tested in the new cultural context.

The aim was to translate OPUS to Swedish and test the linguistic validity in a Swedish context.

METHODS AND SUBJECTS

Methods

A modified version of the translation process suggested by the WHO (2) was used. Four medical professionals (P/O, OT, PT, orthopaedic surgeon) independently translated OPUS to Swedish. The translations were merged to a single document by one of the authors (GJ). Translators and authors met twice to discuss the translations and a consensus version was created. A professional translator performed a back-translation to English. The English original, the Swedish consensus version, and the back-translation, were compared by one of the authors (GJ) and a new Swedish version was created.

One intention with the Swedish version of OPUS was to use it for evaluation of insoles. However, many of these clients are relatively fit and a high ceiling effect could be expected in the lower extremity function part of OPUS. Therefore, eight new items assumed to be more difficult were added to the Swedish version of this particular questionnaire.

Linguistic validation was performed by systematically debriefing the clients who answered the five questionnaires. Ten subjects answered each questionnaire (each subject completed one or two different questionnaires).

Subjects

Thirty-nine clients (27 women, 12 men, mean age 59.8) at the Department of Prosthetics and Orthotics, Örebro University Hospital, participated. Clients younger than 18 years, and clients unable to understand written Swedish, were excluded. The study was approved by the Regional Ethics Committee review board.

RESULTS

Minor linguistic changes were made during the translation process. Most items were understood as intended but some words and expressions were changed because of misunderstandings or cultural differences between Sweden and the USA.

DISCUSSION

The translation procedure used is well established and has been used in several studies. The quality of the translation was improved by involving people of different professions and experiences.

CONCLUSION

The translation and validation resulted in a Swedish version of OPUS that may be a reliable and useful contribution to outcome studies in Swedish O&P service. A study assessing construct validity and test-retest reliability is in process and preliminary results will be presented.

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RESEARCH IN PROSTHETICS AND ORTHOTICS BACHELOR LEVEL EDUCATION. NEEDED AND INEVITABLE?

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Abstract

This article discusses the importance of fully integrating research activities into the Bachelor level programs (undergraduate programs) in orthopaedic engineering / prosthetics and orthotics. To work according to evidence based principles and acquire the competences to do so it is necessary for students to engage in research activities from within the educational programme as soon as possible. Involvement in research not only creates more insight in what research means and what the effects are, but also generates a number of cross links with the stakeholders involved in P&O education (see fig 1) which were not apparent before for the student. Also, the interaction with orthopaedic companies is stimulated in a broader context than is traditionally the case. A structure enhancing the interaction of educational institution, companies, research groups and institutions is presented which operates at the intersection of these stakeholders. A whole new world is therefore coming into range which will generate all kinds of new and unexplored opportunities.

INTRODUCTION

To date a growing need for research is becoming visible for the P&O professional. As a professional being part of a multi disciplinary team the prosthetist and orthotist primarily has to rely on skills and knowledge obtained by years of experience and tradition. The adjacent professions such as medical doctors, physiotherapists, occupational therapists etc. by now have more a tradition in research and evidence based practice compared to the prosthetist and orthotist. More proof of effectiveness of orthopaedic devices and scientifically based selection procedures and protocols are needed. This is partly due to a changing role of health care services with changing reimbursement systems. More effort will be needed in obtaining and collecting evidence which can be used to account for the expenses associated with particular devices or therapy. Besides that, research and evidence based techniques are needed for the P&O engineer to take full part in multidisciplinary teams. To catch up with the P&O related disciplines whom all have a long experience in working with evidence based medicine / practice it is necessary that the P&O profession will adapt this way of working (1). This will set a large demand on the research competences of the novice professionals. Educational programmes thus have an important role in familiarising students with research as well as with evidence based techniques.

The provision of research based education at all levels is a particular strength of Europe and Europe's universities. Institutions offering research based higher education should ensure that a research component is included and developed in all cycles. (2). This allows students to acquire research experience. This also applies in relation to the acquisition of a broad range of transferable skills that should be included not only at a doctoral (PhD) level but in curricula at all levels. A new generation of professionals emerges that are able to integrate multiple perspectives in their work, and that are responsive to the needs of a rapidly changing labour and health market which the orthopaedic profession is part of. In 2006 the European University Association published a report titled: "Universities as Catalysts of Regional Development". This report discussed the underestimated influence of regional developments of Institutes of higher education (Bachelor and Master). Improving collaboration between Universities and expert / knowledge centres and the Industry will result in a better tuning of the needs and questions generated by Industry and Institutions. Alumni will provide the knowledge transfer between Universities and Industry, better known as knowledge on legs. To bring about this knowledge development and transfer, clusters are formed to promote research and innovation. In these clusters a collaboration has been established between local authorities, Industry (orthopaedic companies in this case), Universities and research institutions. This form of collaboration will result in an expanding knowledge base and shortening innovation cycles

by a horizontal (government, industry and universities) and vertical collaboration (vocational professional education, Bachelor and Master level education and research) (3). It is in this perspective that a lot of effort has been and will be put into the research programs of educational institutions. Research and Innovation is therefore a spearhead in the Bachelor program Orthopaedic Engineering of the Fontys University of Allied Health Professions.

METHODS

In the Netherlands the educational system at University level consists out of two grades, Bachelor and Master level. Historically the Master programs are already more equipped to do research in combination with doctorate (PhD) research programs. To date also Bachelor programs are fully involved into research programs. In order to provide a sound research facility within the Bachelor program research groups indicated as "Lectorates" have been formed to realise the above mentioned concepts and ideas. The Fontys University of Allied Health Professions, of which the orthopaedic engineering program is part of, has now a Lectorate in Health Care & Technology for Quality of Life. A major assignment for Letorates in general is to promote the horizontal and vertical forms of collaboration between the different institutions with education and knowledge transfer as a starting point. Of importance is the integration of research in education. On the one hand research has to radiate on the content of educational programs. On the other hand the integration of students in each and every phase of research must take place. The main issue must then be answered; how to realise integration of students in research with respect to the required competences for students? Integration of students into research can be realised by making them part of the research program themselves as a participant. If within the curriculum study time is reserved for research activities starting in the first year with attention for the basic principles for research ending at the final year doing a final project work (partly) linked to a research program, then students can obtain the necessary research competences. Next to this they will have been part of a large research network group. Because they also will have experienced the collaboration between the different institutions and companies they will be themselves part of a knowledge transfer in a most natural way. They become the personification of the term "knowledge transfer on legs".

RESULTS

The formation of a research group, the Lectorate, within the educational context and curricula made it possible to come up to the necessities and expectations mentioned above. During the past years a number of research projects proceeding from out of the University have been realised as leading partner or as a participant in larger research programs. Research projects involving the active participation of students and performed by teachers, associate lectors, and lectors in collaboration with other research institutions, knowledge centres, industry and orthopaedic companies / institutions have been established.

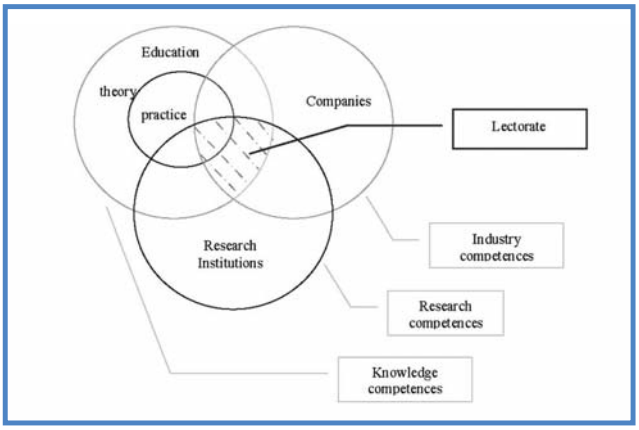

Figure 1: *A visualisation of the shareholders in research and the position of "the Lectorate" of the University.*

Figure 1 visualises the place of the Lectorate in a central position, forming a subset of the joining elements needed in research. Operation at the intersection of education (theory as well as practice), companies and research institutions, creates the necessary environment to develop the skills and competences needed by students.

The validation of this research concept can be shown by a number of successful examples of these projects:

1 The research project "High Tech in Orthopaedics". The main goal of this research project is the acquisition and dissemination of knowledge in the area of the design, fabrication and manufacturing techniques of carbon fibre AFO's (Holtkamp, 2008). This project has been financed by a grant of the Ministry of Economic affairs. A major issue in this project was the collaboration between the participating orthopaedic companies, branch organisations, major research institutions (such as TNO), students and research staff of the Health Care and Technology Lectorate. Outcomes of this study generate evidence to be used in the manufacturing process of carbon fibre AFO's and have direct implications on educational courses, with results that are close to the area of interest of students

2 Orthopaedic Health Care Innovation is a second example of a successful research project. This project is collaboration between the University Hospital of Maastricht, the K.H. Kempen University College (Belgium), Fontys University and a number of orthopaedic companies. The project focuses on the actual practice in providing orthopaedic insoles, including materials used etc. A selected number of cases was treated by experts. Variation in prescription and manufacture is inventoried, and

the insoles are assessed by gait analysis (insole pressure measurements), subjective evaluation etc

3 Sports prosthetics. This research project concerns testing sports prosthetics in order to improve and tune the set up and alignment of the prostheses. This project also is in tight collaboration between a number of leading orthopeadic companies, research institutions and the NOC*NSF (Dutch Olympic Committee and Dutch Sports Federation).

4 Dynalop: a research program aiming to improve dynamic alignment of below-knee prosthetics using plantar force distribution data (funded by IWT as a Tetra project). In this type of projects the integration of research in education is a necessary condition to obtain funding.

Other examples of projects bridging the gap between research and education will be given.

DISCUSSION

Developing research in the way mentioned above will have effect within an existing curriculum. Adaptations must be made to the curricula to enable students to participate in research. Therefore space must be made in study load within the curricula, expressed in ECTS. Also teaching staff must be trained and must develop skills in research. Therefore a number of staff members is stimulated to obtain a PhD or pursue other study programmes. This in combination with staff already academically trained will give a firm fundament to the need of integrating research into education in an appropriate way.

CONCLUSION

In conclusion it can be stated that the introduction of a research facility in the form of a lectorate is an enrichment in improving curricula, skills, and knowledge as summarised in competences of students. Doing research in this way is indeed a way to condense and intensify the collaboration between the involved and interested participants. The outcome of these research studies generates evidence which then can be used to improve processes, therapies or the design of orthopaedic devices. Therefore it can be fully confirmed that Research in Prosthetics and Orthotics Bachelor level Education is needed as well as inevitable in the current evolution of educational processes.

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EDUCATION OF PROSTHETISTS AND ORTHOTISTS IN THE REPUBLIC OF CROATIA

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Abstract

In many countries there are still different ways of education of orthopaedic technology. Until now, in Croatia education of prosthetics and orthotics has been sporadic. In the paper a project of organization of a new professional study of prosthetics and orthotics is described, the study which would be carried out at Polytechnic of Zagreb (PZ) in Croatia and in accordance with the directives of Bologna Declaration and requirements of education concerning the needs of certification of potential candidates according to ISPO (International Society for Prosthetics and Orthotics) classification.

INTRODUCTION

Despite the intention of standardizing the programmes and criteria for education of technical specialists in prosthetics and orthotics, different education ways and methods are still present in many countries.

Until now education of technical specialists in prosthetics and orthotics in Croatia has been sporadic and mostly based on courses (theory and practice) and annual seminars (theory through lectures and workshops). For that reason we decided to analyse the actual state of specialists in orthopaedic technology in the Republic of Croatia and the current state of education in prosthetics and orthotics and to propose the possibility of regular education in the frame of a new professional study.

METHODS AND SUBJECTS

In the paper the technical workshops for orthotics and prosthetics in Croatia as well as present specialists were recorded. The data were collected by a telephone poll and by available data from official reports. In addition, different available texts and programmes of education of the specialists in orthopaedic technology carried out in our region were analysed.

RESULTS

Prosthetists and orthotists

According to the data, in Croatia, there are 20 orthopaedic-technical workshops and about 100 medical houses (specialized shops for orthopaedic and other aids to 4.437.460 inhabitants (in 2002). In orthopaedic-technical workshops work 3 graduated engineers, 4 engineers of prosthetics and orthotics, 3 CPOs (certified prosthetist-orthotists), 5 technicians and about 40 semiskilled technicians with secondary education being educated in prosthetics and orthotics by working in such workshops.

All the moderators of technical workshops in Croatia have passed formal education. They graduated in Ljubljana (Slovenia) at University College of Health Studies, Department for Orthopaedic Technology (Visoka šola za zdravstvo, oddelek za ortopedsko tehniko), in Belgrade (Serbia) graduated at Polytechnic for Prosthetists and Orthotists or in Zagreb (Croatia) at Technical High-School. Three prosthetists-orthotists were educated at Federal School for Orthopaedic Technology in Duderstadt (Germany). Medical education for technical specialists in Croatia theoretically and practically was carried out by the Institute for Rehabilitation and Orthopaedic Devices of University Hospital - Zagreb. The moderators of technical workshops with education are trainers to their collaborators.

Education project

Education is planned as a three-year professional study according to regulations in accordance with the directives from Bologna Declaration. Teaching would be carried out through six semesters and by a semester the class load (lectures and exercises) would be up to 25 hours per week. The attitude of the authors of this project is that exercises compared to lectures should have some larger fund of hours.

During each semester the students would attend from 5 to 7 courses and have the possibility to gain 30 ECTS by semester. For most of the courses the students would have the possibility to sit for the exam through preliminary exams, written tests, seminar works and team made solutions. Thus, after finishing such planned professional study, the students would master about 33 courses and gain 180 ECTS, meeting in this way the conditions for continuation of education in the frame of specialized studies, if wishing to do so.

After successfully graduating the specialized study and passing the final exam (thesis), the candidates would gain the title of a bachelor (baccalaureus) engineer of orthotics and prosthetics.

The next, higher stage of education would be possible in continuation at the Specialized Studies of Polytechnic of Zagreb (two more years, i.e. the 7th, 8th, 9th and 10th semester) which already exist for three study orientations. After successfully finishing the two years of specialized study of orthotics and prosthetics, the candidate would obtain a degree of the specialist in orthotics and prosthetics.

Theoretical part of teaching would be carried out at Polytechnic of Zagreb. In the Institute for Rehabilitation and Orthopaedic Devices of the University Hospital - Zagreb the medicinal part of education would be carried out as well as working with patients, and practical work would be carried out in technical workshops of Otto Bock Adria in Sveta Nedelja. All three institutions have personnel and adequate equipment for carrying out teaching, and Polytechnic of Zagreb, after obtaining the licence from the Ministry of Science, Education and Sports, would be authorized for issuing the corresponding diplomas.

The conditions for the enrolment to professional study of prosthetics and orthotics would consist of three parts: results (achievements) in secondary education and passing the national (school-leaving) examination respectively, an interview of the candidate by the commission and testing the skills for practical technical work. The commission would consist of the selected teachers of that particular study.

DISCUSSION

On the basis of the analysis of the current state in orthopaedic technology, we decided to propose the regular education of prosthetists and orthotists in the Republic of Croatia, along the lines of Bologna process and with the programmes in accordance with ISPO - classification. Having the development of science in mind, as well as the rapid development of technologies and relevant materials, we reached the conclusion that it would be necessary to ensure, together with the proposed professional study, a regular and permanent education of specialized personnel as one of the ways of life-long-learning, which would satisfy increasingly rigid requirements of contemporary orthotics and prosthetics.

Besides the use of new materials, there are also design and technologically very extensive and demanding solutions which implicitly include mastering of series of new technological cognition from biomechanics, information technology, electrical engineering and electronic solutions. These are the following courses: Biomechanics, Biomechatronics, Ergobiomechanics, Computer Design, Theory of Mechanisms, Theory of Elasticity, Design of Prosthesis and Implants, etc. In addition, there is still a series of new knowledge in medicine science and it can be anticipated that education of these students besides medicinal knowledge (40-45 %) would need a series of cognitions which can be called by a common name of biomechatronics (55-60 %).

Since Polytechnic of Zagreb has appropriate experts, technical and computer laboratories and a ten-year experience with education of engineers, the Institute for Rehabilitation and Orthopaedic Devices of the University Hospital - Zagreb has experts in medical rehabilitation and adequate premises for work with patients and Otto Bock Adria has excellent infrastructure and technology for practical work, we think that joining these groups of experts and their institutions on the project is a solid precondition for very good education of the specialists in prosthetics and orthotics.

In the opinion of the authors of the project, the professional study of orthotics and prosthetics could be started in Croatia with 20 enrolled candidates each year. Such number of enrolled students would enable a very correct, even excellent education, in accordance with the Bologna principles and a serious practical work in groups of up to 10 candidates. Our wish is to enable by this professional study the complement or continuation of education to students who up till now were not able do so. Since even the candidates from a wider region may be interested in this professional study, the possibility of their education is also anticipated.

CONCLUSIONS

Pursuant to the data, we consider it necessary to carry out a regular, professional and specialized education of technical specialists in prosthetics and orthotics in the Republic of Croatia, which will enable a permanent education on new technologies, materials or actual technological solutions. We consider that carrying out such education through the studies at Polytechnic of Zagreb in collaboration with the experts from the School of Medicine and Oto Bock Adrie d.o.o. and in accordance to the Bologna Declaration and requirements which are to be fulfilled for ISPO classification and certification would be the best possible solution.

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E-LEARNING / CONTINUING EDUCATION NEEDS FOR PROSTHETICS AND ORTHOTICS: PRELIMINARY RESULTS

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Abstract

A questionnaire was developed to survey people in the prosthetics and orthotics (P&O) field regarding access to communication technology, experience and attitudes regarding e-learning, and continuing education needs. Preliminary analysis from 54 respondents represented a cross section of the global P&O community. Since most respondents were frequent Internet users with broadband Internet access, desktop e-learning approaches could succeed from a technical and user-technology-training perspective. However, the in-person learning modality was the preferred method for continuing education, with audio-conference and audio-tapes having the lowest ratings. The majority considered P&O technology and clinical methods as topics of most interest. However, the most consistently requested topic was on documentation. Almost 50% expressed interest in therapeutic topics, although only 17% of respondents were therapists. Since employers typically pay continuing education costs, education opportunities could be designed to fit into the workplace.

INTRODUCTION

E-Learning can be defined as an "approach to facilitate and enhance learning through the use of devices based on computer and communications technology. Such devices would include personal computers, CDROMs, Digital Television, P.D.A.s and Mobile Phones. Communications technology enables the use of the Internet, email, discussion forums, multimedia, and collaborative software." (1). While some may limit their view of e-Learning to reading content on a web site, the possibilities reach far beyond this approach.

As a result of the Orthotics and Prosthetics E-Learning Network (OPEN) meeting in Hong Kong (2007), the need for a better understanding of e-learning requirements and capabilities within the prosthetics and orthotics community was identified (2). To address this need, a survey was designed to obtain information about continuing education needs within the multidisciplinary, global prosthetics and orthotics profession. This paper describes initial results from this ongoing survey.

METHODS

A P&O e-learning questionnaire was developed and peer reviewed by an international expert group of educators from Hong Kong Polytechnic University (Hong Kong, China), Northwestern University (Chicago, USA), University of Texas (Dallas, USA), University of Don Boscol(San Salvador, El Salvador), Cambodian School of Prosthetics and Orthotics (Phnom Pehn, Cambodia), LaTrobe University (Melbourne, Australia), George Brown College (Toronto, Canada), Norwegian Centre for Telemedicine (Tromsø, Norway), The Ottawa Hospital Rehabilitation Centre - Institute for Rehabilitation Research and Development (Ottawa, Canada), Centre for International Rehabilitation (Chicago, USA), Human Study (Belgrade, Serbia), Orthopädie-Technik (Dortmund, Germany), China Training Centre for Orthopaedic Technologists, Capital Medical University (Beijing, China), and Zhong Shan University (Guangzhou, China).

Initial data collection occurred at the 12th ISPO World Congress in Vancouver (July 29-August 3, 2007), by including paper questionnaires in the delegate bags. Announcements were made throughout the congress to encourage delegates to complete the questionnaire. No financial, or other incentives, were provided to people who anonymously completed the questionnaire. Descriptive statistics were used for data analysis.

RESULTS

A total of 54 questionnaires were received, out approximately 1,300 questionnaires distributed. Since this return rate was extremely low, data collection via other means (web page, etc.) continues.

Respondents

The respondents were 50% male, 50% female, with continuing education opportunities available for 89% of these people. Continuing education credits are required in 62% of the cases and 80% require that the person maintains an education record. Most respondents were from Western Europe and North America. No questionnaires were received from Eastern Europe or the Middle East. The majority were prosthetists (30%), orthotists (30%), and physicians (20%). Only 17% of respondents had less than 5 years experience in the field.

Technical Factors

The predominate communication methods were web sites and email. Desktop video experience was small (Table 1). As shown in table 2, almost all respondents have access to a computer, broadband Internet, and digital camera - at work and at home. Video conference access at work was almost 50%, although few people had access to a Webcam. Technical support at work was generally available, but limited support was available at home.

Table 1: *Experiences with communication methods.*

Technology	Use more than 3 days/ week	Use frequently	Use occasionally	Never
Web sites	63.0	27.8	7.4	1.9
Email	85.2	11.1	1.9	1.9
Internet phone	11.1	13.0	14.8	59.3
Streaming	5.6	20.4	35.2	37.0
Desktop Video	1.9	3.7	20.4	68.5
Room video	0.0	11.1	37.0	50.0
File transfer	16.7	31.5	27.8	22.2
Web form	5.6	22.2	51.9	18.5

While in-person courses were the preferred method for continuing education, all options received predominately average or above ratings (Table 3). Over 30% of respondents had minimal experience with learning technologies.

Continuing Education Factors

Cost, personal time constraints, and staffing issues at work are the main factors preventing participation in current continuing education activities. Event location (36%) and lack of information on learning opportunities (26%) were also common concerns that prevent participation. Internet email was the preferred contact method (90%), followed by mailed brochures (46%).

Table 2: *Access to commuication technology.*

Technology	Home	Work	Other	None
Computer	96.3	98.1	1.9	0.0
Phone Internet connection (slower)	22.2	13.0	5.6	33.3
High-speed Internet connection	72.2	83.3	1.9	3.7
Webcam	22.2	14.8	1.9	51.9
Digital camera	87.0	81.5	0.0	1.9
Conference room video conference	1.9	42.6	9.3	37.0
Cell phone	77.8	38.9	3.7	5.6
Technical support	27.8	87.0	1.9	7.4

Table 3: *Rating of method(s) towards achieving learning goals.*

Technology	Excellent	Above Average	Below Average	Poor	Never	Used
In-person course	75.0	21.2	3.8	0.0	0.0	0.0
Video conference	5.8	23.1	21.2	7.7	5.8	32.7
Web audio + slides	3.8	17.3	30.8	5.8	3.8	30.8
Web site course	7.7	21.2	21.2	5.8	7.7	34.6
PowerPoint file	17.3	26.9	46.2	5.8	0.0	3.8
Audio conference	1.9	13.5	23.1	11.5	7.7	40.4
Audiotapes	3.8	17.3	23.1	11.5	3.8	38.5
Texts / Manuals	25.0	32.7	32.7	5.8	1.9	0.0
Other	3.8	1.9	1.9	0.0	0.0	0.0

In almost 60% of the cases, the employer pays for continuing education activities. Approximately half (52%) of people indicated that they pay for their continuing education. Most respondents (76%) considered advanced standing recognition as an important continuing education criterion, with half considering this as essential.

Questionnaire respondents were asked to select topics of interest to them for continuing education. Since people could select multiple topics, many topics were considered important by the respondents (Figure 1). The majority considered prosthetic and orthotic technology and clinical methods as of most interest. However, the most consistently requested topic was on documentation. The result of almost 50% interest in therapeutic topics was higher than anticipated, when only 17% of respondents were physiotherapists or occupational therapists.

DISCUSSION

While the initial questionnaire response rate was low, the small sample does provide a cross section of global prosthetic and orthotic needs and an understanding of the potential for using e-learning approaches to achieve these needs. While international conferences provide a large potential sample for surveying the global P&O community, questionnaire return

rates without added incentives are low. Other strategies may be necessary to obtain representative data for from Africa, South America, and Middle East.

Since almost all respondents (approximately 90%) are frequent users of the Internet, and have access to a computer with broadband Internet access, desktop e-learning approaches have a high chance of success from a technical and user-technology-training (i.e., learn to use an e-learning system) perspective. However, e-learning approaches are not the preferred method. This may be due to the availability of in-person continuing educational offerings in the respondent's region, lack of experiences with e-learning, or the lack of e-learning opportunities. It was not surprising that audioconference and audio-tapes had the lowest ratings, considering the difficulty describing P&O concepts without visual aids.

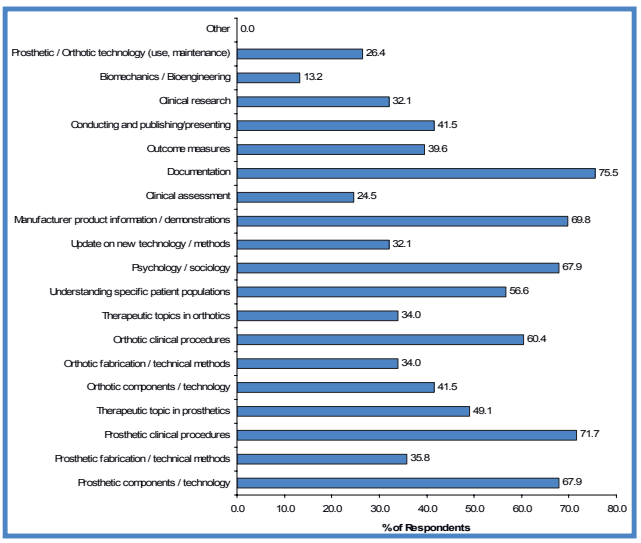

Figure 1: *Continuing education topics of interest.*

From the content perspective, the preliminary results provide a basis for selecting topic areas for e-learning continuing education opportunities. Since most people rely on their employer to cover continuing education costs, these education opportunities could be designed to better fit into the workplace environment (enhanced scheduling, access, module design, etc.).

CONCLUSION

The ISPO e-learning continuing education questionnaire provided interesting preliminary results that help us understand the potential for e-learning and in-person P&O continuing education. Data collection will continue to obtain a satisfactory global perspective on this topic area.

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DEVELOPING ICF CORE SETS FOR PERSONS WITH AN AMPUTATION

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Abstract

The International Classification of Functioning, Disability and Health (ICF) describes health and health related components of well being of the individual and it is a challenge to develop instruments which can be applied in the clinical setting.
The aim of this paper is to give a basic understanding of ICF Core Sets with stroke as an example, outline the process for developing Core Sets and inform the audience about the development of ICF Core Sets for amputees.
Core Sets are a subset of all ICF categories. Brief ICF Core Sets include about 10 to 20 categories and can be used in everyday clinical practice. Comprehensive ICF Core Sets are contain up to 150 categories and may be used in multidisciplinary rehabilitation or other detailed assessments.
The development of ICF Core Sets can be considered in three phases: preparatory phase, ICF core set development and testing and evaluation.
The development of Core Sets for amputees has commenced and a steering group has been formed. Over the next two years the Core Sets will be developed and everyone is invited to contribute to the process.

INTRODUCTION

The International Classification of Functioning, Disability and Health (ICF) describes health and health related components of well being of the individual. The ICF has been translated into over fifty languages. The patient is the focal point of the classification. It is recognized that the individual is in an environment and that manipulation of the environment may facilitate activity and participation or act as a barrier.

Amputation is common in industrialised and in non industrialised nations, with a prevalence of 17 to 30 per 100000 in Europe and as high as 67 per 100000 in Africa (1). Incidence of amputations has increased in line with the continued prevalence of the main aetiological factors of diabetes, motorised transport use and conflicts in particular the use of the land mines.

A challenge is to develop an internationally standardized instrument to use in the setting of the patient with an amputation. The ICF is suitable but needs to be tailored to meet the requirements of clinicians treating amputees, as well as be sensitive to the needs of the person with an amputation. ICF Core Sets are a practical solution in many chronic conditions and may be a solution for the patients with amputations as well.

ICF Core sets can also be utilised as outcome measures (2). This could contribute significantly to standardisation of treatment outcomes for patients with an amputation.

OBJECTIVE

The aim of this paper is to give a basic understanding of ICF Core Sets with stroke as an example, outline the process for developing Core Sets and inform the audience about the International partnership between WHO, ISPO and ISPMR to develop ICF Core Sets for amputees.

ICF CORE SETS

Core Sets are a subset of all ICF categories, keeping the number at a manageable level. Brief ICF Core Sets include about 10 to 20 categories. They can be used in everyday clinical practice. Comprehensive ICF Core Sets are more detailed. They may be used in multidisciplinary rehabilitation or other detailed assessments, where the major aspects of patient function, relevant to the particular condition, should be recorded. They may include up to 150 categories.

The brief ICF Core Set for stroke comprises a total of 18 categories. It includes 6 categories in the component body function, 2 from body structures, 7 from activities and participation and 3 from environmental factors. This is a subset of 14% of the categories of the comprehensive Core Set. The individual categories are: consciousness functions, orientation functions, attention functions, memory functions, mental functions of language, muscle power functions, structure of the brain, structure of the upper extremity, communication -receiving spoken messages, speaking, walking, washing oneself, toileting, dressing, eating, immediate family, health professionals and health services/systems/policies. The last

three items can potentially have a neutral effect or be either a facilitator or a barrier for the patient.

The comprehensive ICF Core has a total of 130 categories. This includes 41 categories from the component body functions, 5 from the component body structures 51 from the component activities and participation and 33 from the component environmental factors (3).

DEVELOPMENT OF ICF CORE SETS

The development of ICF Core Sets can be considered in three phases: preparatory phase, ICF core set development and testing and evaluation (4).

In the preparatory phase all relevant perspectives are addressed.

(a) A systematic broad-based literature review identifies and quantifies the concepts underpinning the published and developed outcome measurements. The underlying concepts are linked to ICF categories.
(b) Patient interviews, either individually or in focus groups, explore the concepts of functioning and health important from the perspective of a patient with an amputation. The underlying concepts are linked to ICF categories.
(c) An electronic survey of clinical experts identifies the perspective of relevant professionals regarding the problems for an individual with an amputation. The survey includes experts from all WHO regions and all health professional groups involved in the treatment of amputees.
(d) An empirical cross sectional multi-centre study using an extensive ICF check list identifies the most common problems and describes function and health in an amputee population.

The final result of the preparatory phase is an extensive and all inclusive list of ICF categories.

In the Core Set development phase the ICF categories derived from the preparatory phase are discussed and refined in detail over numerous iterations until consensus is reached about which categories should be included in the Core Sets. The final iterations take place in a consensus conference attended by a broad range of international representatives.

The final phase of the development of initial ICF Core Sets is the testing and validation phase which is carried out as international multi-centre study.

CORE SETS FOR PERSON WITH AN AMPUTATION ICF

Core Set(s) have been developed for numerous chronic conditions and are being integrated into clinical practice. The development of Core Sets for amputees has commenced.

A steering group with representation from the major collaborating partners WHO, ISPMR, ISPO and representatives of the WHO health regions has been formed. A scoping paper is being published. Funding is being sought to support the development costs.

Over the next two years the Core Sets will be developed and everyone is invited to contribute to the process.

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FUNCTIONING OF ELDERLY LOWER LIMB AMPUTEES - PATIENTS' PERSPECTIVE

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Abstract

The aim of the present study was to find out whether International Classification of Functioning, Disability and Health (ICF) can be used to describe all the problems in the area of activities and participation and to define the most important environmental factors influencing the functioning of elderly lower limb amputees. All the subjects visiting lower limb amputee outpatient clinic in January 2008, who had been amputated at least one year before, had prosthesis and were willing to participate were included into the study. Nineteen out of twenty-four subjects experienced pain, they had problems with 15 activities and participation items on average (0 to 34) and had 14 facilitators (8 to 21) and 13 (6 to 19) barriers in the environment.

INTRODUCTION

Most lower-limb amputations in the developed countries are performed due to vascular pathology (1). Most of the patients are therefore elderly at the time of amputation and may have many other diseases (2). Vascular problems usually affect the vessels of other organs which may together with age, other diseases and the amputation itself cause several problems in the patients' functioning, such as phantom and stump pain, balance problems, walking and other mobility problems and others (3-5).

There are several outcome measures and clinical tests used for assessing outcome and functioning after lower-limb amputation. Some of them are generic, others have been developed especially for lower limb amputees, but there is no consensus among clinicians regarding the most appropriate one (6). Besides, they cover only partial and not the entire functioning of an individual person. In particular, there is a lack of outcome measures for participation and environmental factors.

The aim of the present study was to find out whether International Classification of Functioning, Disability and Health (ICF) can be used to describe all the problems in the area of activities and participation and to define the most important environmental factors influencing the functioning of elderly lower limb amputees.

METHODS AND SUBJECTS

Methods

The subjects' functioning was assessed by ICF. All the codes relevant to each individual were used from Activities and Participation and from Environmental Factors. Only the subjects' performance was assessed and two qualifiers only were used: 0 - no problem, 1 - problem. All the included subjects were interviewed by a trained student of occupational therapy. The results were statistically analysed.

Subjects

All the subjects visiting lower-limb amputee outpatient clinic in January 2008, who had been amputated at least one year before, had prosthesis and were willing to participate were included into the study.

RESULTS

The study included 24 subjects, 21 men and 3 women, amputated 2 to 68 years before the study. Eleven had transfemoral and 13 transtibial amputation. Ten subjects were amputated due to an injury to lower limb, 12 due to peripheral vascular disease and 2 due to diabetes.

Nineteen out of twenty-four subjects had pain which affected their functioning. Four subjects had problems with some basic learning activities, up to 14 had problems with Mobility, Self care, Domestic life and Participation. On average, they had problems with 15 activities and participation items (0 to 34). Most of them had problems moving around, walking, driving, caring for household objects and doing housework. They had 14 facilitators (8 to 21) and 13 (6 to 19) barriers in the environment. Health professionals were facilitators for all of them, followed by products and technology for use in daily living. Design, construction and buildings for public use, attitudes of people in positions of

authority, support and relationships of peers, neighbours, community members and physical geography were the most frequent barriers.

The subjects amputated due to an injury had fewer problems at the activities and participation level than those amputated due to vascular problems and diabetes (9 versus 18). The number of problems, facilitators and barriers did not depend on the amputation level.

DISCUSSION

The study found that elderly lower limb amputees had several problems at the activities and participation level and several barriers in their environment. Most frequent activity problems were those with mobility and household activities. Some mobility problems are more or less addressed in almost all the outcome measures used in the assessment of lower-limb amputees (FIM, Locomotor Capability Index), but household activities are not. Also driving and using transportation are mentioned only in some studies that used questionnaires and are not found in most frequently used outcome measures (4). However, they are important especially at the level of participation (4). Most household activities covered by the interview are important for independent living.

There were several facilitators, but still many barriers in the environment of the included subjects. In spite of the law on the accessibility of newly-built public buildings, these were still the main barrier in the environment. Additionaly, support and relationship of peers, colleagues, neighbours and community members was low and worriesome, but even worse were the attitudes of people in positions of authority. People in Slovenia seem to have a very negative attitude towards persons with disabilities and are not really willing to help. Much more has to be done in the field of education to change those attitudes.

The subjects included into the study were not a true representative sample of lower-limb amputees in Slovenia. In general, most of the amputees have been amputated due to vascular problems whereas in the present study almost half of the subjects had been amputated due to an injury.

CONCLUSION

Elderly lower limb amputates were found to have several activity limitations and barriers in their environment. Many of them have to be addressed and changed in order to improve the lives of lower limb amputees in Slovenia as well as the lives of other persons with disabilities.

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AMPUTEES' REHABILITATION SYSTEM IN CROATIA

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Abstract

This paper describes the current state of the amputees' rehabilitation system in Croatia and discusses its further advancement. The basis of three elements served for the analysis of the system's effectiveness measurement: structure, process and outcome of rehabilitation care. The structure represents sufficient number of inpatient beds for the amputee rehabilitation with inadequate facilities for the optimal care. The rehabilitation training, as a process, is preformed by the actual professional standards. As well as, the outcome of rehabilitation care is measured by variety of widely used tools. These used tools are useful for the amputees' inpatient follow up. Thus for the long term follow up after the discharge are not applicable, according to the authors. Therefore, to conclude, the future research should be emphases on the late outcome of the rehabilitation care and its predictors. Moreover, the Locomotor Capabilities Index (LCI) is proposed as the measurement and follow up tool due to its simplicity.

INTRODUCTION

According to the latest collection in 2002, the Republic of Croatia is a country with 4.437.460 inhabitants. The Croatian amputees' register doesn't exist. Therefore, the incidence of 0.26 ‰ is extrapolate from the available publications and the number of amputee inpatients per year. There is no mortality data. Therefore, this paper aims to describe the current state of the amputee's rehabilitation system in Croatia and to discuss its further advancement.

METHODS AND SUBJECTS

The review of the system's effectiveness and quality the basis of three elements approached is used: structure, process and outcome of rehabilitation care (1, 2). The amputees' rehabilitation data were collected from the statistical data pertaining to the national Institute for Rehabilitation and Orthopaedic Devices, University Hospital CenterZagreb (IROD), as well as from official statistical statements.

RESULTS

The structure

Croatia has a total of 55 amputees' rehabilitation beds contracted by Croatian Institute for Health Insurance. In the IROD 40 beds and the rest in the FMR department of University Hospital Centres: Rijeka, Split and Osijek, each having 5 beds.

The prosthetic rehabilitation training is running by approximately 10 specialist, physiatrists and orthopaedic surgeons, more focused on the field.

The extended team members are: 20 ortho- technical workshops with 3 ortho - prosthetics bachelors, 4 ortho - prosthetics engineers, 3 CPO (certificated ortho - prosthetics) 5 technicians and approximately 40 taught technicians.

The process

The amputees' rehabilitation begins at the surgical departments and transfers, for period of 21 days, either at home with visiting physiotherapist or either in special hospitals for medical rehabilitations. Physiotherapy treatment include: kinesiotherapy, stump rehabilitation and ambulation with orthopaedic devices (crutches or walker). The period of average 16 weeks after the amputation, takes for the amputee to be admitted to the inpatient prosthetics rehabilitation in our Institute, whilst for children and trauma or tumour amputations lasts from 4 to 6 weeks. Some statistical oscillations occurred during the war period because of the gross number of trauma amputations.

In total of average 280 inpatients per year is admitted to the primary rehabilitation in our Institute, as well as 230 inpatients to the secondary rehabilitations due to the causes of amputations, as follows: diabetes (54%), peripheral vascular disease (29%), trauma (10.7%), tumours (3.65%) and congenital abnormalities (2%) (2).

The first prosthetic training program takes average of 4 weeks for the transtibial amputees and 6 weeks for the

tranfemoral amputees. There is focus on three essential activities: prosthetic use, learning how to walk and teaching basic ADL. Prosthetic training is planned and done according to the individual pre designed program at the admission team check up, evaluated daily and weekly. Moreover, the final outcome of prosthetic training is measured at the team discharged check up.

The rehabilitation team in consisted of: orthopaedic surgeons, physiatrist, nurse, physiotherapist, occupational therapist, prosthetic technician and patient. If needed, social worker, psychologist, vocational consular and priest could be team members. An internal medicine doctor (diabetologist, cardiologist), vascular surgeon and psychiatrist are in close team collaboration.

The type of prescribe prosthesis is standardised and is based on the 4 level evaluations: 1. indoors prosthetic use, 2. outdoors prosthetic use, 3. public places and transportations prosthetic use and 4. indoors and outdoors prosthetic use with recreational activities. Prosthetic engineer is opinion leader in the matter of prosthetic type (modul) and materials.

The outcome of rehabilitation care

At the time of discharge outcome of prosthetic training is routinely evaluated by: prosthetic use in a day (time in hours), walking speed (seconds per 10 meters), independence of prosthetic donning, use of technical aids (1 or 2 crutches, walker), rehabilitation training period (in days) and independence in ADL. For research purposes we used: FIM, Barthel index, The Reintegration to Normal Living Index (RNL), Quality of life index, Prosthetic Profile of the Amputee (PPA) and Locomotor Capabilities Index (LCI).

DISCUSSION

The structure represents sufficient number of inpatient beds for the amputee rehabilitation with inadequate facilities for the optimal care. Because of our demands for the early prosthetic training (4 to 6 weeks post amputation), average time of 4 months prior to the Institute admission does not satisfy. Despite, at that mentioned time, more than 90% amputees are able to walk short distances with use of technical aid (crutches or walker) and are moderatly independent in ADL. This serves as a good predictor of successful prosthetic training.

The rehabilitation training, as a process, and the outcome of rehabilitation care in our Institute satisfy our needs, as well as outcome measurement tools routinely used. Thus for the long term follow up after the discharge, research tools is not applicable due to consumption time. Therefore, to conclude, the future research should be emphases on the late outcome of the rehabilitation care and its predictors, focused on the prosthetic use and ADL independence.

CONCLUSION

From our experience primary prosthetic training program should be received in specialized inpatient facility. It is planned to categorised prosthetics training facilities as well as ortho - prosthetics workshops. Secondary prosthetic training program could be received in outpatient clinic. There is a need for amputee register and consequently optimal framework of facilities, personel and equipment. The future research should be aimed to the late outcome of the rehabilitation care and its predictors. Moreover, the Locomotor Capabilities Index (LCI) is proposed as the measurement and follow up tool due to its simplicity.

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A COMPARISON OF TRADITIONAL GAIT TRAINING VERSUS GAIT TRAINING ON THE GAIT TRAINER IN TRANSTIBIAL AMPUTEES

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Abstract

This study is planned to compare the results of gait training done by conventional methods and Biodex Gait Trainer in trans-tibial amputees. The study group is consisted of 40 amputees. Amputees who received conventional exercises formed the control group while the study group is consisted of amputees who practiced the gait with gait trainer. After the patients were assessed, gait training was given for 10 days and they were evaluated by gait trainer for their gait characteristics. Patient's physiological cost index was also assessed. It was found that there weren't any statistical demographic differences between the two groups (p<0.05). There were significant differences in gait velocity, gait distance and physiological cost index between the two groups (p<0.05). Although two forms of gait training are found to be very effective on improvement of gait characteristics, gait trainer is determined to be more effective in diminishing the energy consumption.

INTRODUCTION

After amputation, gait speed usually declines and the energy cost of walking increases. Many researchers have reported that unilateral trans-tibial amputees (TTA) walk asymmetrically and differently from able-bodied people (1, 2). The reasons given for asymmetrical walking vary. It is generally believed that socket fit, prosthetic alignment, and prosthetic components (including prosthetic parts' weight and design) can all influence the gait of amputees. Others predicted that degenerative changes in the lumbar spine and knees would occur due to the asymmetrical walking that overloads the musculoskeletal system (1-3). These problems should be determined and stated into the prosthetic training program. This study is planned to compare the results of gait training done by conventional methods and Biodex Gait Trainer in the restoration of gait which is the most important functional loss in unilateral trans-tibial amputees (1-3).

METHODS AND SUBJECTS

The study group is consisted of 40 amputees between 20-45 years of age. The subjects divided into two groups. Amputees who received conventional exercises such as Proprioceptive Neuromuscular Facilitation Techniques, weight bearing (by footstep), gait and balance training formed the control group while the study group is consisted of amputees who practiced the gait with gait trainer.

After the patients were assessed for their demographic characteristics, gait training were given for 10 days and they were evaluated by gait trainer for their gait characteristics, such as velocity, stride length, cadence, step cycle and ambulation index. Patient's physiological cost index was also assessed. The data evaluated by the suitable statistical methods.

RESULTS

It was found that there weren't any statistical demographic differences between the two groups (p<0.05) (Table 1).

Table 1: *Comparison of the subjects' demographic characteristics*

Demographic Characteristics	Group I X±SD	Group II X±SD	p
Age(years)	37.25±6.45	38.65±6.33	0,49
Height(cm)	170.15±7.61	167.70±5.12	0,24
Weight(kg)	68.65±6.45	65.00±6.65	0,08

(Independent Samples Test-t test)

There were significant differences in gait velocity, gait distance and physiological cost index between the two groups (p<0.05) (Table 2).

Table 2: *Comparison of the groups in terms of gait parameters, weight bearing and physiologic cost index*

Parametres	Group I X̄ ± SD	Group II X̄ ± SD	p
Velocity (m/sn)	1.05 ± 0.35	0.69 ± 0.28	0.00*
Step cycle(sn)	0.74 ± 0.19	0.66 ± 0.24	0.24
Step inequality(cm)	4.5 ± 2.95	4.6 ± 1.71	0.11
Weight bearing on amputated side (%)	44.20 ± 4.09	42.40 ± 5.64	0. 25
Ambulation index score	74.80 ± 13.79	72.25 ± 15.35	0.58
Gait distance(m)	358.45 ± 143.61	266.55 ± 104.75	0.02*
PCI	31.79 ± 2.88	40.61 ± 4.08	0.00*

(Independent Samples Test-t test)

DISCUSSION

Although two forms of gait training is found to be very effective on improvement of gait characteristics, balance and coordination; gait trainer is determined to be more effective in diminishing the energy consumption due to the selection of gait velocity related to personal structure(3, 4).

With equipment such as force plates, electrogoniome-ters, and electromyographs, a number of research studies have presented objective, quantified analyses of amputee gait. Basically, gait analysis involves the identification of gait deviations and determination of the causes associated with each deviation. With this accomplished, the treatment team can then plan and recommend corrective actions to improve the situation. This process works well so long as the clinic team understands normal gait, biomechanics, and prosthetic fit and alignment (3, 4).

CONCLUSION

It was found that both conventional gait training and gait training by Gait trainer effected in terms of gait parameters, weight bearing on amputated side and energy expenditure in the trans-tibial amputees.

It can be concluded that Gait trainer is useful to determine the effectiveness of gait training were offered trans-tibial amputees and to achieve the objective data were obtained by gait trainer.

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WEIGHT-BEARING TRAINING WITH SMARTSTEP BIOFEEDBACK SYSTEM

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Abstract

The article discusses weight-bearing training on the impaired lower limb during gait with SmartStep biofeedback system on patients after stroke and lower-limb amputation. The aim of the present study was to find out whether by using SmartStep biofeedback system, which gave the patients a sound signal when they put enough weight on the impaired limb, the weight bearing and gait pattern could be improved. The study found that by using SmartStep biofeedback system the weight bearing of the hind foot and the whole foot increased as well as the patients' self-confidence and safety.

INTRODUCTION

Most patients admitted for rehabilitation have gait problems. Patients after fractures and joint replacement are not allowed to walk with full weight bearing whereas stroke patients and amputees do not put enough weight on the impaired lower limb or on the prosthesis. Gait training is one of the most frequently used trainings by means of which, physiotherapists try to teach patients the appropriate weight bearing with different physiotherapeutic methods and approaches (1-6). Until now, there has been no simple method to confirm the success of their work.

The aim of the present study was to find out whether by using SmartStep biofeedback system, which gave the patients a sound signal when they put enough weight on the impaired, limb the weight bearing and gait pattern could be improved.

METHODS AND SUBJECTS

Methods

SmartStep system consists of a flexible polyurethane insole containing two separate air pockets and a wireless control unite which is attached to the patient's ankle. The control unite has two pressure sensors, each connected to one insole air pocket. In addition, the system also consists of an air pump for inflating the insole, a laptop with SmartStep software and a USB-key which allows wireless connection between the control unit and the computer.

Weight bearing was tested in standing position, transfer from sitting to standing and during walking.

Subjects

Fifteen stroke patients and nine lower-limb amputees were included into the study. All of them were admitted for the first rehabilitation at the Institute for Rehabilitation in Ljubljana. The inclusion criteria were the following: the patients had to be aged from 18 to 85; full weight bearing had to be allowed; the patients had to be able to walk at least 10 meters; they had to fully cooperate and to sign a written consent. The patients were randomly divided into a control and a training group.

Both groups used the SmartStep system during their physiotherapy sessions; in the control group the system was switched off. Each day before starting physiotherapy, the therapist measured the weight bearing and in the training group he adjusted the sound signal to be triggered when the weight bearing would exceed the initial level increased by ten percent of a patient's body weight. When starting the training, the therapist measured the weight bearing, gait velocity, 10m walking test, cadence, swing-stance phase ratio and FIM score. The patients after stroke started training with SmartStep immediately after the admission, the patients after lower-limb amputation started training after having been fit with prosthesis (the second week after the admission).

RESULTS

Thirteen out of twenty-four patients were in the control and eleven in the training group.

There were five amputees in the control group and four in the training group. There were eight stroke patients in the control group and seven in the training group. The study included

sixteen male and eight female patients. The average age was 60.2. The rehabilitation of stroke patients took six weeks on average, the rehabilitation of lower-limb amputees took five weeks on. At the beginning of the therapy, there were no significant differences between both groups in regard to the subjects' age, height, gender, diagnosis, need of walking aids, total FIM score, weight bearing of the impaired lower limb or the prosthesis on the whole sole, hind and fore part, stance and swing phase, cadence, gait velocity and 10m walking tests.

At the end of the study, the patients in the training group put 12.88 percent more of their body weight on the impaired side, whereas the patients in the control group put only 2.43 percent more. In all the other measured parameters, there were no differences between the two groups. However, differences between the amputees and the stroke patients were observed.

DISCUSSION

In spite of the small number of included patients and short duration of the therapy, the study found that by using biofeedback system the weight bearing of the hind foot and the whole foot increased. Those are the two main aims of physiotherapy since they also contribute to the prevention of osteoporosis. In addition, the patients' self-confidence and safety increased. Slightly greater improvement was observed in lower-limb amputees. The study did not succeed to demonstrate that using biofeedback system improved functional walking (gait velocity, 10m test, cadence, swing and stance phase and total FIM score). The patients put too much attention on weight bearing of the impaired limb during walking, which caused the symmetry of walking to become worse. The stance phase became longer and the swing phase shorter. Those pesults suggests that it would be appropriate to consider training weight bearing with SmartStep biofeedback system only in standing position and then after improved weight bearing in standing position one could begin weight bearing training during walking without SamrtStep system. The study did not succeed to demonstrate that using SmartStep system could save some time for the physiotherapist. Preparing the system and the patient was very time consuming.

More patients would need to be included into the study to reach firm evidence of the method but the first results were promising.

CONCLUSION

In spite of the small number of included patients and short duration of the therapy the study found out that by using SmartStep biofeedback system the weight bearing of the hind foot and the whole foot increased. However, preparing the system and the patient was more time consuming that it had been expected.

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REHABILITATION OF BILATERAL TRANS-FEMORAL AMPUTEES

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Abstract

Bilateral trans-femoral (TF) amputees are rare in comparison to those of trans-tibial ones and there is a difference between these two not only according to their frequency but to the final outcome as well. In five-years period, 10 patients with bilateral femoral amputee have been rehabilitated. 5 patients have been successfully provided with prosthesis which are being used daily, the other 5 patients use wheel-chairs. The average rehabilitation has lasted for 7 weeks. All patients do their activities of daily living (ADL). The evaluation for the prosthetics with two-way bilateral amputee must be done in hospital and with test prosthesis.The final decision on prothesis usage must be made according to the patients' motivation and the functional status.

INTRODUCTION

Bilateral TF amputees are rare in comparison to those of trans-tibial ones and there is a difference between these two not only according to their frequency but to the final outcome as well. At bilateral trans-tibial amputees, walking with prothesis and crutches is being done successfully, with no difference in age, whereas, at billateral trans-femoral amputees at the age of 50 and more, wheel-chairs are most frequently used. In five-years period, we have participated in team rehabilitation of 10 patients with bilateral TF amputees and in our work we would like to present the final outcome of their rehabilitation and physiotherapist's experience in the process itself.

METHODS AND SUBJECTS

At the last 5 years, the prosthetics rehabilitation with 10 patients with bilateral TF amputees, aged 20 to 65, has been done at Institute for Rehabilitation and Orthopaedic Devices University hospital Zagreb. There has been 6 traumatic amputees; 3 caused by blood sugar disease and 1 by peripheral vascular disease (PVD) according to the cause of amputees.

After the addmittance of patients, physiotherapeutic evaluations have been made: volume of the leg, lenght of the leg, mobility (goniometrics), strength (dynamometrics, MMT), selfreliance in ADL (feeding, dressing up, personal hygiene, transfers) and the evaluation of the patients' activity level for the prosthesis usage.

Later on we have tested the verticalization of the patients having prothesis on the parallel bars; in the first 7 to 10 days only at the lowest height. Test deposits and the prothesis modules (knee unit with Lock and SACH foot) were used.

On the basis of the results gained through the testing, the plan of the prosthetics rehabilitation or the usage of the wheel-chairs has been done on the team indication meeting (a doctor, a physiotherapist, a working therapist, a rehabilitation nurse, a prosthetics, a patient). In prosthetics, the following has been adapted:

- A patient (a male), aged 55, traumatic amputee, modular prosthesis with quadrilateral socket, knee with lock the right, self-braking knee left, dynamic foot.
- A patient (female), aged 42, traumatic amputee, prosthesis titanium tube, longitudinal oval socket, knee with lock the right, self-braking knee left, dynamic foot.
- A patient (male), aged 56, traumatic amputee, modular prothesis with quadrilateral socket, one-axis hydraulically knee right, knee with lock the left and dynamic foot.
- A patient (male), aged 20, traumatic amputee, modular prothesis with longitudinal oval socket, C-leg two-way, carbonized foot (for high level activities).
- A patient (female), aged 59, diabetic amputee, modular prothesis with quadrilateral socket, knee with lock the right, self-braking knee left, SACH foot.

During the rehabilitation, individual kinesiotherapeutic procedures for the strengthening of the leg muscle with PNF technique (proprioceptive neuromuscular facilitation), coordination and positioning exercises for preventing the possible contractures and the school of prothesis walking in the period of 7 weeks in average by a rehabilitation algorithm: the verticalization on the parallel bars, walking down the parallel bar, in free area, across the obstacles and walking in a natural environment.

The following data have been made in the rehabilitation form: the time of the daily prothesis usage in hours, the speed of the walk (sec./10m), the overall duration of the rehabilitation in days and the functional status.

RESULTS

Five patients have been supplied with the prothesis:

1. A patient (male): trained to four-stroke walk with forearm cruches, the speed of the walk 17 sec/10 m, 5 hours of prothesis usage, self-supporting in putting on and taking off the prothesis.
2. A patient (female): trained to four-stroke walk with forearm cruches, the speed of the walk 15 sec/10 m, all day prothesis usage, self-supporting in putting on and taking off the prothesis.
3. A patient (male): trained to four-stroke walk with forearm cruches, the speed of the walk 13 sec/10 m, shorther distances with no cruches, all day prothesis usage, self-supporting in putting on and taking off the prothesis.
4. A patient (male): trained to four-stroke walk with forearm cruches, the speed of the walk 15 sec/10 m, all day prothesis usage, self-supporting in putting on and taking off the prothesis.
5. A patient (female): trained to walk with walking frame, the speed of the walk 21 sec/10 m, 4 hours of the prothesis usage per day, needs help with putting on and taking off the prothesis.

The average duration needed to master the balance and coordination on parallel bars was 4 days, walking down the bars 6 days and walking in free area with the walking frame 12 days. Within the following 10 days, the three-stroke walk with two forearm cruches has been mastered, in average. The obstacles, walking up and down the stairs, mastering the architectural barriers, walking on the bias, going down on the floor and getting up have been successfully mastered with the four-stroke walk within 10 days in average.

During the rehabilitation, the patients used therapeutic weekend in their own homes and environment for the cause of testing in ADL.

Other five patients used wheel-chairs because they did not master the usage of the prothesis:

– A patient (male): aged 42, traumatic amputee, an alcoholic.
– A patient (female): aged 54, traumatic amputee.
– A patient (female): aged 55, diabetic amputee.
– A patient (male): aged 57, diabetic amputee.
– A patient (male): aged 53, PVD amputee.

All the patients were self-supporting in ADL and mastered the wheel-chair transfers.

DISCUSSION

Bilateral TF amputees is a severe disablement and together with the prosthetical aid presents a huge strain for cardiovascular system of a patient. In pre-prosthetics preparation, the evaluation of a collaboral internist is very important as well as the cause of amputation, comorbidity and the motive of a patient which all have a crucial role for the evaluation team.

Physiotherapists and working therapists spend most of the time with the patients in their preparation for the prosthetics, participate in exercises and bandage, putting on and taking off the prothesis, their school of walking, educational courses for the prothesis and wheel-chair usage and mastering the transfers. Therefore, beside all the measurments, they participate in the evaluation of the prosthetics rehabilitation.

According to our unassuming experience, we believe it is not possible to make decision on prosthetics of bilateral TF amputees without detailed evaluation of patients' activity level and tested prothesis usage. Just at the basis of this evaluation of the functional status, walking with testing prothesis and patients' activitiy level, the proper modular prothesis can be chosen as well as the prosthetical supply.

Pre-prosthetics preparation is a very significant because the rehabilitation procedures can be changed during the prosthetics and the school of walking and further on pointed to some other important activities for the patient, like, encouraging the hobbies, recreation, sports and more successfull re-socialization.

In most cases, with bilateral TF amputees, the supply of only traumatic amputees is possible because there is no comorbidity, but our experiences have shown that neither all traumatic amputees can be supplied with the prosthetics which explains that the patients' motive is a crucial factor in the process of rehabilitation.

CONCLUSION

High-grade prosthetics rehabilitation is a step forward towards the reintegration in to normal living. The evalutation of a patient with bilateral TF amputees for the prosthetics aid needs to be done in hospital on the basis of the functional capacity evaluation, motivation of a patient and an adequate testing with test prothesis in order to make the final decision about the prosthetics.

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POSTURAL STABILITY OF BILATERAL AND UNILATERAL BELOW KNEE AMPUTEES

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Abstract

After the amputation the postural stability is generally decreased and is influenced by the extent of amputation. The poorer results of rehabilitation of bilateral amputees are well known. The aim of our study was to investigate a link between the results of rehabilitation and the standing balance of the bilateral amputees. Subjects were 10 unilateral below-knee amputees, 6 bilateral below-knee amputees, and 15 healthy control subjects. Stabilometry was used to asses the excursion of centre of pressure during quiet standing and a dynamic feed-back test was used to assess the fine coordination. The standing balance, the visual dependence and the fine coordination of unilateral and bilateral amputees were very similar. According to our results, we suggest that in the present context the standing balance ability was not influenced by the status of amputees, thus other factors might be responsible for poorer results in rehabilitation.

INTRODUCTION

Postural control is crucial in order to maintain standing stability, especially in case of elderly people. The postural control is influenced by several factors, e.g. age and body height, neural and muscular disease. After the amputation the postural stability was reported to decrease and influenced by the level of amputation., while age and physical activity played only secondary role (1). Compared to healthy subjects, amputees made a significantly poorer performance at the dynamic balance stability tests. At static balance, the role of visual control was more pronounced in the latter group (2). Definitely worse rehabilitation results of bilateral amputees compared to unilateral ones can be found in literature. Unlike to age, rehabilitation results were influenced by the level of amputation, concomitant diseases, and the success of the first prosthetic fitting (3). Half of the patients with successful first prosthetic fitting was able to reach good functional results after the second amputation (4). Among from the literature data dealing with bilateral amputees, only a few was investigating parameters of walking, and to our best knowledge, standing stability was not investigated so far. The aim of our work was to examine the connection between results of rehabilitation and both static and dynamic standing components of bi- and unilateral amputees.

METHODS AND SUBJECTS

Methods

A stabilometry was used to asses the excursion of centre of pressure during quiet standing. Apart from the patients, two other people were present during the examination, one of them worked on the computer, while the other gave instructions to the patient standing nearby. The latter person was also reponsible for the safety of the patients during their tasks. The patients accomplished different Romberg-tests on a force plate: (i) standing on both legs for 20 seconds, with lowered arms and open eyes (2O), (ii) standing on both legs for 20 seconds, with lowered arms and closed eyes (2C). To examine the fine coordination, a visual feed-back task called "Coloration-feed back task (CFBT)" was used. In this case, the patient stood on the force plate, on two legs, and was to spread around the area presented on the monitor, with the help of the cursor configuration which showed the motion of the centre of gravity. Variables used for statistical analysis were (1) the radius of body sway, (2) the visual dependence (Romberg-quotiens (RQ)), which was calculated as ratio of results acquired from closed eyes/open eyes tests, (3) time and (4) success-percentage of CFBT. Statistical analysis: Data were expressed as mean ± SEM and were analysed by Statistica 7.0 for Windows. Kruskall-Wallis ANOVA was used to express differences between groups. Mann-Whitney U-tests were also used for *post hoc* comparisons. The level of significance was $p<0.05$ in each caseThe data were processed with the software Statistica for Windows (and also Microsoft Excel). To demonstrate the difference between certain groups, we used Kruskall-Wallis ANOVA and Mann-Whitney U-test as a post hoc test. The level of significance was $p<0.05$ in each case.

Subjects

The unilateral below-knee amputated group consisted of ten patients aging 61.13(±3.33) years, eight males and two

females, who lost their limb 4.05(±2.28) years ago. The bilateral below-knee amputated group consisted of six patients aging 56.5(±1.88) years, who lost their limbs 3.66(±0.56) years ago. These patients were wearing the protheses 8-10 hours per day, thus they could be considered skilled prosthetic users. Without exception, the cause of amputation was vascular disease. The activity levels of the patients were defined by The Amputee Mobility Predictor, measuring 2.1(±0.74) and 1.5(±0.55) for unilateral and bilateral amputated group, respectively. The intact control group consisted of 15 people, 10 men and 5 women, aging 60.47(±0.74) years. Exclusion criteria were unstable angina pectoris, congestive heart failure, peripheral arterial disease, severe dementia, language problems that precluded following simple commands consistently, painful orthopaedic conditions involving the pelvis, hips, knees, or ankles. The Research and Ethics Committee of Semmelweis University, Budapest approved the study methods, and all patients gave their written informed consent according to the Declaration of Helsinki. The Hospital's Ethics Committee also approved the study.

RESULTS

All of the patients were able to perform the Romberg tests. One patient was not able to fulfill CFBT. All control subjects were able to perform the tests. The body sway of Romberg test with closed eyes (CO) was bigger than that with open eyes (2O) at all subjects (p=0.0001, Z= 4.12). Compared to healthy subjects, the radius of body sway of amputees at the static tests was significantly higher. The Romberg-quotient of amputees was higher compared to the control group, but unilateral and bilateral amputees were not different. Regarding the success of the feed-back test, the control group was more effective, but the time was not different. No difference was observed between the unilateral and bilateral amputees (Table 1.)

Table 1: *Results of stabilometry and the fine-coordination*

Variable	Control group N=14	Unilateral amputees N=10	Bilateral amputees N=6	H-value	p-value
	Mean±SEM	Mean±SEM	Mean±SEM		
2O radius	5,6±0,62	10,90±1,69*	9.67±1.05*	13.27	0.001
2C radius	5.6±0.47	13±1.28*	23.83±5.26*	19.87	0.000
RQ	1,47±0,12	2,30±0,31*	2.47±0.42*	10.16	0.0062
Coloration succes%	62.87±2	55.33±3.06 (N=9)*	45±4.5*	1.04	0.002
Coloration time%	87.47±2.62	90.78±1.91 (N=9)	94,33±1,87	12.36	0.60

*Significant difference in comparison with control group

DISCUSSION

In accordance with earlier studies, we experienced that compared to healthy subjects, the amputees' body sway was increased. Furthermore, the visual information played a crucial role in the postural control, similar to the results of earlier studies (2, 5). Unilateral and the bilateral amputees' visual dependence and the radius of his body sway did not differ, in spite of the fact that the bilateral deficiency caused bigger somatosensory and a movement deficit. The colouration feed-back task (CFBT) was more difficult for the patients, because it required a fine coordination. These fine movements at amputees proved to be most limited, but they did not differ between the two amputated groups. The main result of our examination was that the postural stability, the visual dependence and the fine coordination of unilateral and bilateral amputees do not differ from each other. It seems that the postural stability is not the main reason for impaired rehabilitation results. We suppose that an increased energy need might be responsible for worse treatment outcome. Literature data indicate that the amputee highly depends on the number of limbs and the type of the prosthesis (6-8).

CONCLUSION

Our results point it out, that the reason of bilateral amputees' weaker rehabilitative results not the postural stability. The results with the application of prostheses with smaller energy need can be developed.

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PROSTHETIC RESULTS AFTER AN UPPER AND LOWER LIMB AMPUTATION

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Abstract

The paper deals with prosthetic fitting of twelve patients, out of which seven with lower limb amputation, one with lower and upper limb amputation and four with below elbow amputation, out of which one with bilateral amputation. The patients were fitted with standard prosthetic components and in three patients components were replaced in order to achieve better prosthesis retention, increased ankle mobility and increased standard of fitting and comfort. In all the patients, excellent reintegration into normal living was achieved. The conclusion states that the success of prosthetic rehabilitation does not depend primarily on sophisticated prosthetic components but on the patient's motivation, the level of his activity as well as the knowledge of the rehabilitation team.

INTRODUCTION

The development of sophisticated prosthetic components and high technology brings new tasks concerning the choice and the application of these aids in everyday clinical praxis. Prosthetic fitting and rehabilitation are always individual and aimed primarily at achieving mobility and independence in the activities of daily living. However, it is also necessary to enable the active patients to participate in other activities such as travel, recreation and sports. In the article we showed how this could be accomplished by "standard" prosthetic components combined with high level of patients' motivation and the knowledge/skills of the rehabilitation team.

METHODS AND SUBJECTS

The article deals with prosthetic fitting in twelve patients, out of which seven with lower limb amputation, one with lower and upper limb amputation and four with below elbow amputation, out of which one with bilateral amputation. The patients are fitted with standard prosthetic components and in three patients components were replaced in order to achieve better prosthesis retention, increased ankle mobility and increased standard of fitting and comfort.

The results of their mobility and reintegration are shown in a film in order to document prosthetic fitting, mobility and reintegration into normal living.

RESULTS

All the patients daily use their prostheses, they are fully reintegrated into normal living, i. e. their level of activity is high in the social, recreational and professional field. Otto Bock modular prosthetic components were used.

Lower extremity prostheses

1. An 11-year-old boy. A transtibial prosthesis made from carbone fiber and a Dynamic foot (1D10) are fitted. Activities: tennis and horseback riding.

2. A 54-year-old man, a clerk. A transtibial prosthesis is fitted: a titanium tube and a Greissinger Plus foot (1A30). High level of activity is achieved.

3. A 56-year-old man, a machinist. After twenty years of standard prosthesis with SACH foot use due to a short stump, a silicon-liner with pin screwed to the shuttle lock and a Dynamic foot is fitted. Excellent prosthesis retention, improved walking and increased level of daily activities.

4. A 40-year-old man, a war veteran. A standard below-knee prosthesis and a Greissinger Plus foot (1A30) are fitted. Increased walking time and the level of daily activities are achieved.

5. A 76-year-old woman, a retired teacher. Low activity, geriatric fitting. Moderate functional level, i. e. mobility inside the house and around the yard, consistent with the patient's age, is enabled.

6. A 26-year-old woman, a final year student of two faculties. A transfemoral prosthesis is fitted: a knee joint with constant friction and extension assist and a Dynamic plus foot. A prosthesis for shoulder disarticulation is also fitted: a Myohand Digital Twin and a myoelectric Hosmer

elbow. A very demanding prosthetic fitting process and a complex rehabilitation resulted in excellent reintegration into normal living.

7. A 62-year-old man, a retired driver. A hip disarticulation prosthesis is fitted. A knee joint with constant friction and extension assist and a Dynamic plus foot. Good mobility and excellent dynamics of walking are achieved.

8. A 27-year-old man, a computer programmer. A transfemoral prosthesis is fitted: an electronic C-Leg knee joint system and a 1C40 C-Walk foot. Excellent walking and comfort are achieved. Activities: car racing.

Below-elbow prostheses

1. A 18-year-old man, a student. The first trial of alignment and functioning of the Myoelectric hand prosthesis was done. A prosthesis for elbow disarticulation and a myohand Digital Twin are fitted.

2. A 60-year-old man, a chemistry engineer. A prosthesis for elbow disarticulation and a Myohand DMC are fitted. Activities: handwriting.

3. A 54-year-old man, a machinist, retrained as computer operator. A bilateral myoelectrically controlled below-elbow prosthesis is fitted. Activities: morning hygiene (teeth, shaving).

4. A 51-year-old man, an economist. A myoelectrically controlled below-elbow prosthesis and a Myohand DMC are fitted. Activities: gardening (lawn mowing).

DISCUSSION

A number of patients, in consistence with their age, activity level and profession, can use their prostheses in all the fields of family life, recreation and sports. In these patients it is possible to individually apply all available prosthetic components. In our case, the components were replaced in only three patients (no 3, no 4 and no 8) with lower extremity prostheses in order to achieve better prosthesis retention, increase ankle mobility, walking and comfort. We believe that it is necessary to replace prosthetic components when this procedure allows to eliminate imperfections or an error in the choice of prosthesis as well as to increase the level of activity. However, we think that the choice of a component is not a predictor of successful reintegration into normal living.

The key to a successful prosthetic rehabilitation is not the prosthetic component but the patient's motivation as well as the knowledge and skills of the rehabilitation team.

CONCLUSIONS

High rehabilitation and prosthetic goals can be achieved by high motivation and collaboration with the patient. The key to a successful reintegration into normal living does not lie in sophisticated prosthetic components but in the knowledge and the skills of the rehabilitation team, in which the patient plays the major and active role. Medicine and technology have their own tasks aimed at achieving the same goal.

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RISK OF CARDIOVASCULAR COMPLICATIONS DURING WALKING WITH ABOVE-KNEE PROSTHESIS IN ELDERLY PERSONS

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Abstract

A decision for above-knee prosthetic fitting in elderly patients suffering from numerous comorbidities is often difficult to make. The study included 40 subjects with above-knee amputation older than 65 amputated due to vascular atherosclerosis or diabetic angiopathy. Before the discharge, the 6-minute walking test was performed with above-knee prosthesis and walking aids used during the training. By means of telemetry, continuous monitoring of the following was performed: ECG (12 channels), VO2, VCO2, BF, VE, RER (Oxicon mobile - Jaeger). In elderly patients with generalized atherosclerosis, the risk of cardiovascular complications during training and walking with prosthesis is very high. For the sake of prevention of the latter, exercise stress testing up to submaximal heart frequency is essential and is one of the important criteria in deciding for above-knee prosthetic fitting.

INTRODUCTION

A decision for above-knee prosthetic fitting in elderly patients suffering from numerous comorbidities is often difficult to make.

From the viewpoint of safety and prevention of sudden cardiac events, it is essential to know the patient's cardiorespiratory response to ambulation effort.

The data on the energy cost of walking with an above-knee prosthesis in elderly persons are very scarce. The measured oxygen uptake(VO2) in slow, short-distance walking is low. When taking into account the distance walked, the values of the energy cost are very high compared to regular walking (1).

Due to comorbid cardiovascular diseases, the occurrences of clinical symptoms of coronary ischemia or heart failure are frequent (2, 3).

The aim of our study was monitoring of metabolic parameters and heart function with simultaneous ECG in order to determine heart rhythm disorders or coronary ischemia in walking with above-knee prosthesis, defining the energy cost and the required cardiac capacity for walking and confirming the need for exercise stress testing before starting rehabilitation programs.

METHODS AND SUBJECTS

Methods

Before the discharge, the 6-minute walking test was performed with above-knee prosthesis and walking aids used during the training. The subjects walked down a corridor on a level surface. The walking speed was determined individually by each subject. They were allowed to take rests during walking.

By means of telemetry, continuous monitoring of the following was performed: ECG (12 channels), VO2, VCO2, BF, VE, RER (Oxicon mobile - Jaeger).The energy cost was calculated in regard to the distance covered.

Before and after walking, blood pressure values were measured in the sitting position with a quicksilver manometer.

The patients were divided into 4 groups according to sex and the type of walking aids used during walking.

Subjects

The study included 40 subjects with above-knee amputation older than 65. The causes of the amputation were vascular atherosclerosis or diabetic angiopathy. The patients were admitted to the Institute for Rehabilitation, Republic of Slovenia, for primary rehabilitation in 2007.

They were included into standard rehabilitation programs.

Prior to starting the programs, submaximal exercise stress testing was performed on a manual bicycle according to the protocol of discontinuous stressing.

The patients were fitted with above-knee prosthesis with plastic sockets and locked knees. They took part in gait training.

RESULTS

The study included 40 subjects over 65 years old, who had been fitted with above-knee prosthesis with a locked-knee mechanism. There were 18 female and 24 male subjects. The average age was 71.5 ±7.5 years. The women were 73.4 and the men 71.3 years old on average.

All the subjects were included into rehabilitation programs for the first time; the duration of the programs was 32 days on average.

Twenty-five (62.5%) of the patient had been treated for diabetes, 5 patients had ECG criteria for myocardial infarction, 2 patients underwent myocardial revascularization, 1 patient had suffered stroke with good neurological restitution. Twelve (30%) patients took medications for coronary disease.

Twelve (30%) patients used a walker (5 female, 7 male), 28 (71%) used two crutches (11 female, 17 male).

All the subjects performed the 6-minute walking test.

Table 1: *Results of 6-minute walking test and energy cost during walking*

	Male		Female	
	Crutches	Walker	Crutches	Walker
Average (years)	70.8	71.3	73.3	73.6
Distance (m)	99.9	65.7	65.7	49.9
Oxygen cost VO2 ml/kg/min	11.55	10.15	10.5	9.1
Velocity m/min	16.6	10.9	10.8	8.3
RER	0.9	0.88	0.92	0.88
Energy cost ml/kg/m	0.69	0.93	0.97	1.09

Two patients in the group using crutches for walking took medications affecting heart frequency. Among the 26 of the remaining patients, the average increase of the heart frequency was 84.8% of the expected maximal age-related frequency.

In four patients heart rhythm disorders were detected (SVES and VES), three had chronic atrial fibrillation and ischemic changes were shown in one patient.

Among the 12 patients who walked with crutches, 6 took beta blockers due to IBS, in 3 patients heart frequency during walking was over 82.1% of the expected age-related frequency. In three patients, coronary ischemia criteria were observed and heart rhythm disorders were shown in 2 patients (VES).

The differences between the measured values of the systolic blood pressure before and after walking were 29.6 mmHg on average (from 10 to 75 mm Hg). In five patients from the first group blood pressure exceeded 200 mmHg after walking.

In the second group, the average increase in blood pressure was 55 mmHg (from 30 to 80 mmHg). The blood pressure reached over 200 mmHg in as many as 7 patients.

DISCUSSION

Elderly persons with above-knee amputations are mainly able to walk slowly at short distances. In 6 minutes, longer distance was covered by male subjects using either crutches or a walker. In the groups of male and female subjects, those that used walkers were older.

At shorter distances, the oxygen consumption was lower in female subjects.

The energy cost was very high in all the four groups. Walking with a walker demanded the highest energy expenditure. The patient in the group using a walker had the largest number of comorbidities. The walkers had been prescribed since the patients were less secure in walking and had more balance problems. Lower walking economy was therefore understandable.

In the majority of the patients who did not take chronotropic medications, the measured heart frequency during walking was over 80% of the expected age-related frequency. In addition, heart rhythm disorders and/or coronary ischemia were registered in 13 patients.

Significant increase of systolic blood pressure during walking requires good regulation of blood pressure which is sometimes difficult to achieve in patients with multiple comorbidities.

All the measured values confirm the fact that walking with above-knee prosthesis requires adequate heart capacity.

CONCLUSION

In elderly patients with generalized atherosclerosis, the risk of cardiovascular complications during training and walking with prosthesis is very high. For the sake of prevention

of the latter, exercise stress testing up to submaximal heart frequency is essential and is one of the important criteria in deciding for above-knee prosthetic fitting.

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CROATIAN ATHLETICS PARALYMPIC TEAM PROSTHETICS - HI TECH FOR THE TOP RESULTS

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Abstract

In the modern Paralympic amputee athletics, prosthetics is one of the key factors for success. A time of the devoted "solo players" has definitely past. Only coordinated team work of the athlete, coaches, prosthetists, physiotherapists, physicians and other team members, using all procurable and permitted technologies may lead to the amputee athlete highest achievement - competing on the Paralympic Games. Project of prosthetic fitting of the Croatian Athletics Paralympic team members has the aim to ensure adequate prostheses for higher results.

INTRODUCTION

Every active prosthetic fitting is a tempting challenge. Goals are now far beyond only walking, jogging and recreational sports. Lot of active amputees are practicing some kind of sports, but, as with the able bodied athletes, only few of them can materialise every athlete dream - competing on the Olympic - Paralympic Games. Project of prosthetic fitting of the Croatian Athletics Paralympic team members has, somehow, begun almost ten years ago when Croatian Athletics Paralympic team, for the first time ever, had prosthetist among them. Official begging was after the International Paralympics Committee World Championship 2006. We have set the ultimate objective to ensure competent prosthetic fitting for amputee athletes to grant them good basis for training and reaching highly set entry level standards for Paralympic Games in Beijing 2008.

SUBJECTS AND METHODS

Amputee athletes, trainers, selector and team prosthetist realised that present prostheses are limiting possible better results. Target group for the new specialised sport prostheses fitting where chosen from all amputee team members according to their results and capabilities.

Project and study of sport prosthetic fitting was approved and in majority funded by the Ministry of Family, Veterans' Affairs and Intergenerational Solidarity of the Republic of Croatia, in cooperation with Croatian Paralympics Committee, Croatian Athletics Federation for the Disabled and orthopaedic company OTOS Ortopedska tehnika d.o.o. from Osijek, Croatia.

Subjects

For sport prosthetic fitting has been chosen three athletes: one female and two males. Female athlete has long and successful paralympic athletics history. She has congenital longitudinal femur deficiency and was fitted with orthoprostheses. Both male athletes are war time amputees, one transtibial and other transfemoral having thriving disabled athletics careers. All of them are competing in field events - throwing. According to International Paralympics Committee Athletics Classification rules female athlete is functionally classified as a transfemoral amputee, while classification of male athletes is clear due to amputation level.

Female athlete's orthoprostheses had poorly fitted socket, foot with insufficient energy return and in total weighted too much. Transtibial amputee had prostheses with PTB socket with soft wall inside socket and carbon fibre foot. Transfemoral amputee was fitted with quadrilateral socket, hydraulic knee and dynamic foot.

Methods

Fundamental prosthetic design targets were to fulfil prostheses role preferably as a sport device, rather than as everyday use prosthesis, even by high active users like amputee athletes. Their athletic discipline is crucial factor in socket design, component choice and manufacturing (1).

Casting new socket for female athlete was the most complicated foreground task with hers orthoprostheses. Morphology, length, and joint range of motion of her malformed leg where extremely demanding for prosthetists casting technique, having in mind necessity of stabilizing her knee joint placed right under the hip joint, to com-

pensate effect of pseudarthrosis in socket and therefore circumduction during ambulance and instability during the throw. Using Novel pliance-RLS™ system for in socket pressure distribution measurement we have optimized fitting of the socket, minimizing tissue stress and relieving pressure points, whilst retaining and improving retention and muscle force management. Final socket was made of carbon fibre with titanium socket adaptor. For the inside soft socket wall we used only 3 mm thin special Shockicel® shock absorption, closed cell material. Foot choice was low profile high activity level carbon foot with triple "Z" shaped shock absorber and floating heel - Freedom Innovations Renegade LP.

For male transtibial athlete we made prostheses with total surface bearing socket with 6 mm Alps gel liner, titanium components, pin and shuttle, and a very high activity level Renegade foot with full length split shank to achieve the highest level of tibial progression.

Ishial containment socket was the choice for transfemoral athlete. We have used our modification of CAT-CAM casting technique. Excessive scar tissue on the distal end of his stump, required use of Alps 6 mm gel ThermoLiner, despite higher socket weight and impulse tempering, which were less important in this case. To achieve shock absorption and facilitate rotation during the throw we used Otto Bock Delta Twist™ shock absorber. Using Delta Twist™ we have simultaneously reduced strain and counteract extreme torsional load specific for the shot put event. Choice for the foot was Revolution Series Renegade foot, having in mind energy redirection and enhanced foot's heel dynamics, to propel the athlete during the final phase of the throw. Question of the knee joint was disputed. We have tried Otto Bock 3R45 titanium polycentric hydraulic swing phase control knee, which is the common choice for the sprint, long jump, discus and javelin throw events (2). After thoroughly functionally testing, finally we made two variations of prostheses - one with the knee joint - for weight lifting and condition training and the other without knee - for throwing specifically.

RESULTS

We used early pre-season training phase to introduce the new sport prosthetic devices. Following the short initial period of accommodation on using the new sport prostheses, in which athletes showed a slightly lower performance and thrown distances, all three of them started to gain better and better results. Increased ability of basic conditional and power training, combined with the precisely directed strengthening of certain muscle groups improved the features of the prostheses and consequently enhanced athletes performances (3). Adopting individual modified throwing technique assisted athletes in reaching Paralympic entry levels in their events.

DISCUSSION

After first few competitions it was obvious that pure technical improvements of the prostheses would not be right enough to get desired results, without targeted athlete's development in strength and perfecting event technique. Lack of literature and educational resources in top athletics throwing events prosthetics pushed us to use "try and cry" methods in prostheses alignment. We used KineView 3.1 motion analysis system to get simple and efficient tracking, movement report, and velocity and acceleration calculations. KineView, combined with Novel pedar-x™ in shoe pressure distribution measurement system and pliance-RLS™ system validated fine tuning of throwing technique sequence of movement and comparison of amputee athlete technique with the able bodied athlete technique. All measurements, analysis and everyday observations showed that all athletes need quite frequent adjustments and corrections of the prostheses as they learn and train to gain more dynamics for better results.

Only comparison in sport is the result - centimetres, or seconds, all the same! All three newly fitted athletes significantly improved their personal best results and achieved high International Paralympics Committee rankings in 2007 in their events and qualified for Paralympic Games in Beijing 2008.

CONCLUSION

Long practical experience of prosthetist, trainer engagement in disabled and able bodied athletics, specialised physiotherapists and athlete's commitment are essential for reaching the highest level of competition. Pre established and adopted knowledge and experience of whole team are only partially enough to manufacture the best possible prosthesis. Load structures generated in competitive sport prosthetics are something completely different from the everyday prosthetics. Using hi-tech diagnostics, measurement, components and manufacturing technologies can boost athlete's sport prosthetics fitting outcome. Only very close continuous joint efforts of the athlete, trainer, physiotherapist and prosthetist may open brave new perspectives in sport prosthetics reaching the highest paramount of Olympic motto: Citius, altius, fortius!

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INVALIDISATION AND THE ABSENCE OF ALL OR PART OF A LIMB IN THE REPUBLIC OF SLOVENIA

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ABSTRACT

The carrier and provider of disability and pension insurance in Slovenia is the Pension and Disability Insurance Institute of the Republic of Slovenia, within which the Medical Assessment Division and its Medical Assessment Services of First and Second Degree operate. These include first and second degree disability boards. According to Slovene legislation, the definition of disability takes into account the totality of general and occupational work capacities of insured persons, including a combination of medical and non-medical criteria which are checked in expert procedures before disability boards. Disability is classified into three disability categories. Between 2003 and 2007, first and second degree disability boards examined 205,460 disability assessment proposals. Of the 166,961 cases considered by first degree disability boards in this period, 90 disability assessments (0.05 %) were issued due to the absence of all or part of a limb.

INTRODUCTION

Limb absence is one of the rarer reasons for submitting a disa-bility assessment proposal and for claiming disability insurance entitlements. The Pension and Disability Insurance Institute of the Republic of Slovenia is one of the pillars of social insur-ance. It is based on a system of reciprocity and is in charge of implementing disability insurance rights (1). Disability boards play quite an important role in this. Due to the absence of all or part of a limb, 90 disability assessments, which is 0.05 % of all disability assessments, were issued according to the new legislation in the period between 2003 and 2007.

THE ORGANIZATION OF DISABILITY AND PENSION INSURANCE IN SLOVENIA

The Pension and Disability Insurance Institute of the Republic of Slovenia is one of the pillars of social insurance, in charge of implementing disability insurance rights. It includes disability boards as expert bodies that give evaluations of disability of insured persons in the form of expert opinions (2-4). On 1 January 2006, the Medical Assessment Division was established within the Institute, consisting of the Medical Assessment Service, First Degree, Ljubjana, the Medical Assessment Service, First Degree, Maribor and the Medical Assessment Service, Second Degree, Ljubljana. The Medical Assessment Service, First Degree, Ljubjana consists of First Degree Disability Boards Ljubljana, Trbovlje, Kranj, Jesenice, Novo mesto, Nova Gorica and Koper. The Medical Assessment Service, First Degree, Maribor consists of First Degree Disability Boards Maribor, Celje, Murska Sobota and Ravne na Koroškem. The Medical Assessment Service, Second Degree includes second degree disability boards (1, 2).

LEGAL BASIS

The first paragraph of Article 60 of the Pension and Disability Insurance Act states that disability shall be ascertained if, due to changes in health condition that cannot be reversed by treatment or measures of medical rehabilitation and have been ascertained pursuant to the present Act, the capacity of an insured person to secure or keep a job or to advance in their career has been reduced (1).

The definition of disability takes into account the totality of general and occupational work capacities of insured persons. It is a combination of medical and non-medical criteria which are checked in expert procedures before disability boards. When ascertaining disability, it is important that, prior to the disability assessment, the Institute's expert body - the disability board - ascertains whether the treatment or medical rehabilitation has been completed. The causes of disability can be on-the-job injury, occupational disease, off-the-job injury and illness (2-4).

DISABILITY CATEGORIES:

There are three disability categories:

- The first disability category includes insured persons who are no longer capable of performing gainful work

or have an occupational disability and no remaining work capacity.
- The second disability category includes insured persons whose work capacity for their own occupation is reduced by 50 per cent or more which means that the insured person has a limited or reduced occupational disability. The second disability category entails the right to occupational rehabilitation. Entitled to occupational rehabilitations are insured persons under the age of 50 whose remaining work capacity enables training for full-time work. Occupational rehabilitation also includes workplace adaptation so that the insured person can perform their job full-time without the danger of their basic disease worsening. If the insured person is not capable of performing another appropriate work without occupational rehabilitation and is older than 50 years, they are entitled to the rights determined by the first disability category.
- The third disability category includes insured persons who have a reduced capacity for work to which they are assigned or who, with or without professional rehabilitation, are no longer capable of full-time work but can perform certain work at least part-time, or who can still work in their profession full-time but cannot perform the work to which they are assigned (1).

ANALYSIS OF DISABILITY ASSESSMENT PROPOSALS PROCESSING IN THE PERIOD BETWEEN 2003 AND 2007

In analysing disability assessments of employed insured persons by first degree disability boards, we reviewed the disability boards' archive for the period between 2003, when the last reorganization of the Institute and the last changes of legislation took place, and 2007. We retrospectively established how many cases were classified into the first, second and third disability category due to limb absence, in a particular year and in the whole period. At the same time, we examined the frequency of issued disability assessments by gender, education and the work that the insured person was performing (5, 6).

Of all 166,961 the cases considered by first degree disability boards in the period between 2003 and 2007, 90 disability assessments (0.05 %) were issued due to the absence of all or part of a limb (6).

When considering proposals for a disability assessment of insured persons with limb absence, disability boards pay special attention to the functional status of the insured person described in specialists' findings. In the assessment process, one needs to take into account the flexibility and the possibility of straining a particular part of the body that will not lead to the worsening of the insured person's health condition and their capacity to perform a certain work process.

In view of the issued disability assessments due to limb absence in 2007, the majority of considered insured persons were male, the cause being disease. Education-wise, unskilled workers were at the top with 25%, followed by skilled workers with 22.22% and highly educated workers with 5.55%.

Between 2003 and 2007, 44 cases were classified into the first, 13 into the second and 33 into the third disability category due to limb absence, which is 48.88%, 14.44% and 36.66% of all cases classified into disability categories due to limb absence respectively.

According to the international classification of diseases (ICD 10), the greatest number of ascertained disabilities in all three disability categories belonged to Z89.5 (acquired absence of leg at or below knee), followed by Z89.6 (acquired absence of leg above knee) and Z89.2 (acquired absence of upper limb above wrist).

In disability assessments due to limb absence, the reason for the classification into the first disability category was most frequently Z89.5 (acquired absence of leg at or below knee), followed by Z89.6 (acquired absence of leg above knee) and Z89.7 (acquired absence of both lower limbs). The most frequent reason for the classification into the second disability category was Z89.5 (acquired absence of leg at or below knee), followed by Z89.2 (acquired absence of upper limb above wrist). The third disability category was ascertained most often due to Z89.5 (acquired absence of leg at or below knee), followed by Z89.6 (acquired absence of leg above knee) and Z89.4 (acquired absence of foot and ankle).

CONCLUSION

In analysing disabilities ascertained for employed insured persons, we found that the majority of disability assessments were issued to male insured persons and that, education-wise, most persons considered by disability boards due to limb absence were unskilled and skilled workers. The most common causes of limb absence were disease and injury. Limb absence due to occupational diseases in the sense of the Rules on the List of Occupational Diseases (Official Gazette of the RS, no. 85/03) was not ascertained as a reason for disability by the expert bodies of the Institute.

Bibliography:

1. Pension and Disability Insurance Act ZPIZ-1-UPB2/ (Official Gazette of the RS, no. 106/99 including amendments).

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PROPERTIES OF PROSTHETIC FEET - A COMPARISON STUDY

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Abstract

The mechanical properties of prosthetic feet influence stance safety, foot rolling and step length of prosthesis-wearing persons with upper or lower leg amputations. Twenty different commonly used prosthetic feet from different manufacturers with the same size were tested according to impact absorption, energy storage and "rolling" motion of the foot (meaning the deformation of the foot during a normal stance phase cycle) with standardized comparative measurements. Bending moments as well as deformations occurring during the movement are recorded with force sensor and kinematics, evaluating the 'rolling' motion behaviour of the prosthesis foot. These results of measurements allow a characterisation of the prosthesis feet regarding their behaviour at heel strike, the transition from initial contact to mid-stance and from mid-stance to toe-off as well as forefoot support at toe-push off. This makes it possible to describe four different characteristics of one prosthesis foot. These characteristics can be described by a person and make it easier to find a fitting foot.

INTRODUCTION

Some people tend to walk, while others tend to stand. Do they both have the same requirements concerning their prosthesis foot? Or is it possible that the diversity on the market allows us to endure the needs of each individual and find a perfect fit? Various feet were tested to find out whether these differences are objectifiable.

METHODS AND SUBJECT

For the determination of the characteristics relevant for walking and standing each prosthesis foot is tested both statically and dynamically. During the static test the foot is set on a wedgeand semi-statically loaded and unloaded. For the dynamic measurement the prosthetic foot is dropped under weight load using a linear guidance to impinge on a wedge and the developing oscillation is analyzed.

Figure 1: *Testing device foroscillation response of the heel*

Methods

The testing device (Fig. 1) consists of a vertical linear guidance equipped with a distance meter. At its lower end a pyramid adapter for the fastening of prosthetic feet is mounted with a 3-dimensional force sensor.

For the dynamic measurement the prosthetic foot is dropped under weight load from a height of 34mm successively on two surfaces according to ISO standards. The developing oscillation after the impact is evaluated kinematically and kinetically (Fig. 2). This gives an understanding of the impact absorption, the spring characteristics and the energy efficiency characteristics of the foot. For the measurement of the heel, the foot 'falls' on a wedge with 15% inclination. For the measurement of the fore foot characteristic on a wedge with 20% upward gradient.

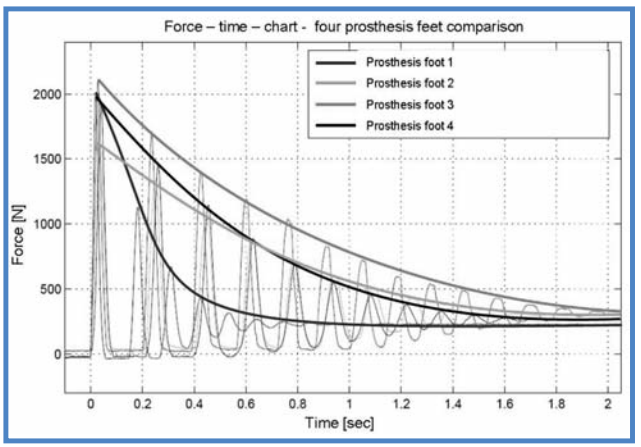

Figure 2: *Force signal at heel strike of four different prosthetic feet*

For the static measurement the prosthetic foot is placed on the ground under weight load with a lower leg vertical angle of -20° (heel strike at initial contact). Afterwards it is rolled under weight load forward to a lower leg vertical angle of +40° (toe off). This corresponds to the stance phase according to ISO standards 22675 and supplies the `rolling' motion curve of the prosthetic foot (Fig.3).

Figure 3: *Static measurement - result of the 'rolling' motion test - comparison of two different prosthetic feet*

Subjects

20 prosthetic feet from different manufacturers, with different activity classes and the same shoe size. The measurement results represented here show the anonymous results of the following prosthetic feet: E-Med Tres Dynamic Foot, Bauerfeind Elite, Otto Bock Trias, Medi Pro Flex VLB

RESULTS

Another possibility to display the results of the 'rolling' motion test is to compare different feet at different loads at a specified vertical angle (Fig. 4)

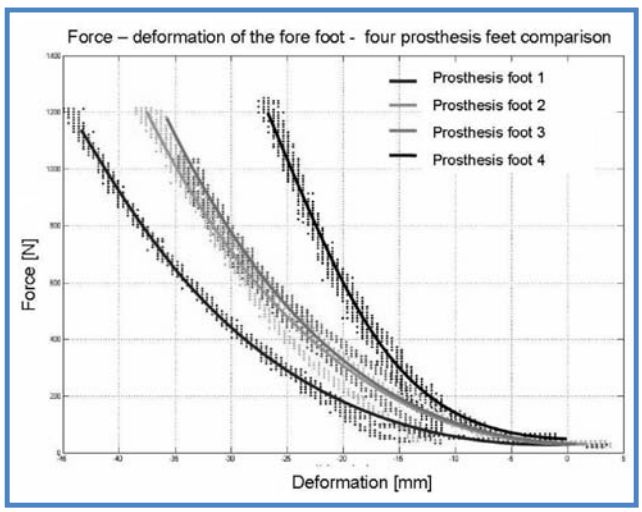

Figure 4: *Static measurement of four different prosthetic feet on a wedge with 20% upward gradient*

DISCUSSION

The results show significant differences between prosthetic feet of the same activity class. Therefore it seems to be necessary to find a new method for classifying prosthetic feet.

CONCLUSION

The 'rolling' motion of the foot indicates stability during the stance phase as well as stance comfort. It also provides results about the tendency of the lower leg to straighten up after heel contact, and the energy that is needed to bend the fore-foot after mid-stance. The information about the impact behaviour at the beginning of the stance phase (initial contact) and at its end (toe off) also describes two main stance cycle phases. This provides four foot characteristics which a person is able to describe. This enables each person to be equipped with their individually, best suitable prosthetic foot selected from all the measured feet.

References:

1. Major MJ, Twiste M, Kennedy L, Howard D. Quantification of prosthetic foot compliance with application to functional performance: Poster 38, ISPO congress Vancouver 2008.

2. Haberman A, Bryant T, Beshai M, Gabourie R. Mechanical characterization of prosthetic feet: poster ISPO congress Vancouver 2008.

LABORATORY EVALUATION OF AN ENERGY STORING FOOT

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Abstract

The necessary steps of testing and evaluating a new energy storing foot for a manufacturer of prosthetic components. Going from laboratory simulations on equipments following international standards to patient evaluation , these tests lead to a certification by an official body. This certification is the guarantee that performances comply with those announced by the manufacturer.

INTRODUCTION

Manufacturer of Prosthetic components are continuously trying to improve products and innovate to bring more comfort and higher performances to the patient fitted by CPO's. Once a new idea has been found by the R&D Department based on close collaboration with CPO's and patients' feedback, trial products are manufactured. It is time to validate whether the new product is adapted to the needs of the amputees, whether it brings the features expected at time of design and last but not least whether it matches the ISO standard. Following working principles and Laboratory Testing, we will show the methods used and results achieved with the launch of a new Energy Storing foot.

METHODS AND SUBJECTS

Methods

Starting from working principles, we work on several steps:
- Laboratory simulations and tests using sophisticated machines and equipments. The ISO standard 10328 gives the way Orthopaedic products have to be tested
- Patients evaluation using a three-dimensional analysis of the gait pattern and field testing
- A certification by an official national agency which guarantees independently that the performances announced by the manufacturer are correct. The example of the French Classification system will illustrate the way products are certified.

Subjects

The product which is tested for evaluation before certification and launch on the French and on international markets is an energy storing foot made of composite fibers. For our case, according to the ISO standard, we took a prosthetic foot, size 27 to be used by an amputee of 80 kg walking faster that 4,5 km/h with high physical activities.

RESULTS

Working Principles of an Energy Storing Foot have lead the manufacturer in its research and design. :
- The energy stored during Heel Strike is released during Rollover and Toe-Off.
- The warping of the composite fibre structure allows dampering at heel strike and then propulsion at Toe Off.
- The split keel provides balance and stability during the gait cycle.
- Energy Storing foot offers 20 % reduction of fatigue for the disabled compared to a standard Sach Foot. This contributes to a faster and easier walking space.

The understanding of the gait cycle will also help to analyse the benefits of the foot for the amputee and compare it with other feet. The gait is split between the following steps: 60 % stance phase including double stance phase (20%) and 40 % swing phase.

The Stance phase itself is split into 4 steps as far as percentage of time with floor contact for each gait phase:
- Heel Strike: 0 - 10%
- Midstance: 10 - 30 %
- Transfer to the forefoot: 30 - 50%
- Propulsion: 50 - 60 %

Laboratory Testing:
For our case, according to the ISO standard, we took a prosthetic foot, size 27 to be used by an amputee of 80 kg walking faster that 4,5 km/h with high physical activities.

The ISO standard specifies procedures (Figure 1) for tests and defines values to be reached (Figure 2):
- Structural Test : static tests to the limits of the foot.

- Cyclic Test: repeated tests to duplicate in millions time the constraints the foot will suffer during its life by accelerating the number and frequency of these constraints. Two feet must go through 2 millions cycles each of pressure applies at the toes and at the heel simultaneously.

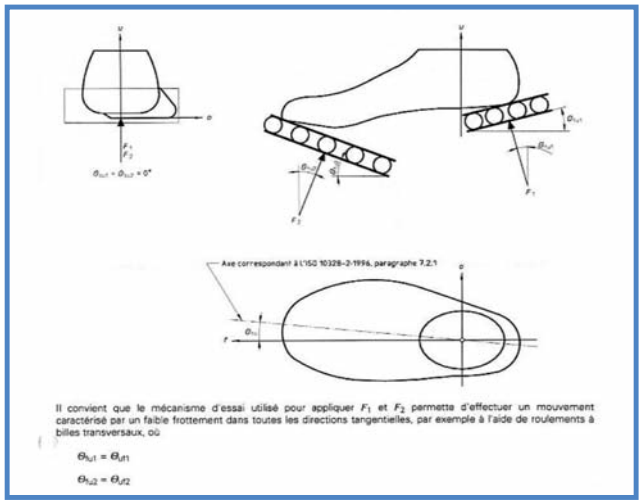

Figure 1: *Cyclic test on ankle foot devices and foot units*

Test forces of all separate tests on ankle-foot devices and foot units and prescribed number of cycles of the cyclic test – (see 17.2)

Test procedure and test load				Test loading level (P_x) and test loading condition (F_{1x}; F_{2x})					
				P5		P4		P3	
				Heel loading, F_{1x}	Forefoot loading, F_{2x}	Heel loading, F_{1x}	Forefoot loading, F_{2x}	Heel loading, F_{1x}	Forefoot loading, F_{2x}
Static test procedure	Proof test force	F_{1sp}, F_{2sp}	N	2240	2240	2065	2065	1610	1610
	Ultimate static test force	$F_{1su,\ lower\ level}$, $F_{2su,\ lower\ level}$	N	3360	3360	3098	3098	2415	2415
		$F_{1su,\ upper\ level}$, $F_{2su,\ upper\ level}$	N	4480	4480	4130	4130	3220	3220
Cyclic test procedure	Minimum test force	F_{1cmin}, F_{2cmin}	N	50					
	Cyclic range	F_{1cr}, F_{2cr}	N	1280	1280	1180	1180	920	920
	Maximum test force	F_{1cmax}, F_{2cmax} $F_{xcmax} = F_{xcmin} + F_{xcr}$	N	1330	1330	1230	1230	970	970
	Mean test force	F_{1cmean}, F_{2cmean} $F_{xcmean} = 0,5\ (F_{xcmin} + F_{xcmax})$	N	690	690	640	640	510	510
	Cyclic amplitude	F_{1ca}, F_{2ca} $F_{xca} = 0,5\ F_{xcr}$	N	640	640	590	590	460	460
	Final static force	F_{1fin}, F_{2fin} $F_{xfin} = F_{xsp}$	N	2240	2240	2065	2065	1610	1610
	Prescribed number of cycles		Cycles	$2 \cdot 10^6$					

NOTE For the additional test loading level P6 the values of the test forces and the prescribed number of cycles are specified in Table D.3 of Annex D.

Figure 2: *Test procedure and test loads*

- Comparison with other products: we judge the energy return performances of a new foot by the comparison with other competitive products.

These tests are in accordance with the ISO standard 10328 used for CE marking.

Equipments used for the laboratory tests:

➔ Certified Testing Machine developed to test feet according to ISO standard requirements.

➔ Software Cosmos Works Advanced Professional Software offers boundless possibilities to test virtually on computers the foot by applying local constraints on specific areas.

French Classification System of an energy return foot:
A classification system has been set up in 2000 to assist CPO's and doctors to select the right energy return foot depending on the patients' needs and capabilities. It defines also the level of reimbursement for each Energy Return Foot according to its class. It acts as a selection guide for the Orthopaedic Industry in France.

Three classes are defined:
Class I: between 50 and 100 points
Class II: between 100 and 150 points
and Class III: above 150 points

The higher is the class, the higher are the results in terms of energy return. Class III feet will be restricted to active patients.

The points are given after technical evaluation made by an independent laboratory. The process of the evaluation has been fixed to measure mainly following criteria:
- Energy stored at heel strike by the heel blade.
- Energy released by the heel blade at toe off.
- Distortion of the heel blade.

The measures are made for a foot size 27, for a patient of 80 kg, corresponding to the recommendations of ISO standard.

The results for the smallest size foot and highest modules must be with +/-10 % of the results of the foot size 27 selected for the tests.

Patients Evaluation & Analysis:
In addition to the tests in laboratory, we fitted an AK patient with the foot and positioned light reflecting markers. His walking cycle was filmed by 7 infrared cameras. Down forces are recorded for the healthy and for the prosthetic leg.

Data recorded:
- Duration of the various gait cycle
- Length of the step
- Force applied on the prosthetic foot

These data are studied and used to draw up the technical notice of the new foot and alignment advices to optimize the use of the Energy Return Foot.

DISCUSSION

The ISO standard defines the way to test products and values to be reached before a product is fitted on patients. National

standards such as the French standard offer on their side a way to classify products in order to set up a selection guide for national health bodies and for the CPO's. Additional tests set up by the manufacturers such as tests on patients with three-dimensional analysis are necessary to compare and improve comfort and performances.

CONCLUSION

The interest of a fabrication in Composite Fibre has been confirmed by the laboratory and patient tests. These tests have helped to optimize the design and resistance of the foot which has been launched in 8 sizes, 2 sides and 5 modules depending on the activity level and weight of the patient.

References:

1. ISO standard 10328

THE DESIGN, DEVELOPMENT AND MECHANICAL TEST OF A LOW COST PROSTHETIC FOOT ACCORDING TO ISO 10328 STANDARD

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Abstract

The prosthetic feet currently in use in developing countries have inadequacies concerning durability. The purpose of this project was to design and develop a low cost prosthetic foot, suitable for use in developing countries, and test it to ISO standards as part of the new product development process. Static and dynamic tests carried out on the foot were successful in both the heel strike and toe off loading conditions. The inclusion of functional testing during the design process has led to the development of a foot that is suitable for use in both the developed and developing world.

INTRODUCTION

Jensen has recommended that it would be useful to test a new foot design to ISO 10328 before releasing it in both the developed and developing world (1). A new prosthetic foot was designed such that the structural element within the foot, the keel, forms the foundation of the entire foot component. Its shape, material and reinforcing components have been optimised using finite element analysis to ensure that it can provide robustness, functionality and affordability. The keel was manufactured using prototyping techniques to enable functional testing, in accordance with ISO 10328, to be carried out.

METHODS AND SUBJECTS

For the purpose of all static testing, and cyclic testing in the heel strike condition only, a keel was manufactured in a polypropylene substitute resin using the vacuum casting technique. For cyclic testing in the toe off condition, a keel was machined in polypropylene. Reinforcing materials were added to complete the foot component. The centreline of each foot was turned out by 7° and both feet were mounted to plates so that they could be fixed in an angular vice. For the position of heel strike, the foot was loaded at the heel at an angle of 15°, and for toe off the foot was loaded at the forefoot at an angle of 20°.

For the static proof tests, the feet were mounted to an Instron universal test machine and loaded to the proof test force of 1610N for 30sec. For the cyclic tests, each foot was cyclically loaded between 50N and 970N for 2 million cycles using a Zwick test machine.

RESULTS

For the static proof test in the condition of heel strike, the Instron overshot the required 1610N force and loaded the foot to 2100N. Loading was reduced to 1610N and held for 30s. During this time a maximum deflection of 2.5mm was recorded and no damage occurred.

In the condition of toe off, the foot was able to sustain the 1610N for 30sec without failure. The maximum extension was 18.9mm, shown in Figure 1.

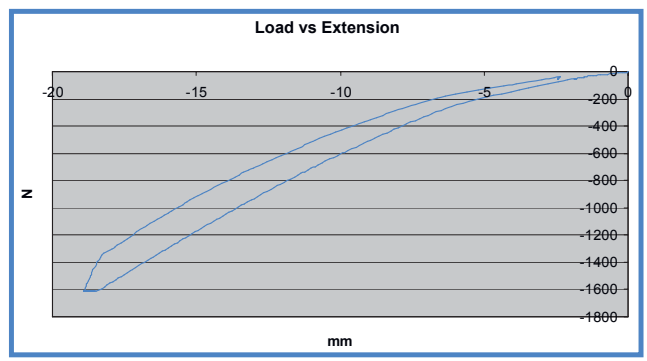

Figure 1: *Load versus extension plot for the static proof test in the toe off condition*

Both feet successfully completed cyclic testing to 2 million cycles. No damage was observed under the condition of heel strike. Figure 2 shows the stroke versus load pattern for heel strike. In the condition of toe off, there was an element of wear in the areas of contact between the components in the foot.

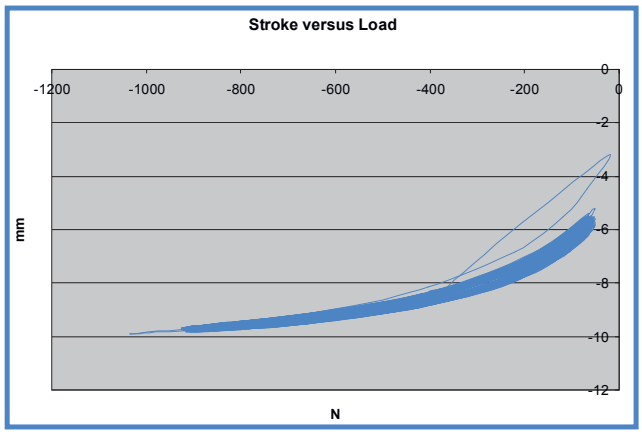

Figure 2: *Stroke versus load plot for the cyclic test in the heel strike condition*

DISCUSSION

Vacuum casting is a rapid tooling process that can be used to produce homogeneous products suitable for mechanical testing (2). This process was used for the fabrication of a keel so that it could be fully evaluated in terms of performance and manufacturability before committing to expensive tooling. The cast foot passed the static proof test in both loading conditions, and the cyclic test under the condition of heel strike.

A foot was machined in polypropylene for the purpose of cyclic testing in the toe off position. This is because previous experience has shown that the vacuum cast feet do not have the required durability under this condition. It is considered that the element of wear present during the toe off fatigue test may have resulted from the contacting components in the foot creating an abrasive surface. Inclusion of the keel in a foot shell infiltrated with foam should prevent this type of wear occurring.

CONCLUSION

A new prosthetic foot, suitable for use in low income countries, has been successfully tested to ISO standards. It is anticipated that this foot will address the inadequacies of currently used prosthetic feet in such countries.

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1. Jensen JS, Treichl HB. Mechanical testing of prosthetic feet utilized in low-income countries according to ISO-10328 standard. Prosthetics and Orthotics International 2007; 31(2):177 - 206.

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A COMPARISON OF THE JAIPUR FOOT AND THE SACH FOOT IN TERMS OF SHOCK-ABSORPTION AND FLEXIBILITY

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Abstract

The Jaipur Foot, a prosthetic foot developed in India, was mechanically tested and compared to the Solid Ankle Cushion Heel (SACH) prosthetic foot in order to gain further understanding of the mechanical behaviour of both prosthetic feet designs. The results show that the Jaipur Foot has 94% more effective shock absorption at heel strike than the SACH foot. The Jaipur Foot demonstrated greater dorsiflexion than the SACH foot at toe-off phase. The SACH foot returned more energy when the forefoot was loaded.

INTRODUCTION

The Jaipur Foot is a prosthetic foot invented by the late Dr. PK Sethi and Ram Chandra during the early 1970's. It was designed to withstand rough rural terrain and accommodate Indian culture and customs. It is fabricated from low-cost locally available materials (1). The Bhagwan Mahaveer Viklang Sahayata Samiti (BMVSS), India's largest supplier of the prosthetic foot, state that squatting is possible with the Jaipur Foot, and not the popular SACH (Solid Ankle Cushion Heel) prosthetic foot, as it permits better dorsiflexion.

The overall objective of this study was to determine the mechanical behaviour of the Jaipur Foot under heel-strike and toe-off loading conditions. The specific aims of the study were to a) compare stiffness and shock absorption properties of the Jaipur Foot to the SACH foot, b) determine if the Jaipur Foot permits greater dorsiflexion than the SACH as stated by the BMVSS, and c) the energy returned when loading the forefoot at toe-off.

METHODS

Five SACH feet from International Committee of the Red Cross and nine Jaipur Foot pieces were used for the study; four from BMVSS and five from the Om Centre, Jaipur. The prosthetic feet were tested using a uniaxial tensile\compression testing machine and a rig which allowed a plate to be orientated at various angles, designed in accordance with ISO 10328. The foot was tested in heel-strike and toe-off positions, angled at 15° and 20°, respectively. Realistic forces of 820±16 N and 760±45 N for heel-strike and toe-off, respectively, were applied, as reported by Arya et al. (2) from gait analyses on the SACH foot and Jaipur Foot.

RESULTS

The results for heel-strike and toe-off loading are illustrated in Figure 1 and Figure 2. The energy absorbed and released by the heel was determined by calculating the area of the hysteresis loops of each loading curve. The transfer of energy for heel-strike and toe-off loading is shown in Table 1.

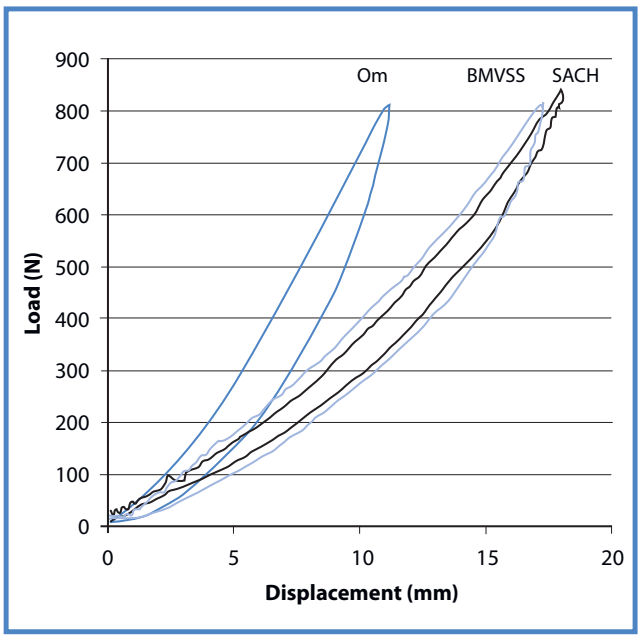

Figure 1: *Heel-strike loading condition*

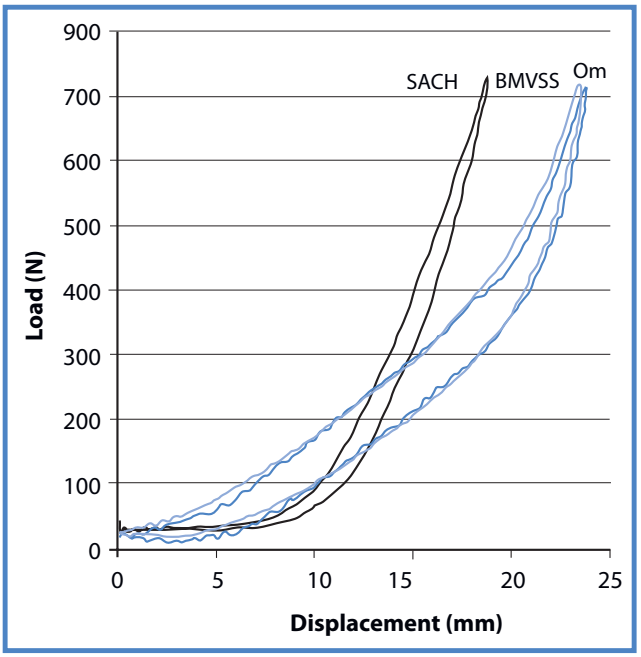

***Figure 2**: Toe-off loading condition`*

***Table 1:** Energy inputted, returned and absorbed by the prosthetic feet for heel-strike and toe-off loading, additionally showing energy absorbed as a percentage of energy inputted*

Heel-strike	Input (J)	Return (J)	Absorbed (J)	Absorbed (%)
Jaipur - BMVSS	6.1 ± 0.2	4.6 ± 0.2	1.5 ± 0.1	24.9 ± 2.0 %
Jaipur - Om	3.9 ± 0.3	2.7 ± 0.2	1.2 ± 0.2	30.5 ± 3.5%
ICRC SACH	6.5 ± 0.2	5.5 ± 0.2	0.9 ± 0.03	14.3 ± 0.4 %
Toe-off				
Jaipur - BMVSS	5.7 ± 0.5	4.2 ± 0.3	1.5 ± 0.2	25.9 ± 1.6 %
Jaipur - Om	5.9 ± 0.2	4.1 ± 0.1	1.8 ± 0.2	29.8 ± 1.3 %
ICRC SACH	3.3 ± 0.3	2.8 ± 0.3	0.5 ± 0.1	16.2 ± 0.7 %

DISCUSSION

The SACH foot and BMVSS Jaipur Foot showed comparable mechanical behaviour at heelstrike loading and proved to be softer at the heel than the Om Jaipur Foot. The mechanical behaviour of the BMVSS Jaipur Foot correlates with that reported by Kabra et al. (1). Both versions of the Jaipur Foot demonstrated a greater capacity to absorb shock than the SACH foot.

The SACH foot demonstrated an overall stiffer forefoot than both Jaipur Foot types for toe-off loading. The Jaipur Foot pieces tested demonstrated greater stiffness compared with that reported by Kabra et al. (1). The SACH foot absorbed the least energy for toe-off loading.

CONCLUSION

The heel properties of the Jaipur Foot were dependant on what centre the foot piece was fabricated at. The Jaipur Foot from the BMVSS demonstrated comparable heel stiffness to the SACH foot. The Jaipur Foot provides greater shock absorption at heel-strike than the SACH foot.

The Jaipur Foot showed consistency between the centres with regard to forefoot properties. Both versions of the Jaipur Foot permit greater dorsiflexion than the SACH foot under the same loading condition, justifying BMVSS's claim. The SACH foot absorbed less energy at toe-off, suggesting a greater transfer of energy from mid-stance to terminal stance.

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1. Kabra SG. Equipment and Methods for Laboratory Testing of Ankle-Foot Prostheses as Exemplified by the Jaipur Foot. J Rehab Res and Dev 1991;28:23-34.

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DEVELOPING A 'PROSTHETIC-KNEE-TEST-TRACK' TO ASSESS FUNCTIONING WITH A MICROPROCESSOR-CONTROLLED PROSTHETIC KNEE-DEVICE IN INDIVIDUALS WITH LOWER-LIMB AMPUTATION

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Abstract

In rehabilitation centres, there is need for a simple and reliable test to demonstrate differences in functioning with a microprocessor-controlled prosthetic knee-device (MPK) compared to functioning with a non-microprocessor-controlled prosthetic knee-device (NMPK). The aim of our study was to develop a Prosthetic-Knee-Test-Track (PKTT) for easy assessment of differences in functioning with MPK versus NMPK. Nine subjects with unilateral lower limb amputation were included in the study. All subjects had sustained experience using both NMPK and MPK. They performed several functional tests with both prosthetic knees. In addition to the test track, all subjects completed a mobility questionnaire. Distinct significant differences were found only for negotiating a slope and a stairway. Other test-conditions could not discriminate reliably between subject's performance with MPK versus NMPK and were excluded from the PKTT. On basis of these results the PKTT exists of a slope and a stairway only.

INTRODUCTION

In rehabilitation centres, there is need for a simple and reliable test to demonstrate differences in functioning with a microprocessor-controlled prosthetic knee-device (MPK) compared to functioning with a non-microprocessor-controlled prosthetic knee-device (NMPK). Moreover, literature lacks studies focusing on proper assessment of functional performance using prosthetic knee devices. The aim of our study was therefore to develop a Prosthetic-Knee-Test-Track (PKTT) for easy assessment of differences in functioning with MPK versus NMPK.

METHODS AND SUBJECTS

Methods

Based on literature information (e.g. 1, 2) we composed a Test Track consisting of several tests, including standing and walking on uneven surfaces, stairs and slopes. Participants were fit with a safety harness (attached to a ceiling rail) during all tests to prevent falling. Subjects performed all tests twice, one time with MPK and one time with NMPK, in random set sequence with ample resting time in between. In addition to the test track, all subjects completed a mobility questionnaire. Main outcome measures were: Balance variables, Timed-Up-and-Go test time, Hill-Assessment-Index score (HAI) and hill ascent and descent time, Stair-Assessment-Index score (SAI) and stairs ascent and descent time; step frequency, zig-zag course step length and walking speed, stepping over obstacles performance, soft surfaces negotiating, walking with a tray performance; Self-Selected-Walking-Speed and maximum walking speed. Daily life representation was determined by comparing the Locomotor Capability Index-5 to the other test results.

Subjects

Nine subjects (8 male, age 39 – 72 years, mean age 52), with unilateral lower limb amputation (5 trans-femoral, 3 knee-exarticulation and 1 hemipelvectomy) were included in the study. All subjects had sustained experience using both NMPK and MPK. The study was approved by the VU University Amsterdam Medical Ethic Committee.

RESULTS

Distinct significant differences were found only for negotiating a slope and a stairway (time and HAI for hills descent, time and SAI for stairs descent). The performance on most other testconditions was somewhat better for subjects using MPK compared to using NMPK, but these differences were not significant due to group variance.

DISCUSSION

Test-conditions that could not discriminate reliably between subject's performance with MPK versus NMPK were excluded from the PKTT.

CONCLUSION

On basis of our results the PKTT (Prosthetic-Knee-Test-Track) needs to consist off a slope and a stairway only.

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PERFORMANCE ON AN OBSTACLE COURSE WITHOUT AND WITH A MENTAL LOADING TASK: A COMPARISON BETWEEN THE C-LEG, THE 3R60 AND THE SNS MAUCH

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Abstract

Using a cross-over design, this short paper presents results of an obstacle course performance evaluation of eleven unilateral transfemoral prosthetics users while subjected to a mental loading task. Participants were fitted with three different knee joints: SNS, C-leg and the 3R60. Performance was assessed using digitized video recording allowing for objective time assessments. Participants completed the course twice: Once without and once with a mental loading task. The task consisted of an arithmetic test. No significant time differences were found to complete the course when comparing the C-leg and the SNS, but differences between the 3R60 and SNS and between 3R60 and C-leg were observed in some sections only, but not on the overall time taken. Further research is needed to test if a different approach and/or different variables can explain the discrepancy between objective observations and literature-reported subjective improvements when using the C-leg.

INTRODUCTION

The C-leg® is considered by many prosthetists and manufacturers to be the leading microprocessor-regulated knee mechanism currently available on the market. What sets it apart from others is its hydraulic knee unit with microprocessor-controlled stance and swing phase damping characteristics that provide monitoring and intervention capabilities during the entire walking cycle.

Previous investigations of microprocessor-controlled knee joints have reported mixed results, ranging from data showing clear benefits for amputees to those that suggest there is no difference at all when compared to conventional knee mechanisms (1-4). The reported results are not sufficient to objectively determine the benefits of the C-leg® as most of the reported studies are related to the Intelligent Prosthesis (IP) by Blatchford. Objective evidence is needed to determine if there is significant benefit when prescribing expensive microprocessor-controlled knee mechanisms over high-performance passive knee units that cost significantly less.

In this short paper the following specific objectives of the study are presented: (1) to determine the participants' walking performance while walking over an obstacle course and (2) to examine the influence of mental loading while walking over the obstacle course with three different knee units.

METHODS AND SUBJECTS

In a crossover study design, each participant wore each prosthetic knee joint–Otto Bock C-leg, Otto Bock 3R60 and Mauch SNS–for a period of four weeks. Test prostheses were fabricated using a duplication of the participant's current prosthetic socket, and each participant was fitted with a Dynamic Plus foot. Alignment was performed in accordance to the manufacturers' recommendations and by the same prosthetist throughout the study.

Methods

The obstacle course was set up in the VA Chicago Motion Analysis Research Laboratory (VACMARL) (Figure 1). It consisted of foam section (3m long, 1m wide, 20 durometer on a shore A scale), narrow slaloms around three chairs, a vacuumized bean-bag section (3m long, 1m wide) simulating sand, a rock section (3m long, 1m wide), a short downward sloping ramp (1.5m long, 1.4m wide), a 90-degree left turn, and a final stair step (height: 12cm). The mental loading test consisted of a mathematical calculation task where the participant had to count vocally backwards in 3-step increments (first visit), in 7-step increments (second visit) and in 3-step increments (third visit). Participants completed the obstacle course twice, once without mental loading,

and once with mental loading where participants counted vocally backwards in set increments. No familiarization run was allowed. They were videotaped allowing time to be measured, however, participants were not aware that time was a variable of interest. The only instruction provided to them was to complete the obstacle course.

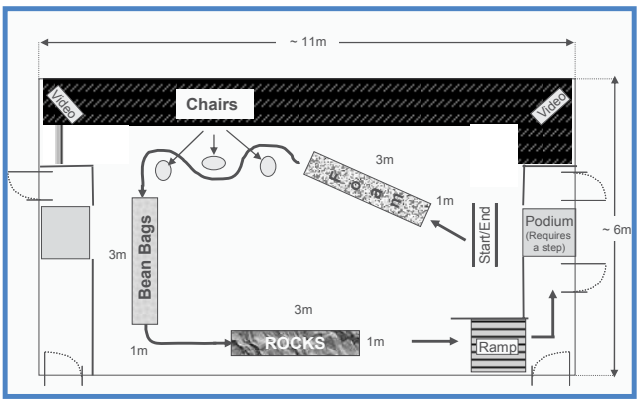

Figure 1: *Overview of obstacle course set-up within the VACMARL laboratory: Foam Section (3m long), Slalom Section around three chairs, vacuumized Bean Bags to mimic sand (3m long), Rock Section (3m long), Ramp (1.5m long), Corner (90° degree left turn) and a Step (12cm high). Two video cameras were set in such a way that the entire obstacle course could be filmed, allowing time measurements for each section.*

Statistical Analysis: Due to the non-parametric data distribution Friedman Test was used to assess the overall performance of the three knee joints. If a variable reached significant level, Wilcoxon Signed Rank Test was used to test between differences of each knee joint. A Bonferroni correction was applied to account for multiple testing, lowering the significance level to 0.016.

Subjects

Persons with unilateral transfemoral amputation, aged between 40 and 60 years, with a body-weight less than 125 kg (due to the weight limitations of prosthetic components), were included in the study if they presented with (a) no serious complications that interfered with their walking ability; (b) had six or more months of experience with a definitive prosthesis; (c) were able to walk unassisted at a comfortable speed without undue fatigue and without health risk; (d) and were able to climb stairs.

RESULTS

Data from 11 participants, two females and nine males, were analyzed. Their mean age was 45.8 ±9.5 years, mean height was 175 ± 9 cm, and mean weight was 81.8 ± 14.1 kg. They were all established walkers with their amputation having occurred 20.1 ± 14.2 years ago. Seven participants had their amputation due to a traumatic incidence, one due to Peripheral Vascular Disease (PVD), two due to infection and one due to a congenital deficiency. Three out of the 11 participants had a knee-disarticulation amputation.

The median time taken to complete the obstacle course with the 3R60 knee joint was 34.9seconds (s), the minimum time (min.) was 23.9s and the maximum time (max.) was 84s. Adding the mental task altered the time only minimally: 34.2s (min. 22.9s, max. 82s). For the C-leg, the total time was slightly lower when compared to the 3R60 knee joint: median time 32.1s (min. 22.1s, max. 73.1s). By adding the mental task the median time for the C-leg increased to 33.9s (min. 18.1s, max. 69.8s). The difference between the 3R60 knee joint and the C-leg was non-significant for both conditions (without mental task: p=0.169; with mental task: p=0.045). Participants performed best on the obstacle course when fitted with the SNS unit. Their total median time without mental task was 30.9s (min. 26s, max. 75.2s). Adding the mental task increased the median time slightly to 32s (min. 23.8s, max. 75.2s). The difference between the SNS and the 3R60 knee joint was significant for both conditions (without mental task: p=0.011; with mental task: p=0.005). However, the difference between the C-leg and the SNS knee joint was non significant (without mental task: p=0.674; with mental task p=0.678) (Figure 2).

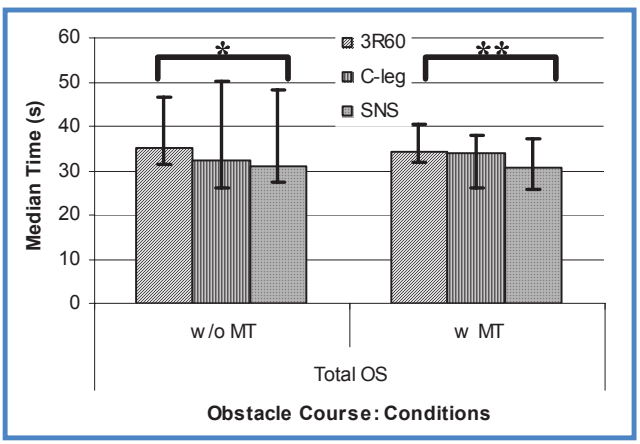

Figure 2: *Total time taken (in seconds) to complete the obstacle course for each prosthetic knee joint.*
w/o MT: without Mental Task *w MT: with Mental Task*
** SNS-3R60: p=0.011.* *** SNS-3R60: p=0.005.*

DISCUSSION

The participants completed the obstacle course in the shortest time when fitted with the SNS knee joint, followed by the C-leg, and they were slowest with the 3R60 knee joint regardless if a mental task was administered or not. Roughly summarized: the more complex knee joint (3R60) and the more sophisticated knee joint (C-leg) performed less favourable in the given context. It could be that the more complex

and sophisticated knee joints require more time and training in order for the user to be able to take full advantage of their characteristics. Thus the given 4-week accommodation period may not have been enough. However, it could also mean that for soft or uneven walking surfaces, a simpler knee joint—represented by the SNS knee joint—simply performs better, as participants have a quicker and direct impact on its behaviour.

The mental task had its biggest impact on the C-leg: participants performing with the C-leg reduced their performance speed by 6% compared to their non-mental task performance. The SNS knee joint induced only a 4% speed reduction compared to the non-mental task performance. This may indicate that the microprocessor-driven knee joint did not reduce mental loading during the obstacle performance as anticipated. Participants slowed down more with the C-leg to perform the two tasks simultaneously—walking safely and calculating correctly—than with the SNS unit. In contrast to the two single-axis knee joints, performance with the multi-axis knee joint (3R60) and the mental task enhanced participants' speed slightly by 2%, possibly indicating the influence of the stability provided by the positioning of the knee's instantaneous centre of rotation (5). In-depth detailed analysis may be possible to perform once the aimed sample size of 15 participants has been reached.

Limitations: The obstacle course was set up within the gait laboratory and thus represented a controlled environment that may not be representative of outdoor conditions. However, the different walking surfaces and narrow curved pathways demanded higher ambulation skills than walking on the level laboratory surface, thus challenging participants' performances.

CONCLUSION

No significant time differences were found between the C-leg and the SNS. Further research is needed to test if a different approach and/or different variables can explain the discrepancy between objective observations and literature-reported subjective improvements when using the C-leg.

Acknowledgements:
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DOWNHILL WALKING, A COMPARISON OF PROSTHETIC KNEE JOINTS

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Abstract

In this study the benefits of four different prosthetic knee joints were measured with a gait analysis. The investigated knee joints were the C-Leg, the Energy, the 3R80 and the Rheo knee. Ten transfemoral amputees had to walk down a slope with an incline of 15 %. During this downhill walking the ground reaction forces and the swing phase of both the prosthetic side and the sound side were investigated. The gait analysis showed that the C-Leg is reliable and easy to adjust. The Energy is almost as good as the C-Leg if the stance phase is adjusted exactly. The Rheo knee needs time to achieve a good performance and allows the lowest speed for downhill walking. The 3R80 reacts quite similar to an electronically knee joint if it is adjusted to a certain situation like walking down a slope.

INTRODUCTION

Nowadays active amputees have high requirements on the prosthetic knee joint they are using. The joint has to react reliable, sure and fast in both the stand phase and the swing phase. It also has to supply high comfort in walking with little effort of energy. Another requirement on the prosthetic knee joint is to make it possible for the amputee to walk down slopes and stairs confidently and alternating. The orthopaedic industry attempts to fulfil these and many other requirements with even more complex prosthetic knee joints. In this study ten highly active transfemoral amputees were measured with gait analysis while walking downhill with different prosthetic knee joints. The target of this study was to find out how the prosthetic knee joint influences the gait of the amputee while walking downhill on the slope.

METHODS AND SUBJECTS

In this study ten highly active transfemoral amputees were measured with gait analysis while walking downhill with different prosthetic knee joints. The investigated prosthetic knee joints were the C-Leg (Otto Bock), the Rheo Knee (Ossur), the Energy knee (Ortho Reha Neuhof) and the 3R80 (Otto Bock).

Methods

The gait analysis in this study investigated the kinematics of the swing phase and the ground reaction force during the stance phase on a slope (Figure 1). The slope is 6.5 m long, 1 m wide, 0.9 m in height with an incline of 15 %. It has two 3-dimensional force plates (Kistler) in the middle which measure the ground reaction force. The kinematics of both the prosthetic side and the sound side are made visible with reflecting markers and recorded synchronically by two video cameras.

Figure 1: *Gait analysis slope with a non amputee.*

All transfemoral amputees had to walk down the slope ten times with every knee joint. The speed for walking downhill was chosen by the amputees themselves. It ranged from three to five km/h. All the prostheses were built up according to the alignment rules of the manufacturers. The rules for the combinations of the prosthetic foot and the prosthetic knee joint were also followed.

Subjects

The following prosthetic knee joints were tested: The two microprocessor controlled knee joints C-Leg (Otto Bock) and Rheo Knee (Ossur) which react in real time;

the Energy knee (Ortho Reha Neuhof) with it's hydraulic stance phase and it's microprocessor controlled swing phase and the 3R80 (Otto Bock) that has a rotations hydraulic without any electronically support. All the amputees included in the investigation were male, between 20 and 53 years old and highly active prosthesis walkers. One of the amputees used the 3R80 as his daily use prosthetic knee, two amputees used the Energy for their daily use, one amputee used the Rheo knee for his daily use and six amputees had the C-Leg aligned in their daily use prostheses.

RESULTS

The data that were achieved in the study were the load maximum (Figure 2), the time of the stance phase (Figure 3), the knee angle at the beginning of the swing phase (Figure 4), the maximum knee angle (Figure 4) and the deviation of the knee angle wave (Figure 4). The waves of the prosthetic sides in the tables are blue and the waves of the sound sides in the tables are red.

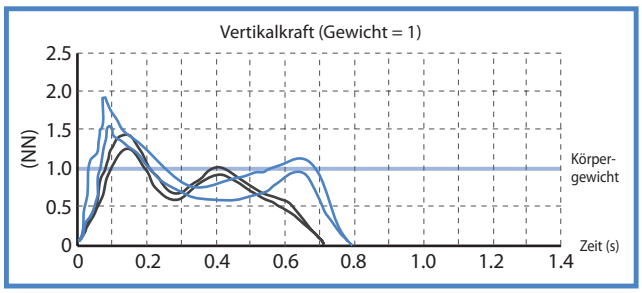

Figure 2: *Load wave with maximum peak*

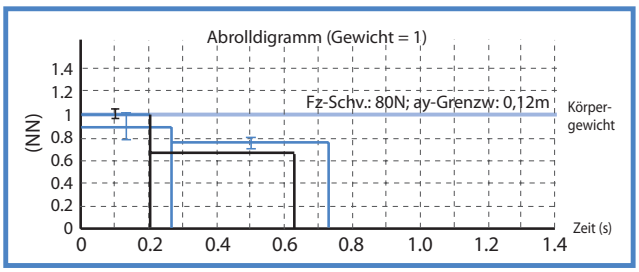

Figure 3: *Time of the stance phase*

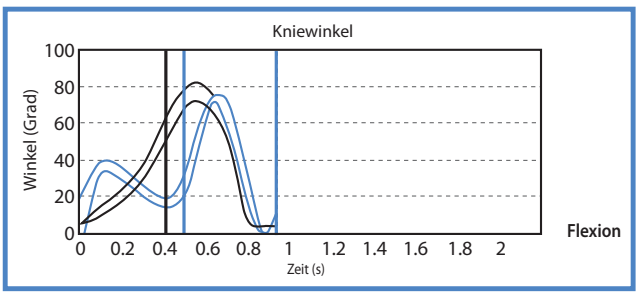

Figure 4: *Knee angle wave*

Looking at the maximum load peaks, the prosthetic sides were equal at all four different prosthetic knee joints. On the sound side the largest maximum load peak was found at the 3R80 (Figure 5).

The time of the stance phase of the C-Leg, Energy and 3R80 prosthetic side are comparable to the sound side. The longest time of stance phase was found at the Rheo knee (Figure 6).

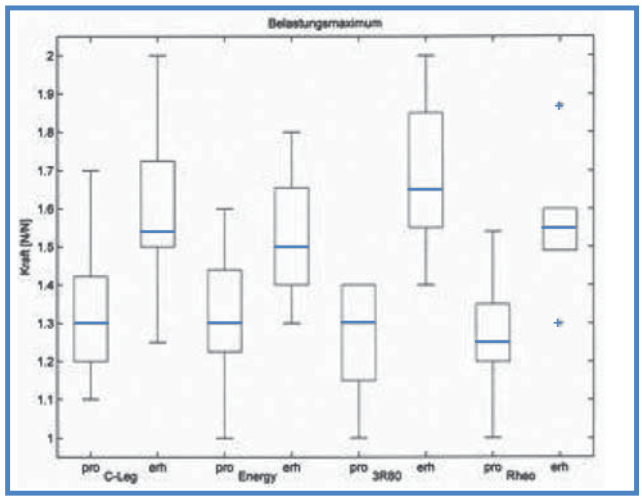

Figure 5: *Max. load related to bodyweight*

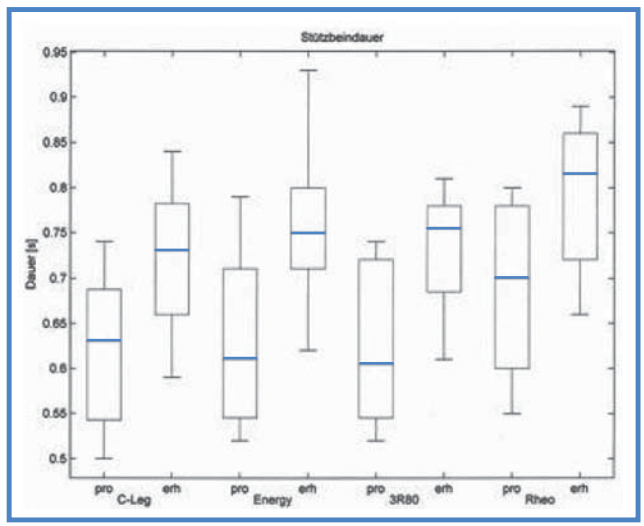

Figure 6: *Time of stance phase*

At the switch from stance phase to swing phase, the C-Leg comes at the lowest angle into swing phase at the prosthetic and the sound side. This behaviour can be called a dynamic gait. The Rheo knee comes at the highest angle into the swing phase at the prosthetic and the sound side. This could be called a cautious gait.

The Rheo knee has the biggest deviation at the prosthetic side (Figure 7).

Investigating the maximum knee angle of prosthesis and sound side, it is obvious that the 3R80 had very similar means. This is a point that a similar gait provides. The C-leg sank in very constantly and the 3R80 and the Energy produced a similar behaviour. The Rheo had the biggest statistical spread (Figure 8).

The statistical spread of the knee angle wave can be seen as a measurement for the precision of the prosthetic knee joint. The knee angle wave statistical spreads of the sound sides of all prosthetic knee joints were comparable. The lowest knee angle wave spreading of the prosthetic side was found at the 3R80, followed by the Energy. The knee angle wave spreading of the C-

Leg´s prosthetic side was hardly twice the amount of the 3R80´s, followed by the Rheo knee which had the largest statistical spread of the knee angle wave (Figure 9).

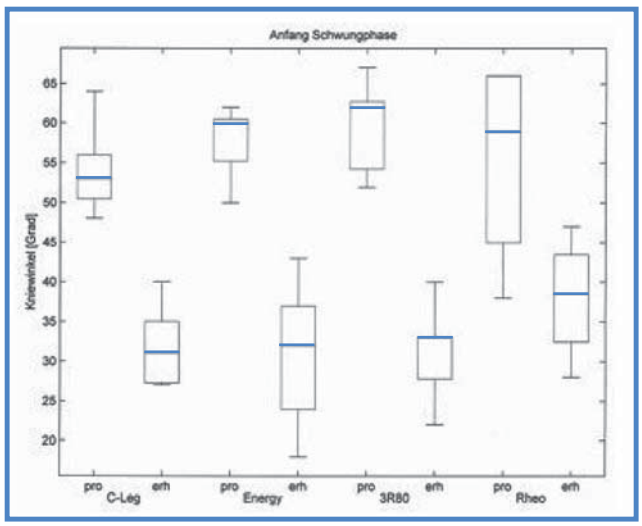

Figure 7: *Beginning of the swing phase*

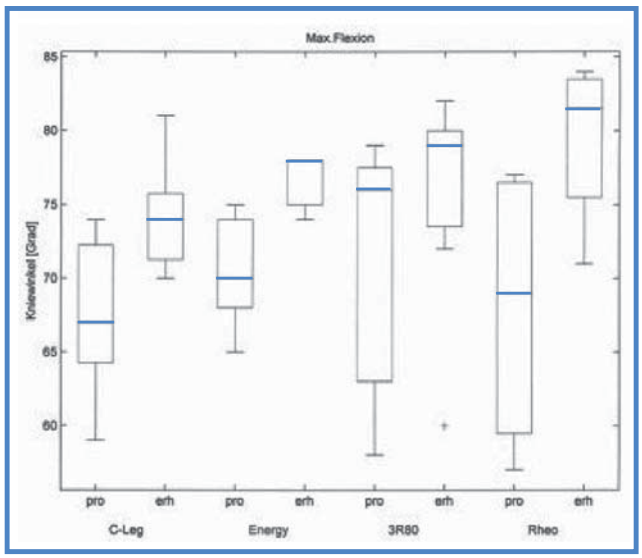

Figure 8: *Maximum knee flexion*

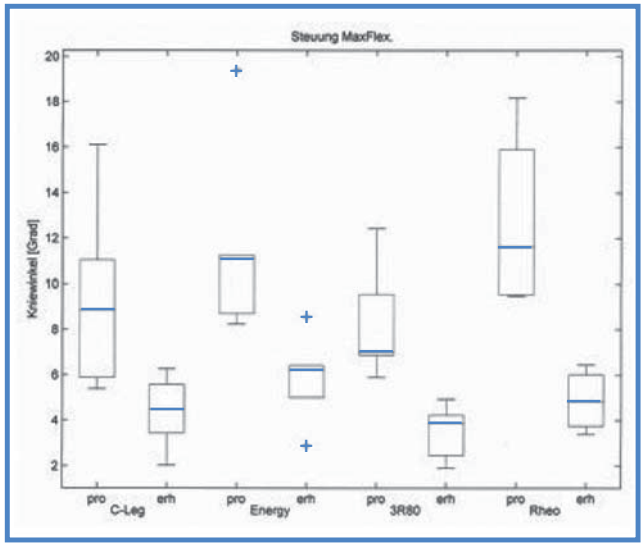

Figure 9: *Knee angle wave statistical spread*

DISCUSSION

The fact that the amputees can choose their speed for downhill walking themselves is the reason for finding the sound sides´ largest maximum load peak at the 3R80, since the 3R80 does not adjust itself to the walking speed like the other prosthetic knees that were investigated.

The long time of stance phase of the Rheo knee is because the knee joint comes slowest into the extension while walking.

The big statistical spread at the Rheo knee prosthetic side comes from the sometimes slightly rocking sinking while downhill walking.

The 3R80 has the lowest knee angle wave spreading because the non-electronically hydraulic of the knee joint was adjusted exactly to the gait analysis slope. The Energy which also has no electronically hydraulic stance support acts similar. The large knee angle wave spreading of the C-Leg and Rheo knee comes from the real time self-adjusting of the swing phase.

The minimum time for the amputees to adapt to the different knee joints was at about two to four hours. The amputees also walked a several hundred meters on a treadmill before starting the gait analysis. The question remains that if the adapting time for each joint would have been a couple of days in combination with special gait training, there would have been other results.

CONCLUSION

With the C-Leg a continuous and permanent sinking into the progression of the knee angle was recognized. It was

possible to directly walk over the prosthetic knee joint without additional muscular securing and high forces on the sound side. The 3R80 with its´ rotation hydraulics enabled a constant sinking while downhill walking over the entire necessary knee angle range. Although the disadvantage was that the sinking speed was adjusted for the slope. So while walking down the stairs the sinking speed was too slow. This is because the knee joint does not readjust itself independently like the other investigated types. The Rheo Knee supplied a rather inhomogeneous sinking behaviour. It judders particularly in the first part of the stand phase. The Energy knee joint sinks constantly and surely while downhill walking and resembles in its sinking behaviour the C-Leg. None of the prosthetic knee joints has a curve progression of a physiological knee joint while downhill walking.

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HIP DISARTICULATION FITTING CONCEPT

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Abstract

The patented Helix^{3D} Hip Joint is the first commercially available exoprosthetic hip joint with hydraulic stance phase and swing phase control. Its design features enable the prosthesis wearer to achieve a harmonious and smooth gait pattern.
The lecture presents the new fitting concept of the Otto Bock company for the fitting with a Helix^{3D} Hip Joint as well as the technical features of the new hip joint.

INTRODUCTION

For a longer time already and due to the relatively low number of cases, the available technologies for the fitting of hip disarticulation amputees have developed much less than in other fields of prosthetics. Otto Bock has newly and systematically dealt with this topic.

The core of the new fitting concept is the patented Helix^{3D} Hip Joint with hydraulic stance phase and swing phase control. The following particularities characterize the hip joint:

Spatial movement of the hip: The patented, multi-axis joint structure effectuates spatial (three-dimensional) movement of the hip. In addition to usual flexion and extension, this spatial movement is a combination of abduction and adduction as well as inward and outward rotation imitating the natural movement. Therefore, the Helix^{3D} Hip Joint is available in two versions for left-side amputees and right-side amputees. In addition, the multi-axis joint structure results in greater reduction of the leg length during the swing phase and thus facilitates walking with the prosthesis.

Hydraulically controlled extension and flexion: A hydraulic unit controls the resistance of the hip joint during each phase of gait. During the stance phase, it allows for dampened, controlled heel strike with significantly reduced backward tilt of the pelvis (hypolordosis) as well as harmonious hip joint extension. The hydraulic unit also controls the stride length during the swing phase. It can be adjusted to the individual requirements of the prosthesis wearer.

Support of swing phase initiation: During the stance phase, integrated expansion springs store mechanical energy. This energy is used to initiate the swing phase in order to compensate to some degree for the missing hip flexors. As a result, less energy is required for walking.

Sitting characteristics: Since the Helix^{3D} Hip Joint has a low structural height when installed, "pelvic obliquity" in the sitting position can be reduced to a minimum. Moreover, the flexion angle of the Helix^{3D} Hip Joint is very large enabling comfortable sitting.

Biomechanical analyses have shown that the C-Leg® in combination with the Helix3D Hip Joint for the first time enables safe knee stance phase flexion for hip amputees. The lecture describes the steps of the fitting with a Helix^{3D} Hip Joint in combination with a C-Leg®.

METHODS AND SUBJECTS

The lecture deals with the following subjects:

Plaster technique:	New 2-stage plaster technique – optionally inischium containment style - using acorresponding, new casting table.
Test socket:	The advantages of a test socket in hip prosthetics. Fabrication instructions will be given.
Static alignment:	New methods for determining the partial body centre of gravity as a reference during static alignment of the prosthesis. Furthermore, transfer of the values to the definitive socket will be shown.
Helix^{3D} Hip Joint:	The new hydraulically controlled Helix^{3D} Hip Joint (7E10) in combination with a C-Leg® – Functions, advantages, outcomes.
Socket material:	New possibilities with the permanently elastic polyurethane lamination resin Polytol® in socket fabrication.

Matching cosmetic cover:	Use of a cosmetic foam cover with new dimensions for hip disarticulation prostheses.
Matching foot:	Information on foot selection for hip disarticulation prostheses.

CONCLUSION

With the Helix^{3D} Hip joint, Otto Bock presents a sophisticated solution for hip amputees. Helix^{3D} is the first artificial hip joint that hydraulically controls three-dimensional movements in the stance phase and swing phase. The system sets a new standard for the fitting of hip amputees by offering significantly increased safety, dynamics, and comfort. Walking gets much easier and more physiological, and a large flexion angle facilitates activities of daily living.

First experience reports with the combination of C-Leg® and Helix^{3D} Hip Joint show that the patients' feeling of safety and, as a result, the acceptance of walking with an exoprosthetic hip prosthesis clearly increase.

The systematic approach during the development and introduction of the Helix^{3D} Hip Joint system becomes evident in the matched Helix^{3D} fitting package. In this package, some techniques are applied for the first time: a new plaster technique in combination with a simplified method of test socket fabrication, new alignment instructions using a partial mass centre of gravity that are easier to learn, the new flexible socket material Polytol®, as well as new cosmetic cover solutions for hip prostheses.

Knowledge about these steps can be improved at Otto Bock during a several-day certification seminar and is a prerequisite for own Helix^{3D} fittings worldwide.

References:

1. Otto Bock HealthCare GmbH, Max-Näder-Straße 15;37115 Duderstadt,Germany.

EVALUATION OF AN OPTICAL CAD SYSTEM USED IN PROSTHETIC SHAPE CAPTURE.

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Abstract

The measuring accuracy of the T-Ring, a non-contact optical prosthetic CAD scanning device, was assessed in the measurement of a model of known dimensions and volume. The T-Ring was located in the normal scanning position for collection of dimensional and volume data. The scanning process was repeated with the T-Ring inclined at 2 °, 4 ° and 6 ° respectively to the normal position. It was found that, in any position the scan results were highly repeatable but differed from the true value. This error increased with angulation giving 5% volume error for each 2 ° of inclination. This highlights the importance of accurate alignment of the T-Ring during scanning.

INTRODUCTION

The quality of fit of a prosthetic socket has a major influence on the function and comfort of the finished prosthesis. The measurement of the residual limb should be repeatable and accurate to minimise errors arising in the design process. A key element of this is the method of data capture. The quality of fit of the resulting socket depends upon the accuracy and precision of this data. Uncertainty still exists as to the best method for acquisition of data. Contacting methods may be more familiar to prosthetists, but may introduce dimensional errors due to soft tissue deformation. The use of non-contacting systems has the potential for greater precision. The T-Ring system is one of the leading non-contact CAD systems available and is currently employed in clinical practice in several prosthetic centres throughout the world.

METHOD

A cylindrical model with a hemispherical end was mounted vertically in a computer numerically controlled machine (CNC) for accurate placement of four equally spaced datum lines and reference points to allow the model to be measured. It remained in this position throughout the entire test programme described in this paper.

The model was measured using a data acquisition system accurate to five microns (0.005mm) and volumes between datum lines were calculated. This process was repeated 3 times and the mean values were taken as a "gold standard" to which subsequent measurements would be compared.

The model remained in situ and the T-Ring was clamped at a suitable level on the CNC machine. The model was then photographed by the T-ring a total of thirty times at each of four different angular settings. All photographs were taken sequentially without moving the T-Ring or model, to minimise the possibility of error. Volumes, circumferences & diameters for different levels were recorded. Accuracy and repeatability of volume measurement was then analysed in SPSS using a one sample t-test to compare the mean of the "gold standard" against the mean of each T Ring scan. The percentage difference between the mean volume scanned at each level and the "gold standard" was determined.

RESULTS

When the T-Ring was held perpendicular to the model axis, variation between individual T-Ring scans was minimal. All T-Ring results were shown to be significantly different from the "gold standard" using a one sample t-test. The mean difference had a tendency to increase as the angulation of the T-Ring to the axis of the model increased (Table 1).

Table 1: *Percentage by which the T Ring measurement exceeds the "gold standard" for different volumes at different T Ring angulations*

	0 °	2 °	4 °	6 °
Volume 1	0.35 %	5.53%	10.23 %	15.17 %
Volume 2	2.71%	-2.68%	-3.14%	-2.83%
Volume 3	-1.02%	2.88%	4.29%	6.15%
Volume 4	-1.63%	3.14%	4.15%	5.40%

DISCUSSION

Table 1 shows that the volumes based on T-Ring measurement differ from those calculated accurately using the

"gold standard". The difference generally increases with the angulation of the T-Ring.

If a socket is too large, the residuum will sink into it resulting in high pressures on the distal end of stump causing pain and skin breakdown. The prosthetist may be able to compensate by adding stump socks if the volume difference is uniformly distributed over the stump-socket interface. Lilja and Oberg (1) equated the volume of one terry towelling sock to a discrepancy of approximately 5% of typical residual limb volume. To place the problem into a practical context, the results in Table 1 could be expressed in terms of socks which would need to be added to compensate for the difference in volume. In some areas three socks might be needed while in others the socket might be too tight by the volume of one sock. When fitting a socket that was scanned at 6 ° to the axis, the prosthetist may be tempted to add a sock over the proximal aspects (volumes 3 & 4) where a space would be seen in the socket. However, this would also be creating a ring of high pressure over volume 2 and there would still be abnormally low pressure over distal area (volume 1). This would result in distal tissue being unsupported and a high pressure gradient near the distal end between the two distal volumes.

CONCLUSION

Evaluation of the measurement accuracy of the T-Ring system has been completed on a simple model of known dimensions. The best scanning accuracy is achieved when the T-Ring is held perpendicular to the stump axis. The accuracy was sensitive to the angulation of the scanner where a tilt of 2 ° could result in a measurement error of 5%.

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VIRTUAL MIRROR FOR ASSESSMENT AND TRAINING OF LOWER EXTREMITIES

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Abstract

The paper proposes the use of visual biofeedback through virtual mirror as a modality of lower-extremities training in virtual reality. A kinematic model of a human body and a corresponding virtual figure were developed, in order to visualize the movements of the subject in a real-time virtual environment on a large display, which represented a virtual mirror. An optical system with active markers was used to assess the stepping movements of a training subject. A preliminary investigation was conducted with a group of healthy subjects, who performed the stepping test by tracking the movements of the reference virtual figure, which represented a virtual instructor. Both figures, the training subject and virtual instructor, were superimposed and shown from the desired angle of view. The subjects performed four stepping tasks. The results obtained included basic kinematic and temporal parameters of adaptation, thereby providing quantitative measures of subject's immersion in the virtual training environment.

INTRODUCTION

Virtual reality (VR) is powerful tool in rehabilitation, providing the use of visual biofeedback as one of the most important augmentations compared to traditional therapy (1). The number of VR rehabilitation applications has been increasing rapidly over the last years; however, most of them have focused on the upper extremities (2). For lower-extremities training, we propose the use of a virtual mirror (VM). This is a large screen in front of which the subject performs the movements and observes them in a three-dimensional (3D) virtual environment from arbitrary viewing angle (Figure 1). The motion in VM is visualized through a human-like figure whose movements correspond to those performed by the subject in real time. In our study we used two virtual figures simultaneously, where the other figure represents the virtual instructor (VI). The motion of the VI was pre-programmed by measuring and recording the movements of a healthy subject. VI figure was rendered yellow transparent in appearance, opposed to the subject's figure which was solid grey. The task of the training subject was to track the movements of the VI as accurately as possible, trying to minimize the pose difference of both figures in the VM throughout the duration of the training.

We studied the ability of adaptation to the VI's movements by using the VM in a group of healthy adults performing stepping-in-place (SIP) tasks (3). Differences between the subjects' and the VI's movements were studied and analyzed for each task. It was our aim to assess and establish the ability of the healthy population to adapt to the VI as a ground for further studies and applications intended for patient training using VM.

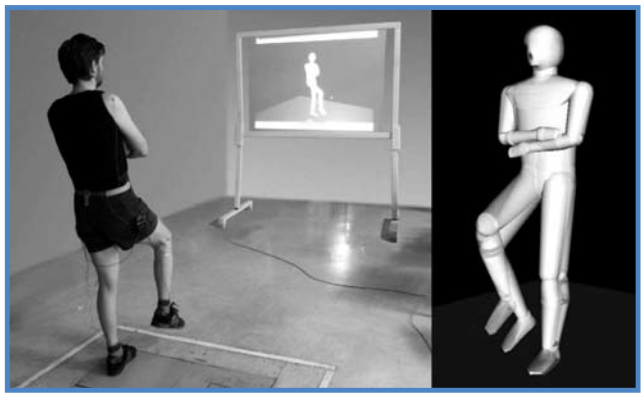

Figure 1: *Virtual mirror: a large screen showing movements of the subject in real time (left), superimposed virtual trainee and virtual instructor enlarged (right).*

METHODS AND SUBJECTS

Visualization in VM was based on the simplified kinematic model of the human body (4, 5). In order to obtain the values of joint angles, 11 active markers were placed on the skin over anatomical landmarks. The positions of the markers were measured using the OPTOTRAK (Northern Digital Inc.) system with a 70-Hz sample rate. Kinematic data were fed to the virtual environment which was facilitated by using VRML 2.0 (Virtual Reality Modelling Language). We achieved 35-Hz refresh rate without detectable lagging, which was sufficient to enable a proper real-time visualization, engaging the subjects' visual biofeedback.

The subjects were instructed to follow the SIP movements of the VI during the test as closely as possible. VI had been pre-programmed with 4 different SIP tasks, featuring cadences of 60, 60, 90, and 120 beats per minute (BPM), whereas the maximal hip angles were 45°, 90°, 90°, and 45° respectively. The number of steps was 30 for all tasks.

A test group consisted of 10 healthy male subjects (age 23 - 39 years; mean value = 28.5 years, standard deviation = 4.7 years). None of the subjects had a medical history of any relevant medical condition.

RESULTS

Results include the maximal angles of the hip and knee joints achieved in each step, the swingphase duration and the SIP period duration, shown in Figure 2. The solid horizontal line

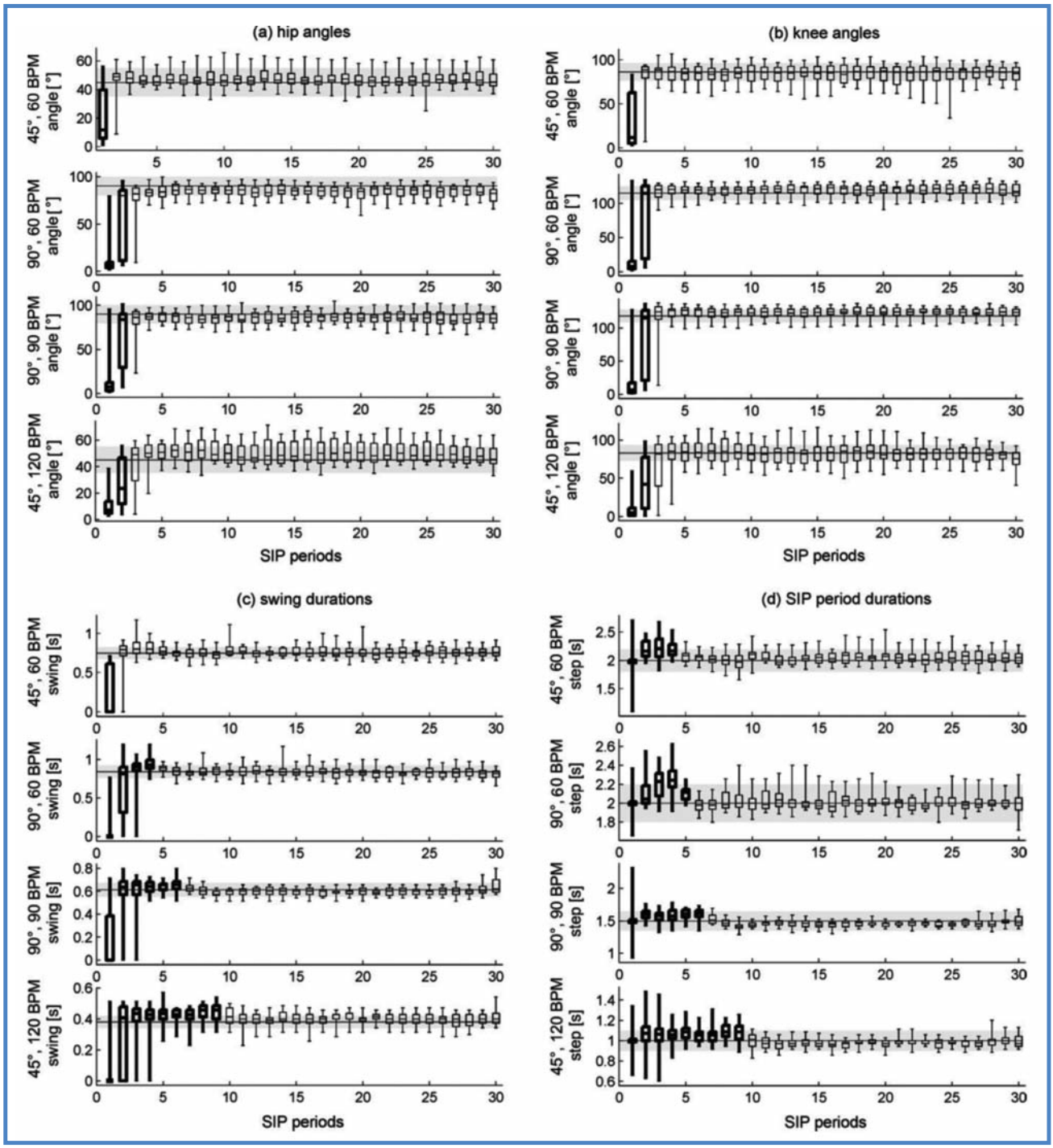

Figure 2: *SIP parameters (a: hip angle, b: knee angle, c: swing time, d: SIP period time) for SIP periods 1-30, showing 25th percentile, median value, 75th percentile, maximal, and minimal value in each SIP period.*

represents the reference value of the virtual instructor. The boxes indicate the 25th percentile, median value, and the 75th percentile in step, while the error bars show the maximal and minimal angles measured in the group of 10 subjects. Grey bands indicate ±10% deviation. Bold lines indicate the steps that were significantly different from the steps that follow ($p < 0.001$ for all tasks, one-way ANOVA).

DISCUSSION

The results suggest that healthy subjects can adapt to the virtual mirror quickly with the proposed tasks, achieving both consistency, and accuracy of kinematic and temporal adaptation; however, kinematic adaptation was generally achieved sooner than temporal adaptation, especially in the more demanding tasks. This phenomenon suggests the use of further modalities in the virtual environment, such as audio devices, to enhance the feedback and improve temporal coordination. Less demanding tasks than those proposed in our study should be considered in clinical practice.

CONCLUSION

The current study offered a preliminary insight into using the VR and visual biofeedback in lowerextremities training. Introducing a virtual mirror enabled active inclusion of subjects in the training process. The adaptation to the VI among a group of 10 healthy persons was evaluated by performing the virtual SIP training. We concluded that healthy subjects were able to track the virtual instructor during SIP which suggests further applicability of the virtual mirror to other forms of lower-extremities virtual training. Introducing the virtual mirror in the rehabilitation environment could be potentially beneficial in terms of process quantification, standardization, and VR-related effects (2).

Acknowledgements

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AUTOMATIC STANCE PHASE DETECTION FROM 3D GROUND REACTION FORCE DATA FOR APPLIED GAIT ANALYSIS

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Abstract

This paper introduces a new stance phase detection method in the field of gait analysis. For the first time characteristic snap-shots represent each of the five stance phases. Three-dimensional reaction force data (frontal, sagittal and vertical forces), acquired from force plates during the entire stance phase, lead to a typical butterfly-shaped looped curve. This significant curve is the basis for the automatic stance phase detection method. The author presents how the five stance phase images Initial Contact, Loading Response, Mid Stance, Terminal Stance and Toe Off are extracted and what impact they have on gait asymmetry. The new stance phase detection method is applied in an experiment with force plates mounted on a ramp. The extracted stance phases from subjects with amputation of the lower extremity and non-disabled subjects are compared and discussed.

INTRODUCTION

In gait analysis an important element is the measurement and demonstration of gait asymmetry. So far stance phases could not be extracted and compared via an automatic gait analysis application. We developed a method in which stance phases are not segmented in percentage-wise concatenated parts (1) (Figure 1) but in five characteristic snap-shots. It enables the immediate evaluation of gait asymmetry by opposing five automatically extracted stance phase images of the left and right leg. Figure 2 shows the stick diagram of the five stance phases.

METHODS AND SUBJECTS

Aim

The method's main goal is the automatic detection of the five characteristic stance phase images using three-dimensional (3D) Ground Reaction Forces (GRF). These images are part of an acquired image sequence taken by analogue cameras. Depending on gait speed the measurement time usually ranges from 2.5 to 6.0 seconds.

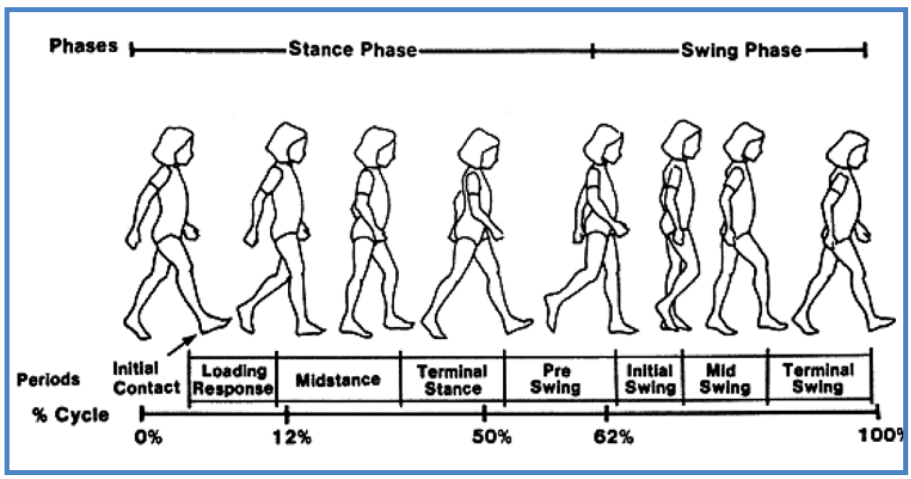

Figure 1: *Percentage-wise segmented stance phases, Initial Contact(IC: 0%), Loading Response (LR: 0% to 12 %), Mid Stance (MS: 12% to 31%), Terminal Stance (TS: 31% to 50%) and Toe Off (TO: 50% to 62%) (Pre Swing) within an entire gait cycle (2)*

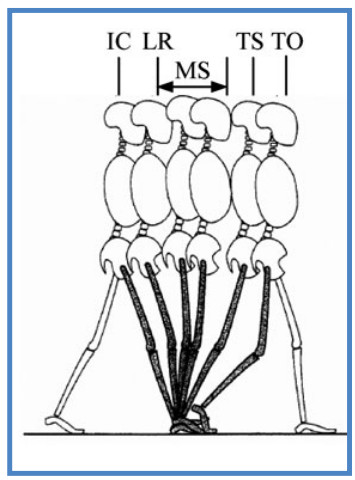

Figure 2: *Supporting leg (gray) during stance phase (1)*

Methods

The method can be applied on two measuring setups: flat surface and ramp. The subject is asked to walk over two force plates that are embedded in a flat surface (Figure 3) or to walk downwards a ramp with 15 percent inclination (Figure 4).

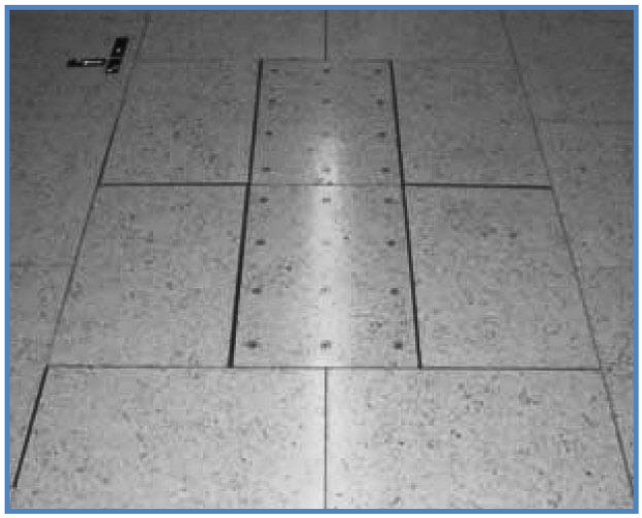

Figure 3: *Flat surface with two force plates*

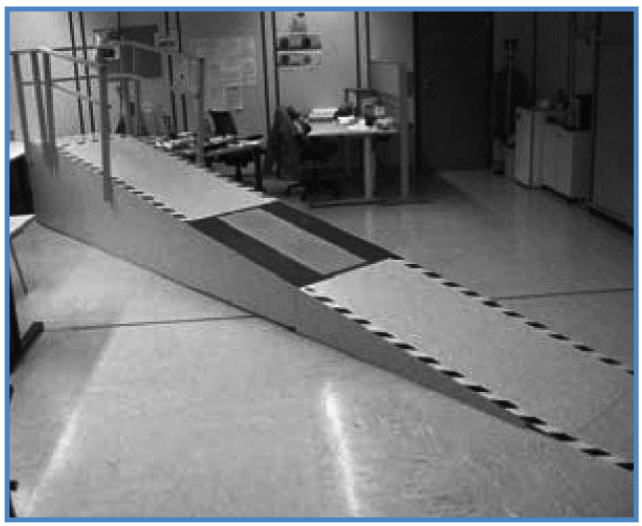

Figure 4: *Ramp with two force plates*

Figure 5 shows a schematic diagram of the Gait Analysis System (GAS) (3). The Motor Learning and Control Processor (MLCP) interface box (4) synchronizes the 3D GRF, which are measured by two force plates, with two analogue camera streams. The resulting normalized sagittal, frontal and total GRF (Figure 6) serve as inputs for the stance phase detection method. The results of the rule-based stance phase detection algorithm are five force-related time stamps for each camera and force plate. These time stamps are correlated with the time series of the cameras in order to extract stance phase images.

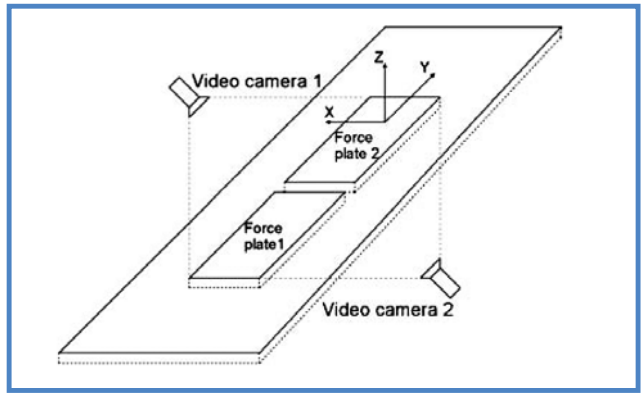

Figure 5: *Schematic diagram of the GAS*

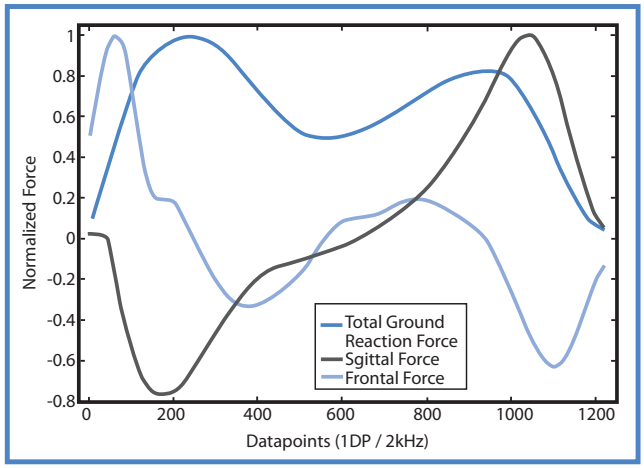

Figure 6: *Normalized GRF*

Subjects

This automatic measurement method is currently applied to pathologic and non-pathologic subjects at the rehabilitation center "Weißer Hof" in Klosterneuburg, Austria, and is about to be used in two further centers. The application mainly serves as a quality assurance tool for orthopedic supply.

RESULTS

The measurement setup is a ramp with 15 percent inclination. Each of the five distinctive stance phases is extracted at specific points from the 3D GRF (Figure 7 to 10). The non-pathologic subject's gait pattern is almost equal (Figure 7 and 8), whereas the pathologic subject (rightamputated) exhibits a major asymmetry (Figure 9 and 10).

DISCUSSION

The results show significant differences between stance phases of the subject with lower extremity amputation and the non-pathologic subject. The well-preserved leg of the pathologic subject contacts the ground 12.8 percent longer

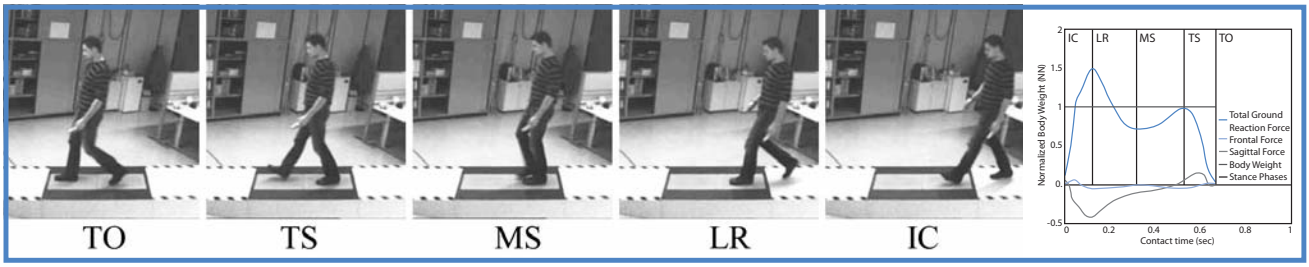

Figure 7: *Detected stance phases of non-pathologic subject's left leg (LR: 0.12 sec, MS: 0.32 sec, TS: 0.52 sec, TO: 0.66 sec)*

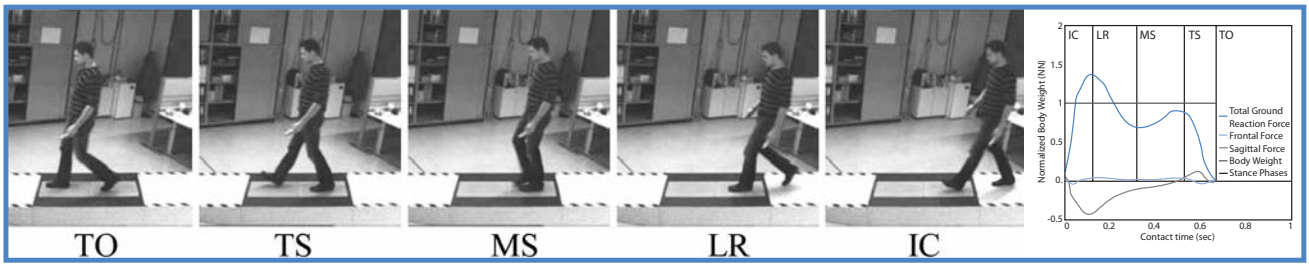

Figure 8: *Detected stance phases of non-pathologic subject's right leg (LR: 0.12 sec, MS: 0.34 sec, TS: 0.5 sec, TO: 0.64sec)*

Figure 9: *Detected stance phases of pathologic subject's left leg (LR: 0.14 sec, MS: 0.26 sec, TS: 0.38 sec, TO: 0.68 sec)*

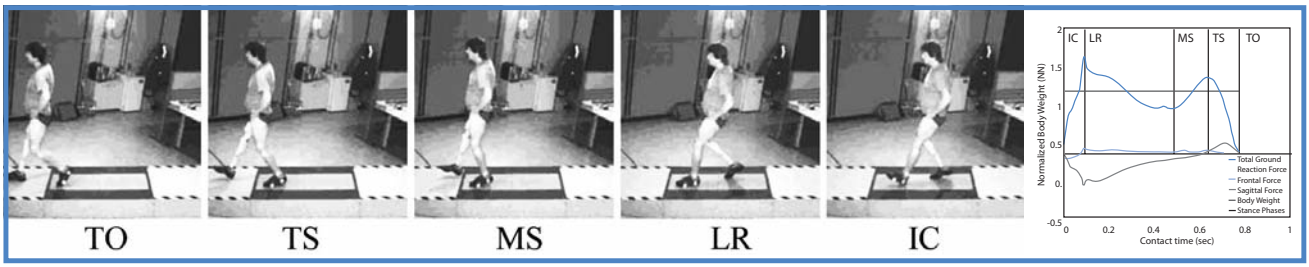

Figure 10: *Detected stance phases of pathologic subject's right leg (LR: 0.10 sec, MS: 0.48 sec, TS: 0.64 sec, TO: 0.78 sec)*

than the amputated leg to keep balance as long as possible. In fact, the mid stance shifts over the half of the contact time.

CONCLUSION

The demonstration of gait asymmetry with percent-wise stance phase ranges, as described in introduction, would be time-consuming and difficult.

In our proposed method we applied specific rules to detect stance phase images. These rules are based on the semantic attributes of the 3D GRF and valid for any gait speed and slope. The method shows that gait asymmetry can easily be visualized by opposing five automatically extracted stance phase images of each leg using two 3D force plates and two analogue cameras.

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INSTRUMENTED GAIT ANALYSIS OF TRAUMATIC TRANSTIBIAL AMPUTEE PATIENTS

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Abstract

Presented study gives findings of investigation of objective, quantitative gait analysis and evaluation of different adaptive strategies of body in 12 traumatic transtibial amputee patients with prosthesis. Gait analysis entails the combination of multitude of measurements (kinematics, ground reaction force kinetics, multichannel surface electromyography of quadriceps and hamstrings) of both, the amputated and non-amputated legs. Results of gait analysis discloses asymmetries in gait parameters between the amputated and sound legs, as well between transtibial amputees and non-disabled persons. Kinematic results showed that the ankle kinematics of prosthetic limb are significantly reduced while hip flexion are increased in late stance phase. Temporal spatial parameters are also different so prosthetic stance phase (ms and % GC) were shorter, while swing phase and prostetic step lenght were significantly prolonged. Walking speed of amputees was slower. Results of kinetic analysis shows decreased ground reaction (vertical Fz 1 and Fz 3, fore.-aft Fx 1 and Fx 2 and medio-lateral Fy 1 and Fy 2) under prosthetic limb while sound limb has larger magnitude of vertical force Fz 2.

INTRODUCTION

Amputees with trauma related amputation represent a very specific group of patients, first of all because of their age (working age adults). It is well known that the amputation is reason of significant impact on employment and quality of life during the next 40 to 50 years of remaining life of the young amputee patient. They have great potential for enhancement of function through appropriate rehabilitation and use of effective prosthetic devices. Very often they adapt a unique way of ambulating with a prosthesis. Most adaptations in their walk can be discerned by means of observation but it is not sufficient enough to note walking complexity, so, objective gait analysis becomes necessary (1-3).

METHODS AND SUBJECTS

Methods

Kinematics procedures measure the motion of the body and limb segments data were assessed by optoelectronic system Elite Bimech (BTS Bioengineering, Milano) with eight-camera high-speed video system. Markers were placed over predefined bony landmarks on the arms, trunk, pelvis, and legs and they were used to track the three-dimensional locations of individual body segments throughout a gait cycle. Kinetic analysis were performed by collection of ground reaction forces data as subjects walk over force plates (Kistler) embedded into the floor of the laboratory. Dynamic electromyography (EMG) is performed to determine the timing of muscle activation and to estimate the relative magnitude of muscle contraction. EMG data were collected on multichannel surface electromyography (EMG) of quadriceps and hamstrings of both the amputated and non-amputated legs (TELEMG).

Subjects

Study population consisted of twelve (12) males with right trans-tibial traumatic amputation in mean age 40.25+6 years (31-52) volunteered to participate in this study. They were all war victims, mostly injured by means of land mines, at the period 1991-1995. The time lapse between the date of amputation and the time of testing ranged from 8 to 12 years (mean time 10.08+1.5 years). All prosthesis were patellar-tendon bearing (PTB) with dynamic feet. All subjects were excellent walkers who used their prosthesis on a regular basis and were leading an active normal life.

RESULTS

Kinematic results showed differences in kinematic parameters of transtibial amputees comparing to able-bodied individuals. Primarily, the ankle kinematics of their prosthetic

limb is significantly reduced while hip flexion is increased in their late stance phase.

Temporal-spatial parameters at persons with lower-limb amputation are also different. Prosthetic stance phase (ms and % GC) was shorter, while swing phase and prostetic step lenght were significantly prolonged. Walking speed of amputees was slower than their ablebodied counterpairs .

Results of kinetic analysis shows decreased ground reaction (vertical - Fz 1 and Fz 3, fore.-aft Fx 1 and Fx 2 and mediolateral - Fy 1 and Fy 2) under prosthetic limb, while sound limb has larger magnitude of vertical force Fz 2.

EMG results show that quadriceps and hamstrings activity on the prosthetic limb is increased in comparison with the sound limb in stance and swing phase.

DISCUSSION

Results of our instumented biomechanical quantitative gait analysis study and evaluation of transtibial amputee persons compared to able bodied person provide objective assessment about the way prosthetic persons walk.

Kinematic results showed that the ankle kinematics of prosthetic limb is significantly reduced while hip flexion is increased in late stance phase (5-7). Temporal spatial parameters are also different, so prosthetic stance phase (ms and %GC) were shorter, while swing phase and prostetic step lenght were significantly prolonged (5-9). Cadence and walking speed of our amputees (1.23 m/s) were slower than at able bodied, as well the other authors claimed (10-14) .

Results of kinetic analysis shows decreased ground reaction (vertical Fz 1 and Fz 3, foreaft Fx 1 and Fx 2 and mediolateral Fy 1 and Fy 2) under prosthetic limb while sound limb has larger magnitude of vertical force Fz 2 (15-20).

Results of our gait analysis discloses asymmetries in kinematic gait parameters between the amputated and sound legs, as well between transtibial amputees and non-disabled persons, as it is well known (6, 21-24).

CONCLUSION

Patients with undergone traumatic amputations adapt a unique way of ambulating with a prosthesis. Most adaptations can be discerned by means of observation but it is not sufficient enough to note walking complexity. In order to better understand complexity of amputee gait, with discrimination of primary mehanisms of abnormal performance from the compensatory mechanisms, objective gait analysis are able to provide objective assessment about the way prosthetic persons walk. Better understanding of the biomechanics of gait of trauma related amputees might be the basis for intervention strategies that enchance the prospect of maximal functional restoration and provide design guidance for prosthetic components in trans-tibial amputees (2, 25, 26).

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MEASUREMENT OF THE ACTIVITY LEVEL OF LOWER LIMB AMPUTEES

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INTRODUCTION

Rehabilitation of lower limb amputees focuses on the mobility and ability of walking. Tests and scales measure the personal skill of mobility and walking in the process of rehabilitation.

METHODS AND SUBJECTS

There were construct a clinical study at the National Institute for Medical Rehabilitation in Hungary for measuring rehabilitation outcome after amputation.

Dysvascular and non-dysvascular lower limb maior amputees after the amputation and first prosthetic care was the selection criteria. Both below-knee (BK) and above-knee (AK) amputees are participate in this study.

There were use mobility measuring tests and self-reporting questionnare to determine activity level of theese patients (Two Minutes Walk Test, The Timed Up and Go Test, SIGAM Mobility Grades Questionnare, Russek scale).

CONCLUSION

The conclusion is, that the activity level of young amputees is higher than old patients. The level of the amputation is a great influence for the rehabilitation outcome. The activity level of dysvascular patients is less than non-dysvascular amputees as well.

USING THE SELF-REGULATION MODEL TO DETERMINE PSYCHOLOGICAL PREDICTORS OF PROSTHETIC USE, INDEPENDENCE AND MOBILITY

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Abstract

There are around 850 primary, lower limb amputees each year in Scotland. Approximately 65% of transtibial and 25% of transfemoral amputees are fitted with a prosthesis. There is some evidence that 20% of amputees do not use, and a further 20% only occasionally use, their prosthesis at 1 year follow up. Physiological variables within the self-regulation model (SRM) have predicted outcomes in other physical conditions and it was therefore used to determine if physiological variables would predict a) prosthetic use and b) independence and mobility in amputees. 166 PAD amputees age 50+ years were recruited. The illness perception questionnaire (IPQR), functional measure for amputees (FMA), and locomotor capabilities index (LCI) were used as assessment tools. Significant SRM physiological variables regression models emerged for predicting prosthetic use, timeline cyclical and treatment control being the most influential. For predicting independence and mobility, timeline cyclical and treatment control were again the most influential variables.

INTRODUCTION

There are around 850 primary amputations of the lower limb performed each year in Scotland, of which approximately two-thirds of cases are male. The average age of such amputees is 69 and the main cause of amputation is peripheral arterial disease (PAD), with or without diabetes, which accounts for nearly 90% of cases. Although there are about the same number of transtibial as transfemoral amputations performed, which together account for over 90% of cases, approximately 65% of transtibial amputees and only 25% of transfemoral amputees are fitted with a prosthesis (1).

Sockalingam et al. (2) found that around 20% of transtibial amputees do not use, and 20% only occasionally use, their prosthesis at 1-year follow-up. This finding has implications for a) patient's well-being and b) healthcare cost efficiency. However, the reasons for this limited prosthetic use are unclear.

Psychological variables within the self-regulation model (SRM: 3) have predicted rehabilitation outcomes in other physical conditions (e.g., cancer). Therefore, the SRM was used to determine if psychological variables would predict a) **prosthetic use**, and b) **independence and mobility**, in lower limb amputees.

METHODS AND SUBJECTS

Methods

Design: A longitudinal predictive study was used.

Participants: One hundred and sixty six (166) PAD amputees (aged: 50+ yrs) were recruited to the study.

Materials: The illness perception questionnaire-revised (IPQ-R) was used to assess psychological variables. Items from the functional measure for amputees (FMA) assessed prosthetic use, and the locomotor capabilities index (LCI) was used to evaluate independence and mobility.

Procedure: The participants were interviewed by the Research Fellow or the Senior Physiotherapist on site as inpatients using the predictor measure at between 3-4 weeks post-operatively. They were then interviewed by a trained amputee visitor at home using the follow-up measures at 1-month and again at 6-months post-discharge from hospital.

Statistics: The outcome variables were entered into multiple regression equations to assess the extent to which they were predicted by the predictor variables.

RESULTS

The symptoms most frequently reported by the participants were phantom feelings, pain, weight change, phantom pain and stump pain (Fig. 1).

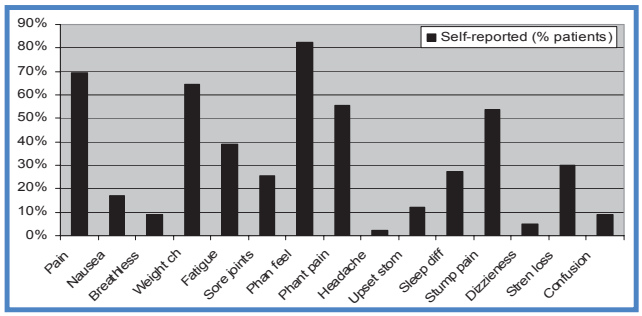

Figure 1: *Self-reported symptoms at recruitment (N = 166)*

Both a) **prosthetic use**, and b) **independence and mobility** improved between 1-month and 6-months follow-up.

Significant SRM psychological variable regression models emerged for predicting **prosthetic use**, with *timeline cyclical* (perceptions of symptoms fluctuating) and *treatment control* (beliefs about treatment efficacy) being the most influential determinants. Their effect was stronger at 6-months than at 1-month. For predicting **independence and mobility**, *timeline cyclical* and *treatment control* were again the most influential psychological variables at both 1-month and 6-months. *Emotional representations* (distressing thoughts) were also influential, but only at 1-month.

DISCUSSION AND CONCLUSION

This study has identified how psychological variables determine **prosthetic use** and **independence and mobility** in amputees. Such knowledge is valuable because it raises the prospect of being able to a) identify patients whose psychological profile renders them more at risk of not rehabilitating and functioning successfully with a prosthesis, and b) formulate elements of psychological care aimed at increasing the number of patients making effective use of their prosthesis and achieving improved independence and mobility post-discharge from hospital.

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INFLUENCE OF AMPUTATION LEVEL ON PROSTHETIC WALKING IN OLDER PATIENTS

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Abstract

The aim of the study was to confirme that the level of amputation influenced walking speed and endurance in older patients. The study included 16 subjects, from 62 to 82 years old with TF (transfemoral) or TT (transtibial) amputation. The speed was measured as the time needed to cover the distance of 10 meters. The endurance was measured as the distance covered in 6 minutes. The subjects were tested when receiving the prosthesis and after 14 days of its use.

INTRODUCTION

Gait is a basic everyday activity of humans and it does not require special attention. It can become a problem when changes of neuromuscular and skeletal systems occur.

In persons with TT amputation the muscular activity of the sound leg during stance phase is normal or very similar (1). On the contrary the amputated side shows reduced activity of knee extensors (1). The toe - off is weak because of the absence of plantar flexors. Extensors of the hip take over the work of plantar flexors. The swing phase is normal on both sides (1).

Sensorymotor function of the leg after TF amputation is strongly reduced. To achieve stability the person should change his or her gait pattern. In the first 30-40 % of the stance phase the person must not allow any flexion of the prosthetic knee. At that time, the activity of hip extensors must increase extremely. The toe- off is normally made by cocontraction of plantar flexors and hip extensors. In person with TF amputation, even though the prosthesis weighs 30 % of the weight of the leg, the hip extensors must generate equal strength of contraction because of the absence of plantar flexors. When the stance phase of the sound leg is observed, one can see increased activity of hip extensors and plantar flexors. In that manner, the person compensates for the absense of toe -off on the amputated side. Sometimes increased activity can be seen in plantar flexors of the sound leg, which causes raising of the body' center of gravity. The swing phase with prosthesis is easier (1).

The aim of the study was to confirm that the level of amputation influenced walking speed and endurance in older patients.

METHODS AND SUBJECTS

Methods

The speed was measured as the time needed to cover the distance of 10 meters. The endurance was measured as the distance covered in 6 minutes. The subjects were tested when receiving the prosthesis and after 14 days of its use.

To measure the speed and endurance a stop watch and a tape measure were used. The results were statistically analysed with SPSS software. T- test , paired T- test and Pearson's coefficient of correlation were used.

Subjects

The study included 16 subjects, all of them after TF or TT amputation. The subjects were from 62 to 82 years old. In each group there were 6 man and 2 women. The subjects had normal ROM (range of motion) of joints, were capable of walking with crutches and had no severe problems with the sound leg. They were all involved in the rehabilitation program at the Institute for Rehabilitation, Republic of Slovenia in Ljubljana. All the subjects were fitted with the prosthesis (PTB prosthesis or above knee prosthesis with locked knee).

RESULTS

A significant increase in walking speed after 14 days of training was found in both groups of subjects (p=0.000). Walking endurance improved significantly after 14 days of training in both groups (p=0.001 ; p=0.003).

Even at the second measurement, the subjects after TF amputation did not reach the walking speed of the subjects with TT amputation at the first measurement (p= 0.001). Walking endurance improved in subjects after TF amputation at the second measurement, however, it did not reach the endurance of the subjects after TT amputation at the first measurement (p=0.001; p=0.000).

The Pearson's coefficient of correlation showed that there was no statistically significant correlation between the length of the stump and the speed and endurance of walking. Also, there was no statistically significant correlation between the age of the subjects and the speed and endurance of walking (independently of the level of amputation), except at the first measurement of walking speed (p= 0.037).

DISCUSSION

On the basis of everyday clinical practice the amputation at TT level is said to be more favourable than the amputation at TF level.

The manner of walking depends on age and sex. Older patients walk more slowly, because it is safer. The research on older persons has found the speed in optimal walking to range between 60 to 100 m/min (women - 74m/min ; men - 82m/min)(2). The results of the present study showed that the level of amputation influenced the walking speed. The subjects with TT amputation walked faster than the subjects with TF amputation. Even at the second measurement the subjects after TF amputation even after second measurement did not reach the walking speed of the subjects after TT amputation at the first measurement.

The level of amputation influences energy expenditure as well as walking speed and endurance. Erjavec (2) states that in persons after TT amputation the oxygen uptake -VO2 is 12.0ml/kg min and the cost index is 0.33ml/kg m . The walking speed with that energy expenditure is 36.2 m/min.In persons after TF amputation, VO2 is 14.9 ml/kg min and the cost index is 0.52 ml/kg min. With that energy expenditure, the walking speed is 28.2 m/min.

Burger (3) compares healthy persons with persons after TT and TF amputation. The subjects were tested with Fullart Functional Test and with Balance Test (Tsukuba Functional Age Inventory). The results showed that the level of amputation influenced activities such as: balance, standing up from chair, walking on the spot, walking distance (in 9 min TT - 441 m ; in 9 min TF -287 m).

Waters (4) finds that persons with TT amputation walk at a speed of 45m/min (59 % of normal gait speed), while persons with TF amputation walk at a speed of 36m/ min (44 % of normal gait speed). The present study found that the average speed in persons after TT amputation at the first measurement was 29 m/min and at the second measurement 34 m/min. The average speed in persons with TF amputation at the first measurement was 22 m/min and at the second measurement 25 m/min.

The difference between both studies is that Waters measured his subjects after 6 month of using the prosthesis, while the present study measured the subjects after 14 days.

CONCLUSION

It can be concluded that the level of amputation influences the speed and endurance of walking. The remaining knee joint is very important for walking with prosthesis and influences rehabilitation outcome.

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MEASUREMENT OF REHABILITATION OUTCOME IN LOWER LIMB AMPUTEE (LLA) PERSONS: PROSTHETIC PROFILE OF THE AMPUTEE (PPA), LOCOMOTOR CAPABILITIES INDEX (LCI) MOBILITY SUBSCALE, FIM AND BARTHEL INDEX

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Abstract

The objective of study was to evaluate the extent of prosthetic use in the group of 40 adult unilateral lower limb amputees (LLA) - 20 transtibial amputation (TT) and 20 transfemoral (TF) amputation, in mean age 64.67 + 5 years. The Prosthetic Profile of the Amputee (PPA) and Locomotor Capabilities Index (LCI) specificate questionnaires were used. Additional measurement was done by Barthel index and FIM.

Results of our study show that all patients use their prosthesis. 97.5% of them wore their prosthesis daily (100% TT, 95% TF). Eighty-five % of TT amputees reported wearing their prosthesis for more than 9 hours per day while 60% of TF patients wear their prosthesis up to 8 hours. Indoors, 82.5% prosthetic users were independent and used their prosthesis for locomotion (90% TT and 75% TF). Outdoors, the proportions of active users were decreased up to 70% (75% TT, 65% TF).

INTRODUCTION

The ultimate goal of rehabilitation in LLA persons is the best possible way of their reintegration with the environment, with an optimal physical, mental, emotional, social, vocational and economic efficiency (1). This type of intervention requires a multidisciplinary approach and has been a cornerstone of the restoration of locomotor function through the use of prosthetic devices (2). There is an increasing demand for objective reporting of outcomes in this field, also in order to better understand the main reasons for long-term use/disuse behaviour after discharge from rehabilitation, including the typical problems encountered by an amputee at home or in the community (3).

METHODS AND SUBJECTS

Methods

The aim of the study was to determine the level of function and extent of prosthetic use (in terms of frequency, duration of use, mobility, activities done, etc.), to measure major life domains connected with prosthesis function, and to study the factors potentially related to prosthetic use. For that purpose we used two self-report scales of prosthetic mobility for the amputee population: the Prosthetic Profile of the Amputee (PPA) and Locomotor Capabilities Index (LCI), in the form of face-to-face interviews.

The objective of the PPA is to evaluate prosthetic wear and active use of the prosthesis and to identify the factors that predispose to, enable, and reinforce prosthetic use. The PPA questionnaire consists of 44 closed-ended questions in which measurement scales are qualitative, nominal, and ordinal scales with a few quantitative ratio scales. The questions were arranged in six sections:1) the physical condition of the subjects, 2) their satisfaction and adaptation to the prosthesis, 3) the prosthetis use, 4) the physical and social enviroment, 5) leisure activities and 6) demographic characteristics of the respondents (4).

The LCI computes the global, basic, and advanced locomotor skills of the lower limb amputee with the prosthesis and assesses level of independence (5).

Measurements of outcome after amputation were also done by using the measures which were developed for subjects with other patologies such as Barthel and FIM (Functional Independence Measure). FIM and Barthel were used to provide a “basic indication of severity of disability” for rehabilitation clients (6, 7).

SUBJECTS

Study population consisted of 40 unilateral adults LLA persons; twenty with TT aputation, in mean age 62.3 years (range 20 - 81 yrs) and twenty with TF amputation, in mean age 67.05 years (range 32 - 85 yrs). All patients volunteered to participate in this study. All patients had completed a prosthetic training program in the Institute for Rehabilitation and Orthopaedic Devices (IROD) University Hospital Zagreb. The time lapse between the date of amputation and the time of testing ranged from one to five years.

RESULTS

The results of prosthetic use analysis have shown that all respondents (40 pts) were prosthetic users. All of TT amputees and 95% of TF amputees reported wearing their prosthesis daily. Eighteen (85%) of TT amputees reported wearing their prosthesis for more than 9 hours per day. Most of TF patients (60%) wore their prosthesis up to 8 hours and 40% for more than 9 hours per day. The respondents were also asked to report the proportion of ambulatory activities done with their prosthesis daily. Figures demonstrated 82.5% of prosthetic users were independent and used their prosthesis for locomotion indoors (90% of TT and 75% of TF). Contrary, the proportions of active users in all outdoors activities were decreased up to 70% (75% of TT and 65% of TF). People with TF amputation reported higher rate of falls (TT 5%, TF 15%), as expected.

Results of FIM and Barthel index indicated the same disability and functioning level for all LLA. According to FIM thirty eight (95%) of all respondents were completely independent and Barthel index showed 95% of them were completely independent to slightly dependent.

DISCUSSION

The results of this survey indicated that almost all subjects wore their prosthesis regularly, weekly (97.5%) and are satisfied prosthetic users. In presented study all respondents took their interview during their renewed prosthetic exchange and training in the IROD. They received their first prosthesis and managed their prosthetic training one to five years ago. Most of TT amputees (85%) reported wearing their prosthesis for more than 9 hours per day while most (60%) of TF patients wear their prosthesis up to 8 hrs. The persons with TT amputation were more skilfull in all tests in comparison with TF amputees. There is higher percentage of prosthetic use for indoors moving around (90% TT and 75% TF) than for outdoors (75% TT and 65% TF) in a day. The results of our study were similar to the results of the Gauthier - Gagnon's study that used the same tools (PPA and LCI) (8).

CONCLUSION

The study participants with lower limb amputation were prosthetic wearers and wore their prosthesis daily. To summarize, parameters of active prosthetic use and locomotor activities were better in the group of TT in comparison with the TF patients.

From the viewpoint of an activity after amputation, although there are several of existing measures, according to our experience and to the literature (8-10), the best option is to use scales which are developed specifically for subjects after lower limb amputation.

The results from our study confirmed PPA and LCI to be the specific instruments for persons with lower limb amputation which are therefore valid and reliable instruments to assess prosthetic use. Moreover, they can measure major life domains connected with prosthesis function, and study the factors potentially related to prosthetic use or nonuse. The LCI, included as a question in PPA, evaluates locomotor capabilities of the fitted lower limb amputation.

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MEASURING QUALITY OF LIFE IN PATIENTS AFTER LOWER LIMB AMPUTATION

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INTRODUCTION

Lower limb amputation represents a demanding life situation for the patient because it can act negatively in the long term, increase stress and cause many complications. Patient must adapt to a new situation and physical, mental and social changes which the amputation breeds. This also impacts on perception of the quality of life. Many studies focus on measurement of psychological distress with accent on anxiety, fear and depression. Less attention has been paid to the level of positive or negative feelings that can indicate so called psychological wellbeing which is also an important component of the quality of life. The aim of our research study was to measure the quality of life and emotional experience in patients after amputation, to compare the results with common population and to analyze the influence of lower limb amputation on patient's quality of life and emotional life.

METHODS AND SUBJECTS

For measurement of quality of life the World Health Organization WHOQOL-BREF questionnaire was used. It comprises 24 issues joined into four domains (physical, psychological social spheres and environment) and two independent issues evaluating the general quality of life and health condition. For findings of mental condition and emotions the modified PANAS (Positive and Negative Affect Schedule) questionnaire was used and be means of it the emotional balance was measured. The questionnaire consists of 16 descriptors of different emotional conditions of which 7 are positive and 9 negative emotions. Subjects recorded on a seven-point-scale (from 1 = always to 7 = never) how often they experienced these emotions during the last four weeks.

Subjects

Research group consisted of 86 patients after lower limb amputation. 63 respondents agreed with inclusion into the research study. All of the 63 respondents filled out WHOQOL questionnaire. Only 50 subjects filled out PANAS questionnaire. Average age of the subjects was 60 years. Average duration after lower limb amputation was 2.17 years.

RESULTS

Average scores of single issues in WHOQOL-BREF questionnaire

In men higher score of quality of life was found in the domains physical health, experience and environment. On the contrary, women had higher score in the domain social relations. No statistically significant differences depending on the time passed since amputation were ascertained.

Testing differences between the studied group and common population

Patients after lower limb amputation have significantly lower score in quality of life in domains physical health, experience and social relations than common population measured by means of WHOQOL-GREF questionnaire.

Testing differences between the studied group and reference population according to age groups

Testing results in particular age groups show that limb amputation influences the score of quality of life in the domains psychological and social sphere only up to the age of 50. Patients after lower limb amputation over 60 had significantly lower score of quality of life only in the area physical health when compared to common population over 60.

Emotional balance evaluation

Lower emotional balance in patients after lower limb amputation was found when compared to healthy subjects. This difference was not statistically significant. During testing the connection between emotional balance and quality of life, relatively high correlation in domains physical health and experience was proved.

DISCUSSION

Results of the survey measuring quality of life show significant decrease in perception of the quality of life in patients after lower limb amputation in physical, mental and social spheres in comparison to common population. Emotional balance correlates with quality of life, namely in the domains physical health, experience and with general assessment of quality of life and health condition. It can be stated that assessment of quality of life itself and general state of health assessment do influence experiencing of positive and negative emotions.

CONCLUSION

Demands of this problem and its extensiveness lead necessarily to the conclusion that a multidisciplinary team should be established for treating patients after lower limb amputations and the team should comprise surgeons, physiotherapists, psychologists, occupational therapists, prosthetists and social workers. Only cooperation of these professionals can provide the patient being cured with respect to his pre-amputation health condition but also with outlook for his future life with amputated extremity when all his physical, mental and social possibilities can be maximally respected and the opportunity to their full exploitation must be given.

DEVELOPING A MEASUREMENT TOOL FOR SETTING GUIDELINES FOR IMPROVEMENT OF LOWER LIMB ORHTOTIC HEALTH SERVICES IN IRAQ

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Abstract

A descriptive cross-sectional study utilizing an evaluation approach carried out on 150 subjects wearing Knee-Ankle-Foot orthosis or Ankle-Foot orthosis attending governmental orthotic workshops in Baghdad city from Nov. 30th, 2005 till Jul. 30th, 2006 to develop a measurement tool for setting guidelines for improvement of orthotic health services in Iraq. Findings show that poliomyelitis was the leading cause (80%) for these disabilities, conventional Knee-Ankle-Foot and rigid polypropylene Ankle-Foot orthoses were the most commonly manufactured orthoses in these workshops. Assessment of currently worn orthoses reveals that they have sever problems (>50%) in their technical and social and general behavioral aspects, and mild problems (<50%) in their medical and technico-medical aspects. The psychoneurotic profile of the studied sample shows Anxiety state as a leading scale (mean value of 11.31) on the Crown-Crisp Experimental Index. Factor Analysis study revealed that in order to set guidelines for improvement of lower limb orthotic services in the country, the following factors should be taken into consideration according to their percentage of participation: 1- Factor one: Anxiety (46.69%) 2- Factor two: Rehabilitation (22.54%) 3- Factor three: User (15.87%) 4- Factor four: Somatoform (14.84%) These factors were built and nominated for the first time in this study, which also sets a sketch of guidelines to be followed in order to improve lower limb orthotic health services in the country.

INTRODUCTION

Increasing number of disabled people is due to the population growth, conflicts, birth defects, aging, emergence of chronic diseases and injuries and medical advances that preserve and prolong life. These trends create overwhelming demands for health and rehabilitation services. Among health related rehabilitation services there are orthotic services that play a very important role in the promotion of functioning and enhancing quality of life. The importance of this study resides in the following two facts: first, there isn't any published study concerning assessment of lower limb orthoses manufactured at governmental orthotic workshops in Iraq and second, no one had set guidelines on how to promote and improve lower limb orthotic health services in the country, based on the increased awareness of the dynamics of human behavior, personality, and psychological factors behind the physical impairment of the patient.

In a country like Iraq, with rich history of wars, conflicts, and lack of effective rehabilitation services, the role played by orthoses in rehabilitation services emerges very clearly and the need to promote and improve these services will be, beyond any doubt, of equal importance The objective of this study is to improve lower limb orthotic health services through assessment of current lower limb orthoses delivered to patients attending governmental orthotic workshops in Baghdad city and developing a measurement tool to set guidelines for promotion and improvement of these services.

METHOD

Subjects: selection criteria involve every patient above 12 years old who wears unilateral Knee-Ankle-Foot or Ankle-Foot orthosis for at least four continuous weeks (not less than 5 hours per day, 6 days per week) regardless the etiology of the disability and referral, attending governmental orthotic workshops in Baghdad city from Nov. 30th, 2005 till July 30th, 2006. 150 patients (83 males and 67 females) participated in this study. *Apparatus:* the study employed a self-completed questionnaire consisting of five groups, namely; technical group (G1), medical group (G2), technico-medical group (G3), social and general behavioral group (G4) and psychoneurotic group (G5). The first four groups of questionnaire were modified from prosthesis evaluation questionnaire using visual analogue scale by Legro, et al 1998 (1) and built on experience and consultation of experts in this field. The fifth group of questionnaire used the Crown-Crisp Experimental Index (CCEI) scales; by Crown and Crisp, 1966 (2); for measuring psychoneurotic

status of the study sample. *Procedure:* 150 subjects from different governorates of Iraq attending the three governmental orthotic workshops in Baghdad city (namely; medical rehabilitation centre, Baghdad centre and Al-Wasity hospital orthotic workshop) from Nov. 30th, 2005 till July 30th, 2006 agreed to participate in the study through answering the questionnaires and responded completely and correctly to its requirements. *Data Analysis:* for the five groups of questionnaire will be as follows:

Group one questionnaire; evaluation of the technical aspects of the orthosis; (G1).

Each patient was requested to respond to the visual analogue scale (VAS) of the questionnaire. The questionnaire of this group consists of seventeen questions about different technical aspects of the current orthosis, such as fitness, heaviness, comfort, alignment, cosmetic features, restriction to uses…etc. Each answer will be measured by using the rating scale extending from 0 (zero) at the low end to 10(ten) at the high end with the cut-off point at 5(five) in the middle and the answers will be scored as follows: <5= Mild response (Mild problem) 5-10= Serious response (Serious problem).

Group two; evaluation of the medical aspects of the orthosis; (G2).

The patients were requested to complete this group of three main questions that covers very specific bodily sensations such as pressure, tickle or a sense of position or location and pain. Each answer will be measured and scored as in group one (G1).

Group three; evaluation of the technico-medical aspects of the orthosis; (G3).

This group of five questions covers the combined effect of technical and medical aspects of the orthosis such as sweating inside orthosis, liberation of bad odor, appearance of rash (es) or ingrown hairs (pimples) on the limb and formation of blisters or sores. Each answer will be measured and scored as in group one (G1).

Group four; evaluation of the social and general behavioral aspects of using the orthosis (G4).

Each patient was asked to complete this group of seven main questions about stranger's reactions to the orthosis, frustrations with the orthosis, response of the patient's partner to the orthosis, ability to move around, ability to do the daily living activities when having problems with the orthosis and importance of different aspects of orthosis to the patient. Each answer will be measured and scored as in group one (G1).

Group five, evaluation of the Psychoneurotic states of the subjects (G5)

The patients were called to complete an Arabic version of Crown and Crisp Experimental Index (CCEI) that is used as a measuring tool for psychoneurotic status of the sample of the study. It is a self -reporting inventory constituted of 48 questions and provided scores of (0-16) on six psychoneurotic scales, to be answered by (Yes) or (No) or Sometimes. The responses were scored accordingly (No=0, Sometimes=1, Yes=2) and the mean of the whole sample on each scale calculated.

RESULTS

Table (1) shows some characteristics of the disability and the work done for such disability. The most common cause of lower limb disability among the studied sample was poliomyelitis (80%), followed by accidents (16%), then congenital causes (3.3%) and finally acquired diseases (0.7%). Most of the subjects (80.7%) had the disability for more than twenty years, the right lower limb being affected in seventy nine subjects and left lower limb in seventy one. One hundred and eleven subjects had their lower limb orthoses done at the Medical Rehabilitation Center, twenty subjects at Baghdad Center and nineteen subjects at Al-Wasity Center. 70% of the manufactured orthoses were conventional KAFOs, 14.7% were hybrid KAFOs, 8% rigid polypropylene AFOs and 7.3% flexible polypropylene AFOs

Table 1: *Some disability and orthosis properties of the sample*

Disability and Orthosis	Frequency	OPercent
Cause of disability Congenital Acquired - Poliomyelitis - Accident - Disease Total	5 120 24 1 150	3.3 80.0 16.0 0.7 100.0
Age of Disability(Years) <1 1-5-10-15->20 Total	6 10 2 6 5 121 150	4.0 6.7 1.3 4.0 3.3 80.7 100.0
Side of Disability Right Left Total	79 71 150	52.8 47.2 100.0
Workshop Medical Rehabilitation Centre Baghdad Centre Al-Wasity Centre Total	111 20 19 150	74.0 13.3 12.7 100.0
Type of Orthosis KAFO, hybrid KAFO, convention. AFO, rigid poly. AFO, flexible poly. Total	22 105 12 11 150	14.7 70.0 8.0 7.3 100.0

Table 2 summarized subjects' responses to the whole four groups of the evaluation questionnaire, where (G1) and (G4) show serious grades, (G2) and (G3) show mild grades and the global response (G) appears to show serious grade.

Table 2: *Summarized statistics of the whole four groups (G1, G2, G3 and G4)*

Group	N.	Range	Min. Score	Max. Score	Mean	S. E.	St.D.	R.S.	Grade
G1 G2	150	6.7 6.4	3.1 0.5	9.8 6.9	6.055	0.123	1.503	60.55	Serious
G3 G4	150	9.0 5.3	0.6 3.8	9.6 9.1	3.868	0.125	1.535	38.68	Mild
G	150	4.1	3.5	7.6	4.626	0.168	2.061	46.26	Mild
	150				5.925	0.101	1.233	59.25	Serious
	150				5.118	0.070	0.858	51.18	Serious

N = Number of subjects, S.E. = Standard Error, St.D. = Standard Deviation,R.S. = Relative Sufficiency G = global response which involve the whole four groups

Table (3) summarized the mean scores of the whole samples on the six scales of the CCEI. Anxiety scale was found to score the highest mean (11.31) among other scales in this study, followed by Depression (9.31), Hysteric (8.96), Somatic (8.92), Obsessive (8.69) and Phobia (8.59) scales respectively.

Table 3: *Summarized statistics of the whole items of the CCEI scales of the psychoneurotic group (G5)*

Psychoneurotic scale	N.	Min. Score	Max. Score	Mean	St. D.
Anxiety Phobia	150	7 3 5 5	16 16	11.31	1.98
Obsessive Somatic	150	6 6	13 14	8.59	3.00
Depression Hysteric	150		14 13	8.69	1.81
	150			8.92	1.81
	150			9.31	1. 58
	150			8.96	1.54

Table (4) indicates that four main factors (components) have been named to construct a measurement tool required for developing guidelines to improve lower limb orthotic health services.

Table 4: *Created Factors from Rotated Component Analysis.*

Components	Variables	More than 50%	Suggested Factor's Nomenclature
1st Component (1)	-Anxiety -Depression -Somatic -Phobia -Obsessive	.751 .743 .723 .719 .624	Anxiety
2nd Component (2)	-Technical (G1) -Social & General Behavioral (G4)	.903 .816	Rehabilitation
3rd Component (3)	-Medical (G2) -Technico-Medical (G3)	.858 .511	User
4th Component (4)	-Hysteric (Conversion)	.914	Somatoform

For the 1st Component; Anxiety, Depression, Somatic, Phobia and Obsessive states of the studied subjects had more than 50% effect, i.e. main contents and types, (.751, .743, .723, .719 and .624 respectively) and suggested to be named **Anxiety*** factor.

* These names were suggested after consultation with the psychiatric specialist Dr. Mushtaque T. Hashim, Head of Department of Psychiatry, Baghdad Hospital, Ministry of Health, on November 5th, 2006.

For the 2nd Component; Technical and Social and General behavioral aspects related to the used orthosis had more than 50% effect (.903 and .816 respectively) and suggested to be named **Rehabilitation** factor.

For the 3rd Component; Medical and Technico-Medical aspects of the used orthosis had more than 50% effect (.858 and .511 respectively) and suggested to be named **User** factor.

For the 4th Component; Hysteric (Conversion) state of the studied sample had more than 50% effect (.914) and suggested to be named **Somatoform*** factor.

DISCUSSION

The art and science of full orthosis construction is so full of subtleties and delicate combinations of resourcefulness that truly successful restoration is not routine occurrences [3].This study has been carried out as an attempt to gain more information, about factors relevant to the success and improvement of orthosis treatment. Throughout this chapter, interpretation and discussion of the findings are presented with supportive evidences; when available; from literature.

Discussion of disability and orthosis properties, table (1):

The majority of the subjects (80.0%) were post poliomyelitis victims and having the disability for more than twenty years (80.7%), this may be attributed to the inefficient or deficient previous national programs for poliomyelitis immunization on one hand and the devastation made by wars that Iraq had gone through during the past three decades on the other hand. Medical Rehabilitation Centre was the leading centre among the three orthotic centers in Baghdad in manufacturing lower limb orthosis (74.0%) because it is the biggest and oldest governmental orthotic workshop in Baghdad and it is well known to the community and the referring physicians. Most of the manufactured lower limb orthses (84.7%) were KAFOs, because the most common cause of disability among the study population was poliomyelitis which affected the whole lower limb muscles, being conventional (70%) more often than Hybrid (14.7%) KAFOs were attributed to the available raw materials. The above findings coincide with the work done by Lung, 2004 (4).

Mtalo, 2006 (5) and Lastring, 2006 (6) about evaluation of Pre-Fabricated Knee-Ankle Foot Orthoses (PFKAFOs) on post poliomyelitis victims.

Discussion of the summarized statistics of the whole four groups (G1, G2, G3 and G4), table (2):

The findings showed that there were serious problems (defects) in the technical aspects and in the social & general behavioral aspects related to the currently used orthoses (R.S. =60.55 and 59.25 respectively), whereas both medical and technico-medical aspects represented mild problems (R.S. =38.68 and 46.26 respectively). The overall response (Global response, G) of the whole four groups showed serious problem (R.S. =51.18).

Discussion of the summarized statistics of subjects' psychoneurotic states (G5), table (3):

Crown - Crisp Experimental Index (CCEI) has been chosen for this study because it had been found to be a valid and reliable instrument to assess the psychoneurotic states of the studied sample (7). It is easily applicable as a self - rating scale and its Arabic version had been used already in other studies in Iraq. The highest score of mean values of the six scales of CCEI of the studied groups was to Anxiety state (11.31), The symptoms of Anxiety were the component of almost every psychiatric disorder, and Anxiety disorders were found to be the most prevalent diagnosis in an adult community sample (8) and since most of the study samples belong to adult age group which represent (71.3%), this explained why Anxiety state was found to score the highest mean value among other scales. The next highest mean value was to depression scale (9.31), this may be due to the fact that the majority of the study samples (83.3%) have had permanent disability which was a painful emotional connotation in addition to their physical trauma, these findings almost coincided with those done on Iraqi war disabled individuals in 1987 (9).

Discussion of factors needed for developing a measurement tool to set guidelines for improvement of lower limb orthotic health services through factor analysis, table (4):

Factor analysis attempts to identify underlying variables, or factors, that explain the pattern of correlations within a set of observed variables. It is often used in data reduction to identify a small number of factors that explain most of the variance observed in a much larger number of manifest variables. Factor analysis can also be used to generate hypotheses regarding causal mechanisms or to screen variables for subsequent analysis (10). The analysis indicates that the process of creating guidelines for improving lower limb orthotic health services is significantly affected by the first factor **(Anxiety)** which is a new factor resulted from studying the psychoneurotic states (Anxiety, Depression, Somatic, Phobia and Obsession) of the study population, followed by the second factor **(Rehabilitation)** which results from studying the technical (G1) aspect and social & general behavioral (G4) aspect of the evaluation questionnaire, followed by the third factor **(User)** which results from studying the medical (G2) aspect and technico-medical (G3) aspect of the evaluation questionnaire, followed by the last factor **(Somatoform)** which results from studying the psychoneurotic state Hysteric (Conversion) of the study population. Anxiety, Rehabilitation, User and Somatoform factors were constructed and named for the first time in this study, as far as our knowledge is concerned.

CONCLUSION

The study findings indicate the following conclusion:

Poliomyelitis was the leading cause (80%) of disability among lower limb orthotic patients (above twelve years old) attending governmental orthotic workshops in Baghdad city.

Conventional KAFOs, which constituted (70%) of whole production and Rigid Polypropylene AFOs (8%) were the most commonly manufactured lower limb orthoses in these workshops.

The assessment of the currently worn orthoses, through Visual Analogue Scale (VAS) evaluation questionnaire, revealed that these orthoses had serious problems in their technical aspects (72.5%) and social and general behavioral aspects (64.8%), and mild problems in their medical aspects (16.6%) and technico-medical aspects (40%).

The psychoneurotic profiles of the studied sample showed that Anxiety state is the leading scale on Crown and Crisp Experimental Index (CCEI). Whereas professional practice in orthotics may not necessitate an in-depth knowledge of associated psychological disorders, professionals should be aware of the psychological issues that may influence the rehabilitation of their patients. Such knowledge may help to facilitate appropriate referrals and enhance the collaborative process of multidisciplinary teamwork.

• Factor analysis study revealed that in order to develop a measurement tool to set guidelines for improvement of lower limb orthotic health services in the country, the following four factors should be taken into consideration according to their percentage of participation:

Factor one: **Anxiety (46.69%)**
Factor two: **Rehabilitation (22.54%)**
Factor three: **User (15.87%)**
Factor four: **Somatoform (14.84%)**

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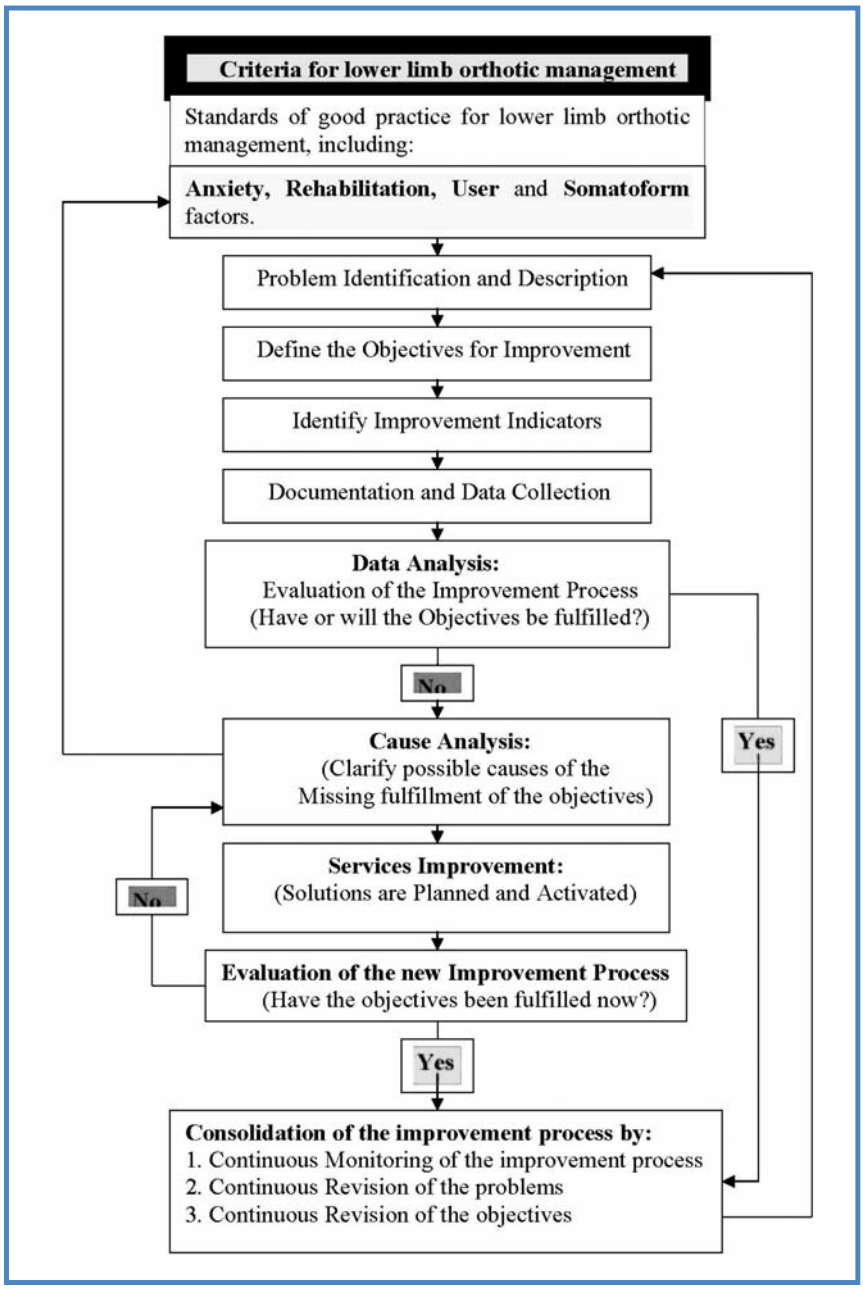
Here in a sketch for guidelines, utilizing the above mentioned factors, to improve lower limb orthotic health services' process



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THE USE OF ORTHOSES IN REHABILITATION OF NEUROLOGICAL PATIENTS

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Abstract

The use of orthoses and other rehabilitation devices is an important part of neurological rehabilitation. The following article presents data about the orthotic use and the results of inpatient rehabilitation of 75 adult patients with neurological diseases or traumatic brain injuries. The acquired data indicate the differences between different age groups regarding the results of rehabilitation as well as the orthotic use. The highest FIM score was achieved within the group of patients under the age of 55. This group of patients was prescribed also the highest rate of orthoses. The analysis of the orthoses use shows that these are the most widely used in the group of patients within the middle range of functional disability. The use of other rehabilitation devices is more equally spread among different functional and age groups.

INTRODUCTION

Patients with neurological diseases or injuries often need appropriate rehabilitation treatment to help them recover their functional abilities and to improve their quality of life (1). The prognosis and the rehabilitation results are influenced by several circumstances (2). Rehabilitation procedures as well as the prescription of an orthosis and other rehabilitation devices are chosen for each patient individually according to their special needs. Orthoses are used in all stages of rehabilitation. They are most commonly prescribed to provide support and improve gait (3, 4) or to reduce pain and prevent contractures of spastic extremities (5, 6). An orthosis may be prescribed for a limited period of time, for a longer term or for permanent use.

The article shows the results of the inpatient rehabilitation of adult neurological patients in the years 2006 and 2007 including the data about the use and prescription of orthoses.

METHODS AND SUBJECTS

The data were collected from patient records of all adult neurological patients, who were admitted to our department in the years 2006 and 2007. All patients were transferred to our department from an acute setting. Fifteen most disabled patients with extremely poor rehabilitation potential (persistent vegetative state, terminal stage of malignant diseases etc), who needed only skilled nursing and medical care, were excluded from the study.

The use of orthoses and other rehabilitation devices were compared within different age and functional groups. Functional groups were formed by using Functional Independence Measurement (FIM) ratings gained at discharge.

RESULTS

A total of 75 patients (40 males, 35 females) with various neurological impairments were included in the study. Of these, 50 stroke patients (CVI), 5 patients with serious traumatic brain injuries, 8 patients with degenerative brain diseases or other impairments of the central nervous system (Parkinson's disease, ALS, states after infections of CNS or states after neurosurgery) and 12 patients with spinal cord injuries or severe polyneuropaties. Among patients with stroke, there were 24 with right sided hemiparesis and 26 with left side hemiparesis. The average age was 69.6 years SD 11.9 (from 43 to 91 years). The average age in the largest group of stroke patients was 69.8 years SD 10.9 (from 43 to 87 years). The average age of all other groups was 69.4 years SD 12.6 (from 49 to 91 years). Patients were divided into 5 age groups: group up to 55 years, 56 to 65, 66 to 75, 76 to 85 years and older than 86 (Figure 1).

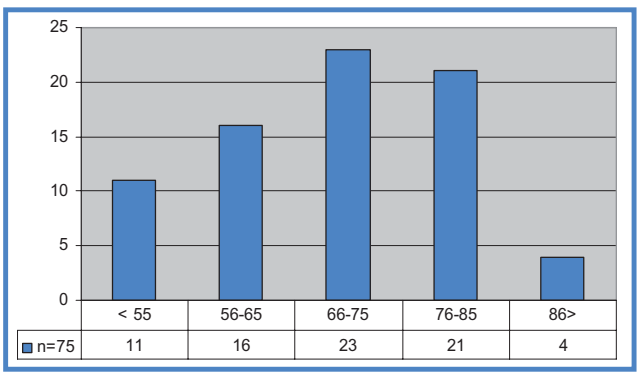


Figure 1: Age groups of patients

The average length of stay was 45 days. The mean admission FIM was 46 points (mFIM 26 points, cFIM 20 points). The mean discharge FIM was 76 points (mFIM 52 points, cFIM 24 points). Differences between age groups were noticed at the end of the rehabilitation. Age groups varied in the length of stay as well as in the final functional assessment (Figure 2). The longest stay was recorded in the youngest group of patients (under age 55). However, the same group also achieved the highest discharge FIM score.

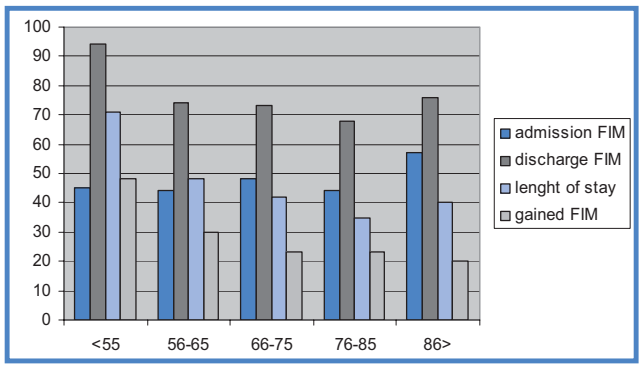
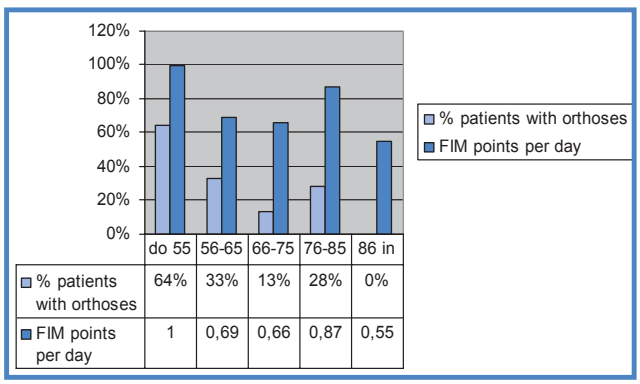


Figure 2: *Differences between age groups*

The highest rate of orthotic use was recorded in the youngest group of patients whereas the lowest rate was observed in the oldest group (Figure 3). Higher rate of orthoses use coincides with faster improvement of functional abilities in rehabilitation process.



	do 55	56-65	66-75	76-85	86 in
% patients with orthoses	64%	33%	13%	28%	0%
FIM points per day	1	0,69	0,66	0,87	0,55

Figure 3: *Comparison of orthoses prescription and improvement in rehabilitation*

The study showed that orthoses for lower extremities were used more often (58% of all prescribed orthoses) than other orthoses. Among these, the ankle foot orthoses (plastic leaf-spring AFO, plastic solid AFO, metal AFO) were most commonly prescribed. Knee orthoses were rarely used. For the upper extremities (42% of all prescribed orthoses) the static wrist hand orthoses and shoulder slings were used in most cases.

The prescription of other rehabilitation devices (wheelchairs, walkers, orthopaedic shoes and other utilities for daily activities), which cover a wide range of disabilities, was much more equally spread among different functional groups (Figure 4).

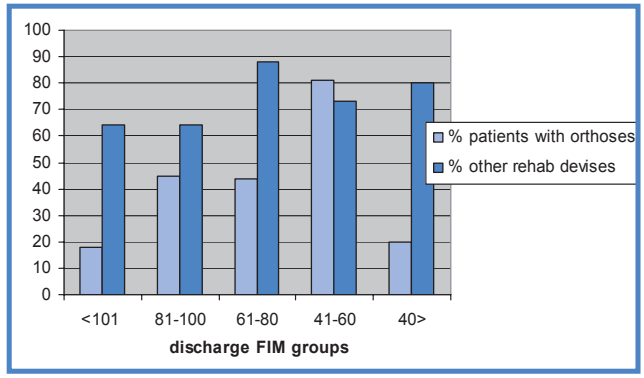


Figure 4: *Prescription of orthoses and other rehabilitation devices for different functional groups*

DISCUSSION

In this study the youngest group achieved the highest FIM score at discharge. Better FIM was reached partly due to longer stay in our rehabilitation department (Figure 2). However, the same group showed the fastest trend of improvement too. On average, patients under age 55 were gaining 1 point on FIM per day, whereas patients in older groups were obtaining lower scores. The oldest group was gaining only 0.55 point per day (Figure 3). The result indicates better rehabilitation potential of younger patients with neurological impairment.

Although one can observe an obvious correlation between the percentage of patients using orthoses and their higher rate of improvement it cannot be confirmed that the relation between these two issues is immediate. Therefore it has to be more carefully interpreted. Firstly, the number of patients and orthoses included in the study was to low to be also statistically significant. Secondly, even if it were statistically significant, we could not claim that better result (number of FIM points per day) is directly influenced by the use of orthoses. Successful rehabilitation depends on the high number of factors, the prescription of a suitable orthosis being just one of important therapeutic interventions in this complex process.

In order to find out whether there exist any correlations between functional disability and the number of prescribed orthoses, patients were divided into subgroups according to their discharge FIM ratings (Figure 4). The lowest percentage of orthoses use was recorded in the groups with mild and severe disability, whereas the highest rate was registered in the groups with moderate level of disabilities. The purpose of orthotic prescription is often to restore or improve walking abilities. In the group with the lowest FIM score functional ambulation is frequently unlikely to be achieved. On the other hand, patients in the group

with mild disabilities often restore adequate gait without using an orthosis.

CONCLUSION

Study results indicate that there are differences between age groups regarding the results of rehabilitation as well as the use of orthoses. At the end of the rehabilitation the best results were achieved in the youngest group of patients. The same group was also prescribed the highest rate of orthoses. But these two facts cannot be so simply connected, as the final result of rehabilitation is also influenced by many other factors which were not researched in the study. The analysis of orthotic use with a regard to the functional status illustrates a higher rate in the groups with moderate level of disability. The use of other rehabilitation devices is more equally spread within different age and functional groups. However, further studies into how and to what extend orthoses influence the final result of rehabilitation are needed.

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ANGULAR-VELOCITY CONTROL APPROACH FOR STANCE-CONTROL KNEE ANKLE FOOT ORTHOSES

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Abstract

This paper defines a new approach for Stance Control Knee Ankle Foot Orthoses (SCKAFO) control. Based on the premise that a SCKAFO user's knee angular velocity is greater during a knee-collapse event than during walking, a threshold angular velocity trigger can control a SCKAFO system. Angular-velocity-based control would not need mechanical or electro-mechanical systems to determine when the body is weight bearing. Therefore, the new approach could have wide applicability. The prototype device described in this paper (Ottawalk-Speed) uses a hydraulic flexion resistance mechanism with angular-velocity threshold activation to provide knee-flexion resistance at any knee angle, with all control mechanisms housed within the knee joint unit.

INTRODUCTION

People with quadriceps muscle weakness often lack adequate strength to walk safely without knee collapse or falling. Knee-ankle-foot orthoses (KAFO) that lock the knee in constant full extension can be prescribed; unfortunately, restricting knee motion results in abnormal gait patterns that can lead to hip and lower back dysfunction causing pain and loss of motion (1). Walking with an immobilized knee reduces walking efficiency by 24% (2), thereby leading to premature fatigue. A standard KAFO also makes walking on uneven ground, snow, stairs, and inclined surfaces difficult.

A Stance Control Knee-Ankle-Foot-Orthosis (SCKAFO) provides knee support in stance while allowing free knee motion when the leg is not weight-bearing. Studies comparing SCKAFOs and conventional locked knee KAFOs reported that SCKAFOs promoted more symmetric gait, improved gait kinematics, improved mobility, and required less compensatory movements (1) and less energy (3) during walking. Many conventional KAFO users have sufficient lower limb strength to benefit from a SCKAFO. This includes the elderly and people with multiple sclerosis, muscular dystrophy, polio, post-polio, incomplete spinal injury, unilateral leg paralysis or paresis, trauma, congenital defects, or isolated quadriceps weakness. Past SCKAFO designs integrated hydraulic (4), friction (5), elastic (6) or impingement (7, 8) based mechanisms or conventional unidirectional clutches (9, 11) and brakes (12, 13) into the orthotic knee joint. Most designs did not result in clinically and commercially practical models due to cost, size, weight, or functionality issues.

Eight SCKAFO designs have been released to the commercial market, all within the past four years. Unfortunately, current SCKAFOs either require the knee to be fully extended to engage the knee joint lock, therefore providing no support during stair walking or stumbling; are excessively noisy; or are too heavy and bulky for many potential users, making the orthosis energy exhaustive, intimidating, obstructive, and awkward. Commercial SCKAFO knee joints are relatively expensive, costing between $800-$8500 CND.

A need exists for a SCKAFO joint that is slim in structure, light in weight, inhibits rapid knee flexion at any knee angle in stance while allowing knee extension, and is more affordable than current commercial SCKAFO knee joints. This paper describes the design and testing of an original SCKAFO knee joint that addresses the structural, functional, cosmetic, and cost limitations of current commercial devices.

METHODS

Design Criteria

- Resist knee flexion at high flexion rates during weight-bearing but allow knee extension while in stance
- Knee joint defaults to locking whenever rapidly loaded during weight bearing
- Withstand fast loading conditions (stairs, falls, etc.)
- Easily integrate with standard orthotic components and allow easy adjustment
- Thin frontal plane profile (maintain cosmesis, limit contact between joints on medial side)
- Low noise level
- Internal control system
- Cost effective

Approach

To address the design criteria, a hydraulic-angular-velocity-based SCKAFO approach was adopted ("Ottawalk-Speed", Figure 1). Since SCKAFO users have some lower-extremity muscular strength and their physical condition typically limits walking speed, there is a threshold knee velocity beyond which rapid knee flexion can be attributed to an unsafe situation, such as the knee collapsing during a fall or the person stumbling. The new angular-velocity-based SCKAFO utilizes a hydraulic knee joint that provides patient-specific knee flexion resistance when the knee flexion rate surpasses the threshold angular velocity. The specific resistance is set by the clinician by adjusting a hydraulic-fluid control-valve screw or changing the spring. This is expected to result in safe locomotion with optimized function.

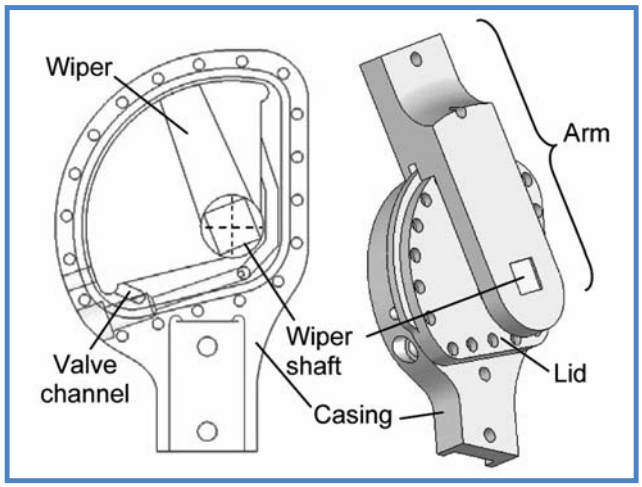

Figure 1: *Ottawalk-Speed components.*

The new SCKAFO knee joint replaces the conventional knee joints on one or both sides of a standard KAFO. When the knee joint flexes at an angular velocity beyond the configured threshold, a valve within the device closes and hydraulic pressure increases (Figure 2). This increased pressure provides resistance to knee flexion. Since knee flexion needs only to be controlled, not stopped, the hydraulic joint will allow flexion while maintaining the pressure in the joint within the mechanical design limits. This will also prevent excessive internal joint pressure and device failure.

When the knee extends, hydraulic pressure within the joint reduces and the control-valve opens. This permits free knee extension during weight-bearing. The knee will extend freely as long as the knee angular-velocity threshold is not surpassed.

During initial weight-bearing (heel strike, etc.), the hydraulic control system may be adjusted to activate as the knee angular velocity increases upon weight-bearing. The hydraulic system could cushion this transition to full single support as weight is transferred onto the forward leg.

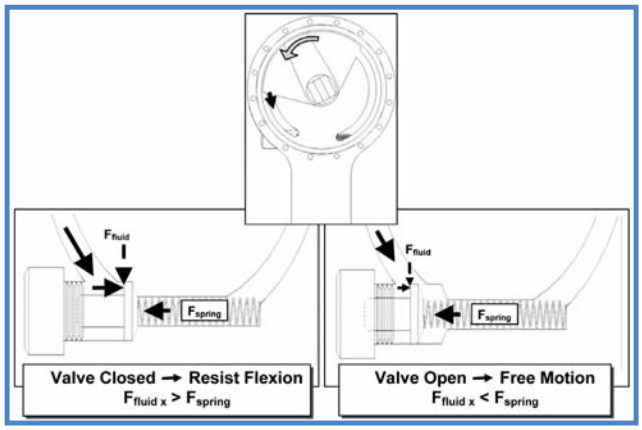

Figure 2: *Hydraulic SCKAFO knee joint valve mechanism.*

VERIFICATION OF VALVE FUNCTION

To assess valve function, the joint's valve section was machined out of Plexiglas and assembled with the plunger, spring, and screw components. Water was run through the meter-value setup, such that the flow rate was increased until valve activation. The valve assembly required instantaneous valve closure at the appropriate flow rate. Using a screw to increase valve spring compression and thus resistance to valve closure, a series of trials were performed to verify that the mechanism could function at varying flow rates (i.e., a greater knee angular velocity threshold could be accommodated by adjusting the valve spring setup).

The valve test produced instantaneous valve closure when the critical flow rate was achieved. As the spring force was increased, a higher flow rate was required to achieve instantaneous valve closure. This verified that the valve design was appropriate for the hydraulic SCKAFO application.

PEAK PRESSURE TESTS

The peak pressure within the joint chamber should achieve a sufficient level to adequately resist knee flexion without leaking. The pressure test used the prototype joint with the valve spring removed (simulating locked position). A digital pressure gauge (Setra Systems Inc., Boxborough MA 01719, Model C206)) was connected to a hole in the side of the flexion chamber and a National Instruments / Labview setup for pressure data collection. With the distal upright securely clamped, the proximal upright was loaded with 78 kg body weight, at a distance of approximately 40 cm from the joint axis of rotation. The joint range of motion was from full extension to 80 deg flexion. Pressure data was collected over 10 trials.

With modifications to increase hydraulic chamber volume and wiper shaft surface area, and using a wiper seal that

could accommodate for lid and casing bottom expansion due to the high pressures during loading, the current prototype was able to resist knee flexion during knee collapse pilot test trials with a 75 kg subject wearing the Ottawalk-Speed joint in a SCKAFO.

CONCLUSION

The novel Ottawalk-Speed SCKAFO design provides a new approach when prescribing an orthosis for people with knee extensor weakness. Future research will involve further mechanical testing for peak load response, repetitive loading, and pilot tests with SCKAFO users.

ACKNOWLEDGEMENTS

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THE EFFECT OF AFO ON PLANTAR PRESSURE DISTRIBUTION DURING WALKING IN SUBJECTS WITH DROP FOOT

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Abstract

An ankle-foot orthosis (AFO) is frequently prescribed to patients with paretic dorsiflexor muscles in order to improve their walking ability and to prevent stumbling. The aim of the study was to find out the influence of AFO on plantar pressure distribution during walking in subjects with drop foot. PLS AFOs were found to redistribute plantar pressures during walking in subjects with drop foot. That needs to be taken into account, especially in subjects with severe deformities of fore foot.

INTRODUCTION

An ankle-foot orthosis (AFO) is frequently prescribed to patients with paretic dorsiflexor muscles in order to improve their walking ability and to prevent stumbling. In subjects with paretic ankle dorsiflexsors, an AFO prevents foot drop during the swing phase of gait and helps to control foot placement after heel strike (1). AFO does not lower EMG activity (1), does not influence restoration of strength in patients with recent peripheral paresis (2) and does not influence time needed for 10m, but it slightly increases distance walked in 6 minutes (3). Usually, off-the-shelf AFO with a design of posterior leaf string (PLS AFO) is used. They are individually adjusted to fit the patient, but no big changes are usually made to unload the callosities or sole areas with increased plantar pressures.

There are several possible causes of dorsiflexsor paresis and drop foot, such as compression or injury of deep peroneal nerve, stroke, poliomyelitis, multiple sclerosis and others. Most of the patients are elderly and have some other foot deformities or problems.

The aim of the study was to find out the influence of AFO on plantar pressure distribution during walking in subjects with drop foot.

METHODS AND SUBJECTS

Methods

In-shoe plantar pressures were measured by the F-Scan system (Tekscan, Boston, MA). The system consists of 0.18mm-thick sensor insoles, which have pressure-sensitive, resistive, and conductive silver-based inks arranged in 60 columns and 21 rows embedded in Mylar coating. The columns and rows intersect, creating a "cell". There are 960 cells in each insole. The resistance at each cell is inversely proportional to the pressure applied on its surface. These insoles are connected to cuff units (preamplifiers), which are attached to the lower leg with a Velcro strap. A 9.25m cable attaches the sensor and cuff unit to a computer. The data were collected at 50 Hz. The F-scan has excellent resolution and provides reliable measures of relative pressure values (4, 5).

In all the patients, the measurements were taken twice, first without orthoses and then with newlyfitted orthoses.

Subjects

Ten subjects with drop foot, nine men and one woman, from 16 to 79 years old (59 years old on average), who already had an AFO but no other severe impairments of lower limbs were included into the study. All had drop foot problems for more than one year. Three had drop foot due to impairment of lumbar root lesions resulting from prolapsed intervertebral disk, three due to stroke, two due to hip endoprosthesis, and one due to TBC spondylolitis and injury of deep peroneal nerve.

RESULTS

The results of plantar pressure distribution are shown in table 1. All the patients were satisfied with the orthosis and said that they walked better with it. The orthotist was satisfied with the results of the correction of gait pattern in seven and partially satisfied with the correction in three patients.

Table 1: *Plantar pressures with and without AFO under several areas of sole*

	Without AFO (mean ± sd) [Pa]	With AFO (mean ± sd) [Pa]	p
Big toe	60.6 ± 19.5	77.7 ± 24.7	.079
Head of 1st metatarsal	62.40 ± 21.5	75.30 ± 24.0	.123
Head of 2nd metatarsal	73.7 ± 20.8	82.8 ± 15.3	.068
Head of 3rd and 4th metatarsal	82.9 ± 13.0	89.1 ± 9.7	.150
Head of 5th metatarsal	83.7 ± 13.7	91.8 ± 10.1	.045
Lateral part	63.6 ± 19.0	77.9 ± 16.7	.032
Heel	65.5 ± 15.1	60.4 ± 17.9	.174

DISCUSSION

PLS AFOs were found to redistribute plantar pressures (Table 1). They especially increased pressures under the lateral part and the head of the fifth metatarsal head, while the increase under the other metatarsal heads was not significant. The latter was due to the force in this area, which keeps the foot in neutral or slightly dorsiflexed position to prevent plantar flexion. Due to that force at the time of the push-off, the wearers have to push more to achieve some plantar flexion, which increases plantar pressures. That may be a problem in subjects with severe deformities of the forefoot, when additional soft padding or insoles may be needed.

Slight but not significant decrease in plantar pressures under the heel was observed. That was quite surprising, since, by preventing drop foot, AFOs should improve the heel loading after the heel contact phase of gait. The reason for that may be inappropriate shoes which did not really push the heel into the heel part of the orthoses. Decreased plantar pressures under the heel have been observed by Rahdolph (5), but he used AFO for decreasing the heel area, not PLS AFO to prevent drop foot.

The main limitation of the study was the small number of the subjects with drop foot resulting from different reasons. However, orthoses are not prescribed and fitted on the basis of the aetiology of the impairment but due to functional problems while performing activities.

CONCLUSION

It can be concluded that PLS AFOs redistribute plantar pressures during walking in subjects with drop foot. That needs to be taken into account especially in subjects with severe deformities of fore foot.

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QUALITY OF TECHNICAL DOCUMENTATION -IS IT IMPORTANT?

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Abstract

The aim of the study was to determine the factors influencing the design and orthotic components of KAFOs, but due to insufficient data the second aim was to assess the quality of technical documentation. Medical and technical records of the subjects who had received a KAFO in 2007 were examined and basic clinical and technical data were recorded. Exactly one half of all the medical prescriptions included the desired function of orthosis, while the others mentioned only the expected functional level of the patient. 71.1% of technical documentation included a description of the used knee joint, 57.9% a description of the ankle joints and 5.3% the design of the thigh brim. It may be concluded that the quality of our medical records and technical documentation for KAFOs has to be improved.

INTRODUCTION

In Slovenia, as is probably the case in most of the Central Europe, orthosis are prescribed by physicians. Physicians may specialize in various fields. The physician prescribing orthosis has to have a clear idea of the current treatment and the potentials and limitations of devices prescribed (1). In Slovenia, physicians prescribe which part of the body the orthosis is for and its desired function. In some cases, as for example in knee-ankle-foot orthosis (KAFO), that usually includes the prescription of materials.

KAFOs are used for patients with functional disorders that affect both the knee and the ankle. Usually they are used in polio survivors, subjects after spinal cord injury and consecutive paraplegia, spina bifida and trauma (2).

KAFOs may have different ankle and knee joints, be made from different materials, different ways may be used to apply posteriorly directed force at the knee joint and the tight part may have a quadrilateral brim or be without it (3). They may have a rigid ankle, limited range of motion or springs to help weak muscles. The knee joint can be free, offset or have various locks (cam lock, drop lock, lever lock).

The aim of the study was to determine the factors influencing the design and orthotic components of KAFOs, but due to insufficient data the second aim was to assess the quality of technical documentation.

METHODS AND SUBJECTS

Methods

Medical and technical records of the subjects who had received a KAFO in 2007 were examined and basic clinical and technical data were recorded.

Subjects

All the subjects receiving a KAFO in 2007 were included into study.

RESULTS

Thirty-eight subjects, 23 men and 15 women, received KAFO in 2007. They were from 6 to 81 year old (46 on average). Fifteen were polio survivors, fourteen had spinal cord injury (SCI), three had pseudoarthrosis or delayed healing of femoral fracture, two arthrogryposis and one stroke, CP and spina bifida.

Exactly one half of all the medical prescription included the desired function of orthosis, while the others mentioned only the expected functional level of the patient. Sixteen patients received orthosis for mild, 21 for moderate and one for severe mobility limitations. In 57.9% of the medical records there was an indication of muscle strength, 50% included an exact description of the range of motion in joints of lower limbs and 44.7% described the limb length.

71.1% of the technical documentation included a description of the used knee joint, 57.9% a description of the ankle joints and 5.3% the design of the tight brim.

The patients who walked without additional walking aids had orthosis for mild mobility limitations, those who walked with 2 crutches mainly for moderate mobility limitations. All the orthosis for mild mobility limitations had a quadrilateral brim, 13 out of 15 had a free knee joint and 10 out of 15 a free ankle joint. Almost all the free knee and ankle joints were prescribed for polio survivors.

DISCUSSION

The study found that the quality of our medical records and technical documentation has to be improved. Only one half of the medical records contained all the information necessary for the orthotist to decide about the design of orthosis and the most appropriate components. Technical documentation also lacked much important information. No data on the design or used components was found in all of the technical notes. The quality of both types of documentation depended also on the person who filled it in. There were some who included all the necessary information in almost all the records, whereas others never wrote any important information. That does not necessarily mean that the examination was incomplete, but negative findings are often not recorded. Later, when the records are reviewed it is not clear whether something was not examined or the findings were negative.

Two types of medical records were used in the study; records from outpatient clinics and records for the admitted patients. For the admitted patients, much of the important information is contained in the files of physiotherapists or occupational therapists; however, those are not always brought to the orthotist when patients come for casting.

Greater attention has to be paid to the fact that successful orthotic prescription requires a detailed analysis of a patient's physical and functional status, followed by careful consideration of their requirements (3) and that all findings have to be recorded and accessible to the whole team.

In the patients with recorded data, the study found that the design and the components of the KAFOs mainly depended on the functional status of the patient (muscle strength, range of motion, abbreviation) and the expected functional level, while the diagnosis itself was not a very important factor.

CONCLUSION

It may be concluded that the quality of our medical records and technical documentation for KAFOs has to be improved.

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CLINICAL TOOLS USED IN DOCUMENTATION AND OUTCOME MEASUREMENTS IN ORTHOTIC PRACTICE

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Abstract

In industrialized countries, with tighter healthcare budgets, there is a growing trend toward increased accountability in the orthotic treatment plans. The orthotist must be able to: 1) identify the problem, 2) design a treatment plan including the orthotic design, and 3) outline the expected treatment outcomes. Proper documentation of the identified problems can be done using several methods: 1) clinical reports that include muscle strength tests, joint range of motion, functional assessment (including visual gait analysis), and sensation, 2) photographs, 3) video-taping, 4) pressure gait analysis systems (In shoe and Mat systems). Some of the techniques can also be used to evaluate the effectiveness of the orthotic design. This presentation will provide case study examples of the application of the clinical documentation methods in recording the gait problem and evaluating the orthotic efficacy.

INTRODUCTION

Orthotists need to have effective and consistent recording skills when observing pathological and normal conditions. There are several articles that describe why and how to take good clinical notes (1-3). It has been cited that the paying agencies are requesting the need for outcome measurements (4, 5). There are increased demands from the consumer for accountability in the healthcare sector (6, 7). For the lower extremity orthotic device, one goal is to improve walking, by making it safer, more efficient and normal in appearance. Outcome measurements are seen as a way to: a) determine orthotic efficacy and b) justify the cost of the service or treatment plan (8).

DOCUMENTATION

Documentation is necessary to: 1) record the medical and/or functional status of the patient; 2) provide justification for: a) adjustments to the orthosis, b) changes to the orthotic design, c) to replace an orthosis due to poor fit or function or extreme wear; 3) measure outcomes in the orthotic intervention to: a) develop a product or service to improve patient care, b) fulfil the patient and physician expectations; 4) record patient satisfaction.

CLINICAL TOOLS USED IN DOCUMMENTATION

Assessment forms

Clinical tools normally used in orthotic practice include the measuring tape and the goniometer. The assessment forms, and the gait analysis guides used to record the information, are also clinical tools.

Photography

Well placed and informative images are an effective and descriptive approach to illustrate a problem and how an orthotic device can correct the problem.

Video Gait Analysis

The videotape of the patient ambulating allows the clinician to review and analyze the walking pattern in greater detail. It also provides the clinician the opportunity to measure important gait parameters that can be used to determine the effectiveness of the orthosis.

Pressure map gait systems

The pressure mat system is used to provide a gait report. The in-shoe pressure system is used to evaluate the effectiveness

of the orthosis in maximizing the load bearing surface and reducing the peak pressure areas.

CASE PRESENTATIONS

The first case will be a diabetic patient with a Charcot foot. The second case will be a spina bifida patient with a transmetatarsal amputation. Documentation will included, photographs, Harris ink imprints, pressure map reports from the mat and in-shoe systems (Figure 1) and video gait analysis (Figure 2) for the non orthotic and orthotic conditions.

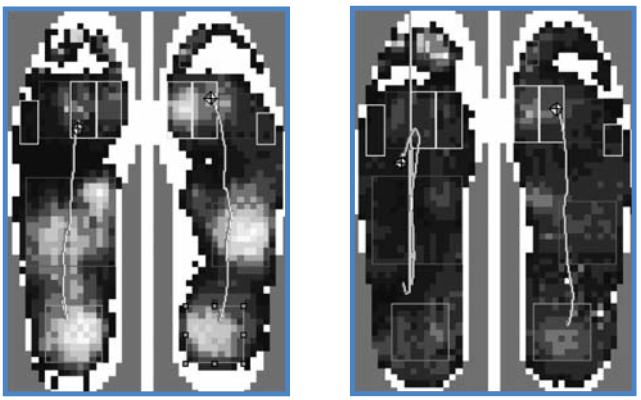

Figure 1: *Example of F-Scan data.*

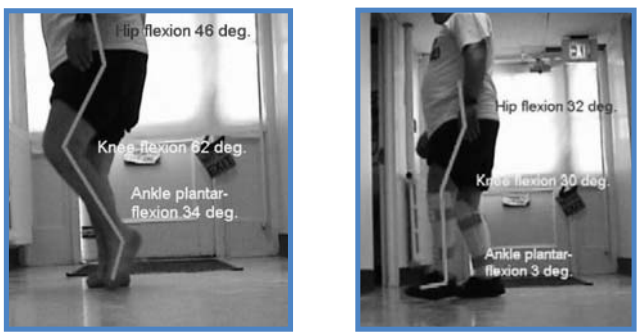

Figure 2: *Example of use of video snapshots.*

CONCLUSION

There are many available tools for the clinician. Photography and videotaping can be effective tools for recording the problems, and the fit and function of the orthotic device. Video gait analysis and in-shoe pressure mapping provide measured outcomes to demonstrate the orthotic efficacy. These tools will improve patient care and service.

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OUTCOME MEASUREMENTS USED IN THE TREATMENT OF THE POLIO PATIENT USING ORTHOTIC DEVICES.

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Abstract

Outcome measurements are becoming a means of justifying the application of an orthotic device and a way of illustrating the effectiveness of the device. More third party payers require, or are requesting, that the orthotic vendor demonstrate that the orthotic device provided is fulfilling the orthotic goals. Is the ankle foot orthosis providing adequate foot-floor clearance during the swing phase? Does the Ankle-Foot Orthosis re-establish heel contact versus forefoot strike for initial ground contact? This presentation will provide 3 case studies illustrating the use of photography and video gait analysis to document the improvements in the walking patterns of the polio client. The presentation will demonstrate why a client's ankle-foot orthosis was changed to a knee-ankle-foot orthosis was necessary, and effective, based upon the documentation.

INTRODUCTION

Polio is a viral infection that attacks the anterior horn cells of the spinal cord (1). The last outbreak in Canada was in 1954. There are five stages to the disease process: a) prodromal phase lasting up to two days, b) an acute illness lasting around two months, c) a recovery period lasting up to two years, d) a stable disability / stage of chronicity, and e) post polio syndrome (PPS) stage (1, 2). Post polio symptoms include fatigue, muscle weakness, muscle and joint pain, and respiratory difficulties (3-5). Many physicians have related PPS to over-use. Currently there is no cure for PPS. The gait evaluation (6) and orthotic management of the polio and post polio patient (2, 5, 7) is well documented.

Documentation includes clinical assessment, which includes the muscle strength testing, joint range of motion and visual gait analysis, photographs, and video gait analysis with video snapshots. Documentation will aid in identifying the problems, assist in design the orthosis and evaluate the effectiveness of the orthotic design.

CASE PRESENTATIONS

Case study 1

The first case is a business woman using a laminated articulated Ankle-Foot Orthosis (AFO). Several physical and biomechanical problems are identified. The orthotic design is documented through photographs, as well as the fit and function of the AFO. The video gait analysis captures the orthotic efficacy (Figure1).

Figure 1: *Example of the Video snapshot of terminal stance.*

Case study 2

The second case is an older gentleman who required an AFO for an equino-varus problem, with primarily lateral ankle instability, and an associated leg length discrepancy. The patient was fitted with a rigid plastic AFO but still exhibited lateral levering. The patient's footwear was modified to increase lateral stability. The example demonstrates how footwear modifications may be warranted to achieve a more stable walking pattern (Figure 2).

Case study 3

The third case is a retired teacher who has worn a flexible plastic AFO for 10 years. She started experiencing increased pain in her braced side knee as well as the unaffected (unaffected by polio) knee. The video documentation demonstrates the inability of the plastic AFO in stabilizing

Figure 2: *Example of the Frontal plane Video snapshot of mid-stance for the bare-foot/ no orthosis, rigid AFO and AFO and footwear modifications*

Figure 3: *Example of the sagital plane video snapshot of mid-stance for the bare-foot/ no orthosis, flexible AFO and KAFO conditions*

the knee in the sagital and frontal plane. This case study exhibits how an AFO has become ineffective and when orthotic design change is necessary. She was fitted with a knee ankle foot orthosis which was effective in controlling the genu recurvatum and ankle plantarflexion during stance (Figure 3).

CONCLUSION

Photographs and video gait analysis, with video snapshots, are effective tools in recording the gait problems of the polio patient. Video snapshots are also effective in documenting poor orthotic designs and effective orthotic designs. These tools will improve your patient care and service.

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DEVELOPMENT OF A NEW ORTHOSIS FOR A CHILD WITH CEREBRAL PALSY, WITH A KNEE (HYPER) EXTENSION IN MIDSTANCE AND INTERNAL ROTATION OF LOWER LIMB PATTERN - A CASE STUDY

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Abstract

In conjunction with other interventions for children with cerebral palsy (CP), orthoses continue to play an important role in the physical management of children with CP. A case study was designed to provide a quantitative and qualitative analysis of gait pattern of a girl, who is using a specially designed twister hip-knee-ankle-foot orthosis (HKAFO). She was referred to our Institute at the age of 4.5 years. She walked with pronounced hyperextension of knees in midstance and internal rotation of lower limbs. Clinical analysis after application of HKAFO showed better gait pattern without knee hyperextension in midstance, with lesser hip internal rotation and good foot position. She was slower, able to stop and to stand for a longer period. Kinesiology supported clinical findings. We expect a beneficial long term effect on gait pattern, but this has to be proved through a prospective study on a larger group of subjects.

INTRODUCTION

Cerebral palsy (CP) is a well-recognized neuro-developmental condition with frequent secondary impairments (1). For the function of ambulation, the Gross Motor Function Classification System (GMFCS) has been widely employed (2). Individuals in levels I an II are able to walk without any aid and those in levels III and IV need different types of orthoses, walker, crutches…

According to specific gait pattern, children with CP belong to one of five groups (3):
1. insufficient foot lift in swing,
2. knee (hyper)extension in midstance without heel rise,
3. knee (hyper)extension in midstance with heel rise,
4. knee flexion in midstance with heel rise and
5. knee flexion in midstance without heel rise.

In conjunction with other interventions, orthoses continue to play an important role in the physical management of children with CP. The aims of lower limb orthotic management of CP are to correct and/or prevent deformity, to provide a base of support, to facilitate training in skills and to improve the efficiency of gait (4).

Most frequently orthoses for ankle and foot (AFO) are used. There are 4 main types: a UCBL, a leaf-spring AFO, a rigid AFO and a floor reaction AFO (5). Quite some studies are dealing with the effects of different types of AFO on the gait pattern, but there are just a few data on the influence of AFO on hip kinematics (6). Children with hyperextension of knee in the midstance and internal rotation of lower limb to our knowledge seem not to benefit enough from AFO.

METHODS AND SUBJECTS

The study was designed to provide a quantitative and qualitative analysis of gait pattern of a child with CP, who is using a specially designed twister hip-knee-ankle-foot orthosis (HKAFO). The orthosis consists of pelvic corset, knee orthosis and foot orthosis, connected by an adjustable spring. It provides prevention of internal hip rotation, correction of knee hyperextension in midstance and a good foot position. Based on individual analysis, compounds are chosen according to intensity of correction that is needed in a particular plane.

A girl was born after uneventful pregnancy 10 days after term: weight over 4 kg, height 54 cm, Apgar score unknown. She had broken collar bone and was vomiting amniotic fluid. Only at the age of one year she was referred to a physiotherapist because of a delayed motor development. She started to walk at the age of 18 months. Team at the regional

health-centre decided to apply inhibitory casting to prevent toe-walking at the age of 3 years. After that parents noticed, that her gait pattern worsened. She was walking very quickly, she was hardly able to stop in was falling frequently.

She was referred to our Institute at the age of 4.5 years. She was able to walk freely, but with difficulties: plantigrade in barefoot but compensating with pronounced hyperextension of both knees in the midstance and internal rotation of lower limbs. We decided to apply the twister HKAFO. Her gait pattern was analyzed clinically and kinesiologically (in the first week after application and again after period of 3 months).

RESULTS

Clinical analysis after application showed better gait pattern without knee hyperextension in midstance, with lesser hip internal rotation and good foot position. She was slower, able to stop and to stand for a longer period.

Kinesiology showed that the gait velocity with orthosis was lower (0.25m/s) and cadence was more variable. Gait pattern, which was based on moving the center of gravity forward and propulsion generation in hips, was changed in terms of propulsion generation and securing the stability; the hip power generation has decreased and pelvis was adjusted toward normal position and consequently moving the center of gravity backward. The spring was helpful in the swing phase, but not easy to overcome its force. At the same time it leaded to less power that was needed for walking. The HKAFO application also resulted in smaller pelvic tilt and abolished the undesired knee hyperextension.

Girl and her parents accepted the orthosis very well. Girl used the orthosis for several hours per day already in the period of adaptation, without any difficulties while committing to daily life activities.

DISCUSSION AND CONCLUSION

Gait patterns of children with CP differ significantly. One of possibilities is walking with knee (hyper) extension in midstance and with pronounced internal rotation of hip. We developed a twister HKAFO to correct this gait pattern. Analysis is showing short-term improvement of gait pattern. It can be applied through all the day, without any functional limitation in performance of daily life activities, which is also very important for a child and its family.

There are some questions remaining to be answered. We expect that a long term effect will be beneficial, and that children will develop a better gait pattern that will persist also through a longer period without KHAFO. But this has to be proved through larger study within a longer period of observation.

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EFFICACY OF DYNAMIC ANKLE-FOOT ORTHOSIS (DAFO) IN A SUBJECT WITH HEREDITARY MOTOR SENSORY NEUROPATHY: RESULTS OF ONE YEAR FOLLOW UP

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OBJECTIVE

The aim of this study was to investigate the effects of a dynamic ankle-foot orthosis (DAFO) on gait parameters and balance in a subject with Hereditary Motor Sensory Neuropathy (HMSN) at short term and at one year follow up.

MATERIALS AND METHODS

This case study was carried out on a 16 year old girl with HMSN. Evaluations were conducted with shoes only condition, and with DAFOs worn in the shoes. The foot print method was used for gait analysis. Functional gait performance was evaluated with Timed Up and Go Test (TUG). Changes in the center of mass were evaluated with a stabilometric platform.

RESULTS

Base of support at initial evaluation was measured as 15 cm with shoes and 13 cm with DAFOs. Initial measurements of step lengths were 59/55 cm with shoes and 55/55 cm with DAFOs. At the end of one year regular usage of DAFOs the base of support was measured as 14 cm with shoes and 11 cm with DAFOs. Step lengths were 62/59 cm with shoes and 69/69 cm with DAFOs. At initial evaluation TUG was completed by the subject in 9.02 sec with shoes and 8.86 sec with DAFOs. At the end of one year regular usage of DAFOs the TUG was completed in 7.54 sec with shoes and 6.70 sec with DAFOs. The deviation of center of mass on the X axis measured at initial evaluation was found to be 14 mm with shoes and 3 mm with DAFOs. At one year follow up the deviation was 11 mm with shoes and 3 mm with DAFOs.

CONCLUSION

These positive findings may indicate that DAFOs which were originally designed for children with CP may be just as effective in children with HMSN for reasons such as providing enhanced proprioceptive input and biomechanical advantage.

THE USE OF A VARIABLE ABDUCTION ORTHOSIS IN THE CHILD WITH EARLY BRAIN LESION

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Abstract

Variable abduction orthosis (SWASH orthosis) and its function by describing an example of a girl with an early brain lesion is introduced in the article. It is a report on the twelve-year old girl's case with a spastic cerebral palsy. Many of standardized assessment protocols have been used during the assessment and analysis of her condition. Orthosis remarkably improves the quality of the movement patterns, it influences the greater gait speed, the cadence, greater single and double step length and step width. Considering the fact that the girl was capable of walking a longer distance than she was while walking without orthosis, advantages are revealed mostly during walking. Orthosis improves the stabilization of the pelvis and the trunk. SWASH orthosis considerably increases her autonomy and independence when moving and performing her daily activities.

INTRODUCTION

Early brain lesion causes the lesion of the central nervous system and slows down or hinders the child overall development. One of the most frequent consequences of such condition is cerebral palsy (1).

Cerebral palsy (CP) is not a disease. It is a condition that has been defined as »an umbrella term covering a group of non-progressive, but often changing motor impairment syndromes, which are secondary to lesions or anomalies of the brain arising in the early stages of its development« (2).

CP is classified according to a combination of two standards. One is based on anatomical distribution (hemiplegia, diplegia, quadriplegia...) and the other deals with the physiological aspects of the condition (spastic, dyskinetic, ataxic, mixed cerebral palsy...) (3).

METHODS AND SUBJECTS

Variable abduction orthosis

SWASH ortohosis is a variable abduction orthosis used for the stabilization of the hip and the pelvis. It influences the function of the entire body. SWASH is an abbreviation of an English word meaning: the Standing, Walking and Sitting Hip orthosis. Thus, it is a brace or a hip abduction orthosis used for standing, gait and sitting (4).

Orthosis enables a child to do everyday activities with no threat of hip dislocation. It increases the ligament strength and ligament flexibility, of other hip joint structures. It hiders the adductive gait model (scissor gait) and maintains the pelvis in the central position. Besides, it maintains the hip abduction and the adequate gait length. Orthosis improves the posture, standing and balance. It enables a better transfer and a greater mobility, learning to use less energy when walking and a better gait quality. Thus, it can be considered not only as a supplement but also an alternative to the operations (4).

Major components of the SWASH orthosis are: pelvic band; hip joint assembly; lateral uprights and thigh cuffs (Figure 1).

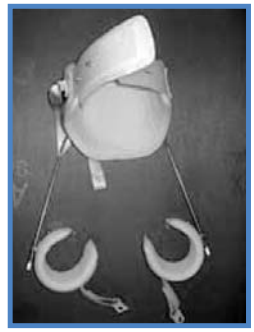

Figure 1: *SWASH orthosis*

The use of orthosis in the function

A girl was admitted to our Centre on the basis of the written order from the Committee of Specialists for classification of the children and adolescents with problems in physical and mental development in September 2003.

The condition of the girl when admitted: she has cerebral palsy (spastic diplegy) and epilepsy. She uses the wheelchair,

which she can run by herself. She can only walk using the crutch and thus she retains her independence. The gait resembles the adduction model. Internal hip rotation has as well been diagnosed. The muscle tonus is spastically increased on the lower limbs. Flexor contractures have been detected in her hips and knees.

Due to her condition we have decided that she is the perfect candidate for the use of the SWASH orthosis. The decision was influenced by the estimation of the extent of the joint mobility, of her muscle strength, the muscle tonus characteristic, the estimation of the sensibility, of the posture and balance (the estimation of the general strength), the estimation of gait and its mutability and of the functional activities. I intend to focus on the estimation of the girl's gait and its mutability with and without the use of the SWASH orthosis, as this is where the differences were most prominent.

The clinical analysis of the girl's gait with and without the use of the SWASH orthosis proved a bigger disturbance in her lower limbs with typical abnormal motive gait models, for instance the excessive flexion in her knees in the support phase, the increased adduction and inner hip rotation. Due to the equinovarus she can only toe walk. Such abnormal motive gait models in her ankle and foot do not provide her with enough support and stabilization. Thus, she is unable to stretch her knee to the desired position. In the support phase she walks with her knees bent. In the swing phase her knee movement changes according to the flexion or the extension. Without the use of the SWASH orthosis the dynamic control of the asymmetric pelvis and the active and correct posture. On the other hand, it has become clear that the SWASH orthosis enables the upright gait. This is the result of the more stable gait, the increased extension in the knees and hips and the abduction and the outer hip rotation.

Thus, SWASH orthosis prevents the crossing of feet and makes the gait easier.

The estimation of the mutability of her gait was made on the basis of the time measured test of 10 m gait. The girl using stable footwear had two highlighters of a different colour stuck to her heels by adhesive tape (micropor). Thus, I was able to differentiate the left footprint from the right one.
The test was carried out six times: three times without and three times with the application of the SWASH orthosis (5).

RESULTS

The results are the following (Table 1):

The distance of 10 m took the girl 29 seconds without the use of the application of the SWASH orthosis. With the application of it, the same distance took her only 18 seconds. Regarding the fact that the outhouses shortened the time spent for 11 seconds it can be said that the gait speed changed from 0.35 m/s to 0.56 m/s. The gait speed increased the cadence from 68 to 85 steps per minute. This is also the result of the girl's safe gait. On average, the length of the single step when walking with the use of the variable abduction orthosis increased by 7 centimetres. The average length of the double step increased for 14 centimetres. The width of the basic step increased for 10 centimetres. The SWASH orthosis relieves the adductive gait model and it decreases muscle tonus in the pelvic hoop and the lower limbs that has changed. It also contributes to the increased abduction hip span, which enables the improvement of the functional gait ability and the ability of its mutability (5).

Table 1: *The results of the time measured test of 10 m gait and its mutability*

	Gait without the SWASH orthosis	Gait with the SWASH orthosis
Gait time (s)	29	18
Cadence (step/min)	68	85
Gait speed (m/s)	0.35	0.56
Length of single step (m)	0.14	0.21
Length of double step (m)	0.28	0.42
Step width (m)	0.06	0.16

DISCUSSIONS

The term early brain lesion refers to the abnormal basic muscle tonus, the abnormal motive models, which enable the child development and lead to the abnormal posture and movement. Later they can also cause the contractures and deformations. Different therapeutic approaches are used in order to preserve and achieve normal gait models (6). One of such approaches is the right choice of the suitable instruments - orthoses for the improvement of the motive functions. This results in the partial inhibition or even prevention of the primary, abnormal and compensatory motive models that a child would develop. The SWASH orthosis fits into this category (4).

It is necessary that all the experts included in the treatment of children with CP cooperate. The therapists, the nurses, the doctors and other members of medial staff have to cooperate in favour of the child with CP. The child's parents have to take an active part as well. In such a way, a child with CP will be enabled to develop all his or her potentials (5).

CONCLUSION

The use of the SWASH orthosis:
- influences the better quality of the movement patterns with a girl having a spastic diplegy;

- influences the greater gait speed, the cadence, the increased length of the single and double step and the increased step width;
- lessens the danger of the deformations and contractures;
- preserves the central pelvis position and a more upright posture.

The variable abduction SWASH orthosis contributes to the girl's greater independence regarding the movement and doing of the everyday activities.

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SURGERY OF EXTRADURAL METASTASES OF THE SPINE

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Abstract

In last decade surgical treatment of spinal metastases improved significantly, mainly because of improvement in diagnostics and surgical technique. Concerning surgical technique anterior approach with corpectomy and stabilization is used whenever type, location and life expectancy do not dictate it as inappropriate.
The aim of our study was to review our experience with segmental resection for spinal metastases.
From February 2003 till February 2007 39 patients were operated for extradural spinal metastases. The primary tumour was located in breast in 16 cases and in lung in 8 cases. There were 8 metastases from kidney and 5 from prostate. Once a disease originated from intestinal and laryngeal carcinoma. Surgery was indicated because of neurological symptoms in 11 cases and because of pain in 17 cases. Other 11 patients were operated because of frank or incipient spinal instability.
Segmental or partial segmental resection was performed in 19 cases and tumour debulking in 20 cases. Three weeks after surgery pain regressed on the bases of visual analogue scale from 7.5 (4-10), to 3.5 (1-7). Five out of eleven patients improved neurologically three weeks after surgery. In segmental resection patient pain dropped from 7.2 (4-8) preoperatively to 1.9 (1-5) postoperatively. 15 out of 19 patients with segmental resection were ambulatory three weeks after surgery. On the bases of our experience we conclude that segmental resection with stabilization should be performed in isolated breast or kidney metastases. In cases of lung metastases without neurological symptoms simple posterior decompression with stabilization provides acceptable morbidity with satisfactory result.

INTRODUCTION

Metastases are the most common form of skeletal tumours, met by orthopaedic surgeons. Spine is the most common place for bone metastases; therefore treatment of spine metastases represents an important part of all skeletal pathology. In the last two decades there has been a significant change of attitude towards treatment of spinal metastases both around the world and in our country. There has been a large qualitative break through in the diagnostics and even more in surgical treatment of metastases. Anterior approach to all the regions of the spine, once practised only by a few orthopaedic surgeons in biggest spine centres, is becoming everyday practice of modern (contemporary) spinal surgeon. Through team approach, which combines spinal surgeon with oncologist, radiologist and neurologist, the quality of treatment has improved significantly for patients with spinal metastases.

METHODS AND SUBJECTS

In Dept. of Spinal Surgery, KC Ljubljana 39 patients with spinal metastases were operated between February 2003 and February 2007. There were 22 females and 17 males. The primary tumour was located in breast in 16 cases and in lung in 8 cases. There were 8 metastases from kidney and 5 from prostate. Once a disease originated from intestinal and laryngeal carcinoma. Average age of our patients was 63 years (44 to 81). The most frequent area of the surgery was lumbar spine (18 times), followed by thoracic (14 times) and cervical spine (7 times).

22 out of 39 patients either had chemo or radiotherapy prior to surgery. In 10 patients, in whom the location of the primary tumour was not known, we performed biopsy prior to surgery. Biopsy was always performed transpedicularly and was in all cases diagnostic.

As a diagnostic procedure we always performed classical X- ray of affected region of the spine, scintigrafic scan using Technitium and MRI. Clinical examination was performed prior to surgery and two to three weeks after the surgery. It included neurological examination by neurologist or neurophysiologist. Pain was asserted according to visual analogue scale (VAS) (7).

Indications for surgery were acute neurologic deficit in 4 cases, progression of neurologic deficit (symptoms) in 7 cases, severe pain, non responsive to conservative treatment in 17 cases, other patients were operated because of frank or incipient spinal instability. In 8 cases only involvement of lower motorical neuron was noted, in 6 cases there was combined involvement of both lower and upper motorical

neuron. All the patients but seven were able to walk by themselves or with assistance of physiotherapists prior to op.

Right after the surgery and three weeks after the surgery classical X-ray of the operated region of the spine was taken.

RESULTS

We managed to perform planned operation in 38 out of 39 cases. The only case we weren't able to finish the operation as planned was the case with kidney carcinoma metastases to fourth lumbar vertebra. We stopped the operation at the 6000 ml loss of blood, whilst we were unable to control the bleeding. In other cases the loss of blood was always less then 2500 ml, except in the case of metastases of hypernephroma when total blood loss was 11.000 ml of blood.

Segmental resection was performed in 7 cases, all of them being metastases of breast carcinoma. Partial segmental resection was performed 5 times with metastases of kidney 6 times breast carcinoma and once with metastases of laryngeal carcinoma. Other operations were palliative in nature with removal of tumour from nerve structures (debulking).

Spine was stabilized in all cases except with partial segmental resection of the kidney carcinoma metastasis to Th 10. That was one of 12 cases in which we performed only anterior approach. Combined anterior and posterior approach was performed 8 times, always during the same operation. In other cases we operated through posterior approach only.

As obtained by VAS, the preoperative pain averaged 7.5 (4-10) and three weeks after the surgery 3.5 (1-7). Neurologic deficit was completely gone only in the case of metastasis to C4, where we preoperatively observed one sided deltoid muscle paralysis which lasted for two weeks. In other patients neurologic status partially improved or stayed the same as before surgery. Patient with hypernephroma metastasis to Th 12 developed cauda equina syndrome with retention of urine after the surgery, which still lasted three months postoperatively.

Patients were mobilised as soon as possible. All but two of them were able to walk by themselves or with the help of physiatherapist from third postoperative day on. Patients that were not treated with radio or chemotherapy preoperatively were transferred to Oncological institute for adjuvant treatment.

All patients were postoperatively given orthoses for additional immobilization of the operated segments of the spine, except those with segmental or partial segmental resection and stabilization.

DISCUSSION

Decision upon operative treatment of extradural spine metastases depends on many factors. The most important ones are location of the tumour, origin of primary carcinoma, radio- and chemosensitivity of the tumour, stability of the spine, pain, neurological deficit and general patient condition. Different kinds of specialists decide on those factors, therefore decision about treatments has to be made in a team. In the last two years we have established a nonformal team of oncologist, radiologist, neurologist and orthopaedic surgeon, which provides complex approach to treatment of spinal metastases.

When we decided to operate, operative plan had to be made. There are numerous reports in the literature about advantages of anterior approach decompression, mainly because it provides bigger improvement in the neurological status and stability of the spine. That is especially the case with thoracic spine where spinal canal is narrow and chances of additional neurological deficit whilst manipulating neurostructures bigger. It is not quite clear whether laminectomy combined with radiotherapy provides better results than radiotherapy alone (1, 3).

Therefore we tended to operate our patients with anterior approach with thoracotomy, thoracolumbotomy or lumbotomy, if bigger operation was appropriate according to life expectancy. In these cases we performed resection or segmental resection. We performed debulking (removal) of the tumour through posterior approach only when compression of neurological structures was only from the back. In our series it was only with metastases of prostate cancer to lumbar spine. Laminectomy with posterior decompression and stabilization was also performed when life expectancy was about six months. We decided not to operate if life expectancy was less then six weeks or if the patient with life expectancy of only several months was bedridden, with no hope of operative improvement (2).

During the operation we always performed stabilization of the spine beside decompression, only in the case of the patient with limited involvement of Th 10, where tumour removal did not destabilize the spine. Proper stabilization provides chances of optimal postoperative mobilization, which in patients with spine metastases means significant improvement in the quality of remaining life. Anterior spinal column was supported in all cases of segmental resection, once with partial segmental resection and in all cases of operations on cervical spine. Spondylodesis was performed on patients with life expectancy more than one year, in other patients we performed only stabilization with osteosynthetic material with or without bone cement.

Metastases of hypernephroma require specific treatment. Considering tumour is resistant to radio- and chemotherapy the only way to treat and significantly prolong life is through

surgery (9), especially when only one solitary metastasis is discovered. This kind of metastasis represents surgical challenge in its vascularity and consequential bleeding at removal. In the last three years we operated six cases of hypernephroma cancer. In the first case we were unable to extract the whole tumour at the level of L4 due to heavy bleeding, even though an embolization was performed a day prior to surgery. In the second case of hypernephroma metastases to Th 12 we planned posterior approach with reduction of tumour and stabilization, followed by anterior corpectomy and insertion of appropriate cage (10). During posterior operation blood loss amounted to 8000 ml, although we closed all proximal and distal epidural blood vessels prior to tumour removal. During anterior operation there was another 2000 ml of blood loss, although we closed all segmental blood vessels at three levels. In the third case of hypernephroma metastasis, it was confined to a part of Th 10 body and half of posterior elements. We decided on isolated anterior approach. We closed all segmental blood vessels at three levels and so managed to cut down blood loss to less than 1000 ml. Other three cases of hypernephroma metastases were anterior approach ligation of segmental vessels and with blood loss of less than 2500 ml. On the basis of our limited experiences we conclude that, in operating metastases of hypernephroma it is best to first approach anteriorly, close all segmental blood vessels at several levels and then proceed with posterior operation if necessary. An embolization prior to surgery, though important, does not guarantee significant reduction of blood loss.

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RESULTS OF TREATMENT OF PAINFUL VERTEBRAL FRACTURES BY KYPHOPLASTY OR ORTHOSIS: A PROSPECTIVE NONRANDOMIZED CONTROLLED STUDY

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Abstract

This study analyzed the results of treatment of painful vertebral fractures in patients with primary osteoporosis with balloon kyphoplasty compared with conventional management. Half of the patients were treated with balloon kyphoplasty and half of the patients with thoracolumbosacral orthosis (TLSO). Outcomes included back pain severity measured on visual analog scale (VAS), activity level (VAS), bed rest, SF-36 medical outcomes survey, subject satisfaction, and radiomorphology. Patients reported severe back pain interfering with daily activities before treatment. Physical functioning and quality of life were also markedly impaired. Statistically significant ($p < 0.05$) improvements occurred in all pain and functional outcomes after treatment in the kyphoplasty group. Minor improvements were noted in the orthosis group. Clinical outcomes were significantly different between the groups ($p < 0.05$). Kyphoplasty increased midline vertebral height of the treated vertebral bodies, whereas in the orthosis group, vertebral height decreased.

INTRODUCTION

Osteoporosis is an increasing burden of an aging society, resulting in over 1 million vertebral fractures in Europe per year. Braces are frequently used in conservative treatment and may help patients to stay mobile. However, patients with vertebral fractures may have severe pain. Kyphoplasty is a minimally invasive procedure improving pain and deformity in patients with vertebral fractures (1). This paper presents prospective controlled study of kyphoplasty in patients with primary osteoporosis with painful acute vertebral compression fractures present for less than 3 months.

METHODS AND SUBJECTS

A prospective nonrandomized controlled study was undertaken in a single centre. The study population consisted of consecutive patients with painful osteoporotic vertebral fractures presenting at our department from June 2006 to September 2007.

Methods

All patients in both groups received medical treatment (standard dose of oral aminobisphosphonate + 1000 mg calcium + 1000 IE vitamin D) and a recommendation for supervised physiotherapy once a week for 6 months. For patients undergoing kyphoplasty, two cannulae were inserted transpedicularly into the crushed vertebral body. Cavities of about 5 ml volume were created by two balloon tamps inserted through the cannulae. After removal of the balloon tamps, bone cement (polymethylmethacrylate; KyphX, Kyphon, USA) was injected into the created cavities. For patients undergoing conventional management, thoracolumbosacral orthosis (TLSO) were prescribed and were worn when patients were awake.

Clinical study of the spine was assessed by evaluation of the lateral X-rays of the spine according to standard radiological analyses and the actual measurement of midline vertebtebral height was performed (2). After a minimum of 6 months new vertebral fractures of the thoracic and lumbar spine and of vertebrae directly adjacent to the fractured vertebrae were assessed. Back pain was evaluated in patients by a visual analog scale (VAS). Activity level and patient satisfaction were also evaluated by VAS. Patients were additionally asked to estimate the time spent in bed in the last 28 days and to answer the SF-36 medical outcomes survey, which has been validated for Slovenian language. Kyphoplasty and TLSO group outcomes were compared at follow-up using multivariate generalized linear regression modelling. Baseline characteristics were compared using independent two-group t-test. All data analysis was undertaken using SPSS V.11.

Subjects

Patients of both genders with primary osteoporosis with one or more painful osteoporotic vertebral fractures requiring hospitalisation were eligible for participation. Vertebral fractures were presented for <3 months before inclusion. If kyphoplasty was technically feasible (absence of burst fractures, vertebra plana, and presence of clearly discernible pedicles) the patients were offered surgery or control therapy with optimal medical treatment of osteoporosis, including bracing (TLSO), physiotherapy and analgesics treatment.

RESULTS

Sixteen patients with twenty osteoporotic vertebral fractures were included. Eight patients chose to undergo kyphoplasty, whereas the remaining eight patients were taken as TLSO group.

Radiological analysis

There was no evidence of a statistically significant difference in the characteristics of the kyphoplasty and TLSO groups at entry to the study. Vertebrae treated by kyphoplasty exhibited a relatively increased midline vertebral height, whereas in the TLSO group midline vertebral height decreased, indicating further collapse of the fractured vertebral body. The midline vertebral height was significantly greater ($p<0.001$) in the kyphoplasty group compared with the TLSO group. New vertebral fracture of the adjacent level was detected in two patients in the TLSO group at the follow-up.

Pain perception and daily activities

At the final follow-up, the kyphoplasty group exhibited a significant improvement of the VAS score compared with TLSO group ($p=0.004$). The pain was significantly lower ($p=0.002$) in the kyphoplasty group compared with the TLSO group. The patients in the kyphoplasty group were also more satisfied with the result of their treatment ($p=0.001$). The beneficial effect of kyphoplasty on patients' complaints seems to be accompanied by improved health perception as determined by the SF-36 score. At final follow-up, the kyphoplasty group exhibited a significant improvement in SF36 scores as compared with controls (Physical Component Summary, $p=0.002$; Mental Component Summary, $p=0.18$; Fig. 1).

No patient in the kyphoplasty group spent any full day in bed because of pain in the last 28 days before final follow-up, whereas 2 patients in the TLSO group spent on average 14 full days in bed ($p=0.75$). No patient in the kyphoplasty group spent half of a day in bed because of pain in the last 28 days, whereas 6 patients in the TLSO group spent on average 13 days half of a day in bed ($p=0.005$).

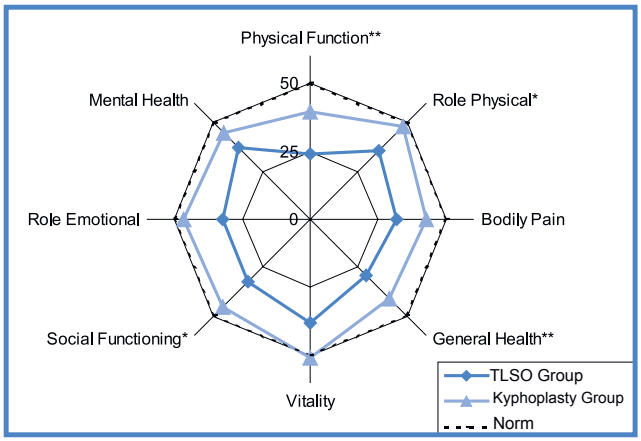

Figure 1: *Norm-based scores for TLSO and kyphoplasty groups (SF-36v2).*
** p<0.05; **p<0.01*

DISCUSSION

The results of this study support the use of kyphoplasty in addition to medical therapy as an effective method of treatment of fractured osteoporotic vertebrae, resulting in reduction of pain, improvement of daily activities, and improvement of total health perception as measured by SF-36 survey. Similar results were described by other authors (3). However, as balloon kyphoplasty is an expensive and invasive procedure, a formal cost-effectiveness study is required to confirm a potential benefit over standard brace treatment.

It has been shown that kyphoplasty may induce new vertebral fractures, particularly in adjacent vertebrae, because of the increased strength of the stabilized vertebral bodies in an osteoporotic spine. However, in our study we did not observe any such fractures in the kyphoplasty group. Moreover, two adjacent vertebral fractures occurred in the TLSO group suggesting that hyperkyphosis at the level of fractured vertebrae alters loading pattern of the spine thus increasing the risk of further vertebral fractures (4).

CONCLUSION

In this study a positive effect of kyphoplasty over standard brace treatment was observed on vertebral morphology and patient's satisfaction, pain, level of activity, and total health perception.

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BRACING ADOLESCENT IDIOPATHIC SCOLIOSIS TODAY

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PURPOSE

The purpose of this report is to give an overview of the existing literature on bracing for scoliosis, and to introduce a special issue of the journal on this topic. We look critically at this treatment, considering not only the possible efficacy but also other key points such as compliance, acceptability and the patient's quality of life, as well as the variability of existing braces.

METHOD

Review of the literature

RESULTS

Bracing is questioned in terms of efficacy, but no alternative exists other than to wait for eventual surgery, or perhaps to do nothing and facing the likelihood of problems with increasing age. Compliance is a critical point, but it isn't a reason to quit. On the contrary, it should be a stimulus for professionals to find the better ways to help their patients in this respect. When faced with the possible alternatives, patients do prefer bracing to the so-called "wait and see" strategy, but we must continue to work to reduce the impairment to quality of life due to the orthosis. The actual variability of braces should be faced, and the BRACE MAP classification is proposed as a unifying tool for the future.

CONCLUSIONS

Bracing is not the best possible treatment, but in the case of scoliosis the alternatives are even more challenging. Thanks to the International Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT) a serious research is ongoing, and in the next few years we will have more data, not only on efficacy but also on compliance, acceptability and quality of life, biomechanics, evaluation tools, informatics in bracing, etc. Hopefully this will lead to better results and choices for our patients.

ORTHOSIS IN THE TREATEMENT OF IDIOPATHIC SCOLIOSIS - FIRST RESULTS

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Abstract

In treatment of idiopathic adolescent scoliosis, we have applied the modified Chenau system and analysed the initial corrective action of the orthosis. The orthosis was administered in 78 patients (65 girls and 13 boys, average age 13 years). Treated were 32 (41%) double thoracic and lumbar curves, and 46 (59%) single curves. In double scoliosis, we detected the initial average correction in the thoracic curves of 31% and 33% in the lumbar curves. In one-curve scoliosis, we had initial correction of average 44.5%. With application of the orthosis, we got good primary correction of the curve, especially in single curves and those with smaller Cobb angle. Further follow-up is necessary for analysis of the final treatment outcome.

INTRODUCTION

Application of corsets in treatment of scoliosis has as primary goal prevention of curve progression and avoidance of operative treatment. Conservative therapy is applicable in idiopathic juvenile and adolescent scoliosis.

Although papers have been published questioning the efficiency of the corrective corsets, as of 1997, after numerous research, the application of the corsets in conservative management of idiopathic scoliosis is no longer questionable. The success of the therapy depends on the primary correction of the curve, early orthosis application in the fast growth phase and the real wearing time.

Since we have introduced the new modified corset type within the last two years, we wanted to check its corrective abilities.

METHODS AND SUBJECTS

In treatment of adolescent scoliosis, we have applied the modified Chenau corset. The modification avoids any pressure in the region of the breasts, enlargement and positioning of the free spaces to enable derotation and better comfort, as well as modelling of the positive in a way to avoid flatback. The production technology was standard casting, modification of the plaster positive (after Wuersching), thermoplastic modelling and fitting, with final application under supervision of the orthopaedic surgeon. The indications were scoliosis with Cobb angle between 20° and 45° Cobb angle, rib hump larger than 1 cm and Risser sign of skeletal maturity up to 3.

The orthosis was applied in 78 patients (65 girls and 13 boys of average age of 13 years). Treated were 32 (41%) double thoracic and lumbar curves with average Cobb angle of 29° thoracic and 27° lumbar, and 46 (59%) single curves of which 14 were lumbar, 12 thoracic and 6 thoracolumbar with average Cobb angle of 29°.

After application of the orthosis, we allowed for a period of adaptation of 1 month, after which an x-ray in orthosis was made. The percentage of primary correction of the curve in the orthosis was calculated for double (thoracic and lumbar curves) as well as for single curves.

We also divided all patients into three groups: scoliosis up to 25° Cobb angle, Cobb angle between 26-35° and over 35° and calculated the correction for respective group.

RESULTS

X-rays in orthosis showed average correction to 18° in the thoracic part and to 19° in the lumbar part in the double curves. That means that we have achieved correction of the thoracic curves of 31% and 33% in lumbar ones. In single curves the average curve of 29° was reduced to 16°, meaning we observed the average correction of 44.5%.

In double curves in the first group, we had the average correction of 35% thoracic (from 20° to 13° with the corset) and 45.5% lumbar (from 22° to 12° with the corset), in the second group 33% thoracic (from 30° to 20,5°with the corset) and 35% lumbar (from 28,5° to 18,5° with the corset). In the third group we measured the correction of 23.5%

(from 40° to 30,5° with the corset) thoracic and 19% lumbar (from 34,5° to 23,5° with the corset). In single curves, the average correction in the first group was 48% (from 21° to 11° with the corset), 46.5% in the second group (from 31° to 17° with the corset) and 40% in the third group, (from 37° to 22° with the corset).

DISCUSSION

In general, we have achieved a larger initial correction percentage in single curves in comparison to double ones. In treatment of double curves, the percentage of correction is dropping with the growth of the Cobb angle. It shows us the importance of early detection so the orthosis can be applied in the fast growth phase. Our opinion is that we can achieve correction with conservative treatment (1, 2). Our patients have accepted this modified Chenau orthosis better than those we have been applying so far. Most probable causes for this are orthosis design, comfort and easier respiration, which have been mentioned also by other authors (3).

CONCLUSIONS

With the orthosis, we got good primary correction of the curve, especially in single scoliosis. The best average correction was observed in scoliosis with lower Cobb angle, as well as in early orthosis application. Further follow-up is necessary for analysis of final treatment outcome.

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PRODUCTION OF SPINAL ORTHOSES WITH CAD/CAM AND CONVENTIONAL MEASURING METHODS

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Abstract

Our experience has shown that introducing CAD/CAM technology to spinal orthotics, due to the decreased weight of models, has facilitated the production and shortened its time compared to using plaster cast which is very time consuming since it requires waiting for the plaster to dry. The aim of the study was to compare the CAD/CAM measuring methods with standard methods in the production of spinal orthoses and to identify the advantages and disadvantages of both. The study included all the persons whose measurements for spinal orthoses were taken at the Institute for Rehabilitation, Republic of Slovenia, in the period between November 1, 2007 and February 29, 2008. When the measuring was performed by scanning the body or the negative, the model (the positive) was 10 to 20 times lighter than when using the classical method of measuring. In scanning, the time of the measuring was shorter by half an hour and working on the model by an hour and a half. The production of spinal orthoses with CAD/CAM measuring is simpler for both, the subject and the engineer. The scanning based models are lighter and can be managed by female engineers as well.

INTRODUCTION

The introduction of computer equipment has put an emphasis on mathematical algorithms that enable an analysis of visual data. On the basis of three dimensional measurements wire models are created that can be then manipulated by CAD/CAM tools (1). There are several ways possible to go from measurement taking to model making. A frequently used method is laser scanning (2) with distance sensors based on laser technology. The Institute for Rehabilitation started introducing that technology seven years ago. CAD/CAM technology by the producer CAPOD was employed. Aportable scanner was used at first and after two years a big orthotic scanner was activated.

The Swedish CAD CAM system CAPOD consists of a stationary rotating device for scanning the entire body. By means of a device for measuring anthropometric data 3D values are taken and transferred into a computer. Adata processing program makes a 3 dimensional model that can be corrected in the software. The model can be contracted or stretched out, it can be polished, rotated or made narrower so as to suit the required dimensions. Then the model is saved in CAD form and transferred to a milling machine, where the actual physical model is made (3,4).

Our experience has shown that introducing CAD/CAM technology to spinal orthotics, due to the decreased weight of models, has facilitated the production and shortened its time compared to using plaster cast which is very time consuming since it requires waiting for the plaster to dry.

The aim of the study was to compare the CAD/CAM measuring methods with conventional measuring methods in the production of spinal orthoses and to identify the advantages and disadvantages of both.

METHODS

In the research process, data were collected for the subjects using spinal orthoses and a questionnaire was used on the type and the production method of the spinal orthoses. The measurements of the subjects' weight and height were taken. For each subject, a questionnaire was filled with the measured data and the measured time of production and design of the spinal orthoses. The measurements of the adult subjects to be fitted with a TLSO PE were performed by scanning, with the exception of the subjects who had problems with standing straight. For the purpose of correction and more precise data in corrective spinal orthoses, the measurements were done with plaster casting and curves were corrected by means of a special table and Glison's loop. The plaster negative was then scanned. The study included all the persons whose measurements for spinal orthoses were taken at the Institute for Rehabilitation, Republic of Slovenia, in the period between November 1, 2007 and February 29, 2008. The data were analyzed by SPSS computer software.

RESULTS

It was found that the negatives of the different types of spinal orthoses weighed differently. The average weight of the Lyon negative was 1.7kg, of Milwaukee 1.2kg and of TLSO 0.6kg.

The next finding was that the method of measuring affected the model's weight. When measuring the trunk of adult subjects by means of scanning the model weighed 4.6kg, when scanning the negative of children it weighed 2.8kg and when plaster casting either adults or children the model weighed 50kg.

Taking the measurements by means of plaster casting was problematic in all the subjects.

The age of the subjects was found to influence the type of spinal orthoses used. The children, aged 12 years on average, wore Milwaukee, 16 years old subjects wore Lyon and the adult subjects, aged 55 on average, wore PE TLSO.

The type of spinal orthoses was found to affect the measuring method. The subjects with Lyon orthoses were measured by scanning the negative, one third of the subjects with Milwaukee were measured with plaster casting. More than two thirds of adult subjects were measured by scanning, the rest were measured by plaster casting.

On average, the scanned models were worked on for one hour while the plaster cast models took two hours and a half. In measuring, the scanning method took one hour on average and plaster casting an hour and a half.

DISCUSSION

The study found differences between the use of CAD/CAM and standard measuring methods that were shown in the weight of the models, the time necessary for measurement taking and working on the models The measuring method affected the model's weight. When scanning the body or the negative, the model (the positive) was 10 to 20 times lighter than when using the standard measuring method. In scanning, the measuring time was shortened by half an hour and working on the model by an hour and a half. Other authors (5) have also reported the scanning method to have shortened measuring time by half an hour and working on the model by more than an hour compared to standard plaster casting method. Wong et al. (6) reports the time of working on the model to be shortened by an hour and a half when using the scanning method compared to the standard method. Standard measuring method can be problematic in subjects who have problems with standing or have certain diseases (such as Mb Parkinson, when the tremor prevents accurate correction).

The next finding was that the type of spinal orthoses affected the weight of the negative and the measuring method. The type of orthoses affected the weight of the negative due to the surface covered with plaster and different numbers of plaster layers. The age of the subjects was found to influence the type of orthoses worn - the children and the adolescents wore corrective orthoses for scoliosis while the adults used PE TLSO for spondylolysis or spondylosthesis. The type of spinal orthoses influenced the measuring method for the purpose of achieving more accurate correction in measurement taking.

CONCLUSION

The development of the technology has brought many advantages such as repeatability of the process, a possibility of changing or updating models without repeated scanning and finally, acomprehensive database that can be accessed remotely, including the patient's medical records.

The results can be summarized in the following: the production of spinal orthoses with CAD/ CAM measuring shortens the production time, which brings positive economical effects. The CAD/CAM measuring method is simpler for both, the subject and the engineer. The scanning based models are lighter and can be managed by female engineers as well.

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THE EFFECTIVENESS OF LUMBOSACRAL ORTHOSIS IN PATIENTS WITH CHRONIC DISCOGENIC LOW BACK PAIN

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Abstract

Lumbosacral orthosis is widely used for patients suffering from low back pain due to various conditions. The aim of this study was to evaluate the effectiveness of the elastic lumbosacral orthosis in patients with chronic discogenic low back pain. 30 consecutive patients presenting to physical medicine and rehabilitation outpatient clinic with chronic (>3 months), discogenic low back pain were randomized into 3 groups (wearing an elastic lumbosacral orthosis for 1 week at least 8 hours a day, receiving standard physiotherapy or no treatment). They were evaluated at the level of pain (visual analogue scale), activities (Oswestry disability questionnaire and Rolland Morris questionnaire) and quality of life (SF-36). According to the first results (first 15 consecutive patients) no significant difference in any of our groups was observed.

INTRODUCTION

Lumbosacral orthosis is widely used for patients suffering from low back pain due to various conditions. There are many proposed mechanisms of action alleviating low back pain, like restriction of trunk motion, reduction in required back muscle forces, increase in abdominal pressure, proprioceptive stimuli and even local temperature elevation. The existing evidence regarding effectiveness of lumbosacral orthosis is conflicting. The objective of this study was to evaluate the effectiveness of the elastic lumbosacral orthosis in patients with chronic discogenic low back pain.

METHODS AND SUBJECTS

Methods

Subjects were randomized into 3 groups: wearing an elastic lumbosacral orthosis for 1 week at least 8 hours a day, receiving standard physiotherapy one week or no treatment. They were evaluated at the level of pain (visual analogue scale), activities (Oswestry disability questionnaire and Rolland Morris questionnaire) and quality of life (SF-36) three times: before treatment, immediately after treatment and 2 weeks after prescription of orthosis or therapy.

Subjects

30 consecutive patients presenting to physical medicine and rehabilitation outpatient clinic with chronic (>3 months) low back pain with discogenic characteristics were included in the study.

RESULTS

The study is still in progress, but according to the first results (first 15 consecutive patients) no significant difference between the first and the second evaluation or the first and the last evaluation in any of our groups was observed, except in the group wearing a lumbosacral orthosis in respect of average pain intensity (between the first and the second evaluation), which got even worse (p=0.043).

DISCUSSION

The study is still in progress, so the results are inconclusive. The fact that none of the chosen outcome measures has not detected any significant improvement so far, supports the idea, that it is very difficult to improve the status of chronic pain patients with orthotic or physical therapy interventions only.

CONCLUSION

Results of the first analysis do not support any of the chosen interventions to be effective for patients with chronic discogenic low back pain.

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MEASURING SPINAL CURVATURES WITH LASER TRIANGULATION METHOD - PRELIMINARY RESULTS

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Abstract

The study presents results for measurements of thoracic kyphosis and lumbar lordosis angles in 78 subjects of both genders aged between 20 and 60 years. The measurement was performed on the surface of the back with laser triangulation method. The average value of thoracic kyphosis was 46.9° and lumbar lordosis 28.4°. Linear correlation between both angles was moderate (r = 0.59). In female subjects (n = 22) we determined a statistically significant larger average thoracic kyphosis angle (p = 0.07) and lumbar lordosis angle (p = 0.001) in comparison to male subjects (n = 56). Differences in the average values of observed angles among younger subjects (aged between 20 - 40 years, n = 39) and older subjects (aged between 41-60 years, n = 39) were not statistically significant.

INTRODUCTION

The analysis of a person's upright posture is important since a deviation from the correct posture causes problems or indicates a present pathological activity. To determine a correct position of the trunk, it is necessary to (also) define the sagittal spinal curvatures. Clinical evaluation can also be complemented with different measuring techniques. Regarding the spinal anatomy, the most precise method is a side view X-ray and measurement of curvatures at the vertebral level (1). Since this is an aggressive method, in clinical practice the measurement is performed harmlessly of the body's surface.

For such purposes, the most common method is the use of gravitational inclinometer. Especially in the studies, other systems were also used: De Brunner's Kyphometer (2), Curviscope (3). Validity, reliability, and with that repetition of measurements is not ideal as it is partially dependent on researcher's experience and accuracy when adjusting the measuring device on the skin. An ideal solution is offered by non-contact measurement methods in the form of photo of the surface which is illuminated by different light sources (4). One of them is the laser triangulation method which has been used for different measurements in medicine for numerous years (5). A review of professional publications does not provide data on measurements of spinal curvatures with this method.

SUBJECTS AND METHODS

Subjects

78 subjects aged between 20 to 60 years (average age 40 years, st. deviation 10.8) participated in the study. 56 (71.7%) were men and 22 (28.3%) women. Their anamnesis had to be without injuries and medical conditions related to the spine and their posture had to be clinically assessed as correct.

Methods

The skin of the back was marked with transition points between C7/Th1, Th12/L1, and L5/S1 disk levels. Basic anthropometric measurements were performed: body height and body weight. A three-dimensional image of the back was obtained with a laser triangulation device (Faculty of Mechanical Engineering in Ljubljana). A specifically designed software enabled image analysis and calculation of desired angles.

RESULTS

Basic anthropometry and descriptive statistics showed in all 78 subjects the following results (Table 1).

Table 1: *Body Height (BH), Body Weight (BW) and Body Mass Index (BMI) of all 78 subjects*

Parameter	BH (cm)	BW (kg)	BMI (kg/m²)
Average	172.8	80.7	26.9
St. deviation	7.2	15.9	4.8
Minimum	157	47	18.6
Maximum	186	121	44.3

Next the results of measurements of sagittal spinal curvatures are presented. Table 2 provides descriptive statistics for thoracic kyphosis angle in all subjects (n = 78) and separately for men (n = 56) and women (n = 22).

Table 2: *Thoracic kyphosis (ThK) angle in all subjects and in men and women separately*

Angle (°)	ThK (all)	ThK (men)	ThK (women)
Average	46.9	45.4	50.7
St. deviation	10.5	9.5	12.1
Minimum	29.3	29.3	29.3
Maximum	75.1	69.6	75.1

Comparison of means ThK(men)/ThK(women) - t-test: p = 0.07

The values of lumbar lordosis angle in Table 3 are presented in the same manner.

Table 3: *Lumbar lordosis (LuL) angle in all subjects and separately in men and women*

Angle (°)	LuL (all)	LuL (men)	LuL (women)
Average	28.4	24.6	38.2
St.deviation	12.6	7.7	17.0
Minimum	6.9	6.9	13.0
Maximum	74.9	39.5	74.9

Comparison of means LuL(men)/LuL(women) - t-test: p = 0.001

The subjects were divided regarding their age in two groups: the younger group (aged between 20 and 40 years) included 39 subjects and the older (aged between 41 and 60 years) 39 subjects. Thoracic kyphosis angle in all patients and comparatively in both age groups is presented in Table 4.

Table 4: *Thoracic kyphosis (ThK) angle in all subjects and separately in younger and older ones*

Angle (°)	ThK (all ages)	ThK (age 20-40)	ThK (age 41-60)
Average	46.9	46.4	47.4
St.deviation	10.5	9.5	11.5
Minimum	29.3	29.3	29.3
Maximum	75.1	69.6	75.1

Comparison of means ThK(younger)/ThK(older) - t-test: p = 0.66

A comparison of lumbar lordosis angle in both age groups provided results shown in Table 5.

Table 5: *Lumbar lordosis (LuL) angle in all subjects and separately in younger and older ones*

Angle (°)	LuL (all 78)	LuL (age 20-40)	LuL (age 41-60)
Average	28.4	27.4	29.5
St.deviation	12.6	11.5	13.7
Minimum	6.9	6.9	7.8
Maximum	74.9	73.3	74.9

Comparison of means LuL(younger)/LuL(older) - t-test: p = 0.46

Linear correlation between individual pairs of data was checked in the analysis of results. The calculated correlation coefficients »r« are shown in Table 6.

Table 6: Linear correlation between chosen pairs of obtained results

Linear correlation	r
Thoracic Kyphosis / Lumbar Lordosis	0.59
Body Height / Thoracic Kyphosis	- 0.32
Body Height / Lumbar Lordosis	- 0.45
Body Weight / Thoracic Kyphosis	0.06
Body Weight / Lumbar Lordosis	0.01
Body Mass Index / Thoracic Kyphosis	0.24
Body Mass Index / Lumbar Lordosis	0.25

DISCUSSION

The study shows preliminary results measured on the initial group of 78 subjects. The obtained average value of thoracic kyphosis angle was 46.9°, lumbar lordosis angle 28.4°. The values were similar to those in literature (6). Linear correlation between both angles was moderate (r = 0.59). In women we determined a statistically significant larger average thoracic kyphosis angle (p = 0.07) and lumbar lordosis angle (p = 0.001) in comparison to male subjects, which differs from the published findings (6). A relatively small number of women (n = 22) represents a deficiency of the comparison in this study. The analysis of sagittal curvatures angles between younger and older group of subjects has shown no statistically significant difference between average thoracic kyphosis (p = 0.66) and lumbar lordosis angle (p = 0.46). In the study among the older population, a positive correlation between age and thoracic kyphosis was established (7).

A calculation of the linear correlation coefficient between observed angles and basic anthropometric results has demonstrated a weak negative correlation between angles and body weight - larger body weight is linked to a smaller thoracic kyphosis (r = - 0.32) or lumbar lordosis angle (r = - 0.45). Linear correlation relations between angles and body height as well as BMI were negligible.

One of the advantages of measuring sagittal spinal curvatures by using laser triangulation method is especially

non-aggressiveness, non-contact measurement, and high resolution of points. One of the deficiencies is a few seconds long measurement, which requires the subject to be at rest, and, of course, only a static scan. Other technical solutions of recording can remove these deficiencies.

CONCLUSION

Medicine has the task to search for effective and subject-friendly diagnostic methods. Both criteria are met by the laser triangulation method used for measuring sagittal spinal curvatures on the body's surface. Such purpose represents the beginning of introducing this method into medical diagnostics. A three-dimensional image of the body's surface offers numerous possibilities for computer analyses. Solutions to certain limitations, especially static scanning, represent new research interdisciplinary challenges.

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COMPARISON OF SEATING DEVICES FOR POSITIONING OF CHILDREN WITH SEVERE MOTOR DISORDER: EVALUATION OF PARENTAL SATISFACTION AND THE RESULTS OF A MEDIUM-TERM FOLLOW-UP

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PURPOSE

The aim of the study was to compare the efficacy of usage of three different types of seating modules for children with severe muscle imbalane who were not able to sit alone or had a very bad sitting posture.

METHOD

A prospective study with matched-pares (the same subject pre- and post-intervention) was carried out. Questionnaires answered by the parents after 2-3 months of usage of the seating device and the results of the 18-36 months follow-up assessment of the patients were evaluated.

RESULTS

We have got back 111 (87 per cent) of the questionnaires. The average time of daily usage of the devices was 3 hours and 55 minutes for all children and youngsters. There was no significant difference among the three groups. The most prominent positive changes were found in the feeding situation after usage of the seating device: 77, 74 and 64 %, respectively of the responses told us that the feeding situation became better. The posture also has improved in many children and young adults: the most changes were observed in trunk posture: among children using the TLSO-SIDO®: 81 per cent of the parents marked improvement, in the other groups 77 per cent and 71 per cent, resp.

The most prominent changes were observed in the TLSO-SIDO® frame group. The overall parental satisfaction was good in the two groups of TSLO, like 77 and 80 per cent, while less good with seating devices: 40 per cent. During the medium-term follow-up it became evident, that more than 90 per cent of the children and young adults have used the devices. The average time of using one device was 14.5 (±3) months for the TLSO-SIDO, 15.6 (±3.4) months for the TLSO and more than two years for the seating module. There were only two young adults who needed new devices due to the intolerance of the first one, and a few, who were in need of extra accessories as they did not feel comfort or safe in the device

CONCLUSION

It is extremely difficult to measure the effect of the postural management on the development of children with significant motor disorders as well as on the daily living skills and posture of children and young adults with multiple handicaps. The improvement in posture, feeding situation, daily living skills, etc. observed during the study period might have been influenced by other factors as well. The beneficial effects can partly be attributed to the fact that the children and young adult were adequately positioned when seated. The comparison of three seating devices on the daily living skills and posture showed no significant difference among the study groups. We have found more beneficial the TLSO and TLSO-SIDO® frame than the seating module as far as the need for the technical re-adjustments
was concerned.

ORTHOPAEDIE TECHNIK - FISH OR FOWL?

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Abstract

When it comes to comparing the few P&O related journals worldwide which are published on a regular and more or less professional basis, German ORTHOPAEDIE TECHNIK can be most easily characterized by a couple of no's. Is it scientific, i. e. peer-reviewed and impact-factored, like P&O International or JPO are? No. Is it more a business paper like O&P News from the US? No. Is it the pendant circular of an organization or community like the Almanac, Russian Westnik, or some other national publications, more or less committed (and limited) to their internal communication? No. Even worse, also members have to pay for it separately, or skip it. Is it being published by a big publishing house, thus kind of a niche journal in a large portfolio, as some of the mentioned journals are? No, it is independent and self-sustaining in its own publishing house.

On the other hand, ORTHOPAEDIE TECHNIK has something of it all. Most of the "big names" in the academic field of P&O have published with us and still do submit articles, without expecting to gain Medline credits, even in the middle of no-name "simple technician" authors. We have business-related features in each issue. We express the standpoint of the profession in Germany among other stakeholders without being the loudspeaker of the owner, the German federal P&O organization.

And, after all, ORTHOPAEDIE TECHNIK is the oldest (from 1949) P&O related monthly periodical, having a subscribed circulation of 3,600 national and 900 international, which is by far the largest number among all other similar journals.

This part of the "Meet the Editor" session will go through the following topics:

- Short history of a specialized journal: from "internal" to open communication
- An apparently quite successful mix: how every issue is being composed
- Balance of powers: the profession and "the industry"
- The role of New Media: current and future
- Going international: license policy (China example) and obstacles
- FAQ: how to submit an article, and related questions

THE EFFECTS OF THE EDUCATION PROGRAM COMBINED WITH EXERCISE PROGRAM ON MECHANICAL LOW BACK PAIN IN ABOVE KNEE AMPUTEES

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Abstract

The purpose of the present study was to determine the effects of the education program combined with the exercise programe on mechanical low back pain, muscle strength and shortness in unilateral above knee amputees. Twenty subjects were randomly enrolled to the education program group and 20 to control group. An education and exercise program, lasting about 1 hour and including theorical and practical education and specific exercises was given to education group during 10 sessions. The exercises were shown to control group once as practically. When two groups were compared significant differences in all measured parameters were found in favor of education group($p<0.05$).

INTRODUCTION

Low back pain (LBP) is one of the most frequent problem that may become chronic after lower limb amputation (LLA). It decreases the quality of life and functional capacity. The preceding studies, few information was given about the reasons of LBP and there is no study including the treatment of LBP in this population. This study was planned to determine the problems as the result of mechanical LBP and to asses the effects of education program combined with exercise program (1-3).

SUBJECTS AND METHODS

Subjects

Forty unilateral above knee amputees (18-50 years) with mechanical low back pain were divided into two groups equally. Twenty subjects were randomly allocated to the education program group (Gr A) and 20 to control group (Gr B).

Method

An education and exercise program including theorical and practical education was given to Gr A during 10 session. The exercises were shown to Gr B once as practically. For the first assesment, muscle strength and shortness tests were performed and pain perception was measured by Visual Analog Scale. These measurements were repeated in first (second assesment) and third (third assesment) months after the first assesment (5, 6).

RESULTS

At second assesment, pain perception and muscle shortness were significantly improved in Gr A ($p<0.05$). In Gr B there wasn't any significant difference in all measured parameters ($p>0.05$). At third assesment, in both groups pain perception; only in Gr A muscle strength and shortness improvements were observed ($p<0.05$). When two groups were compared significant differences in all measured parameters were found in favor of Gr A.

DISCUSSION

A few studies have been carried out in this population and these studies examined the incidance and some reasons of LBP. The incidance of LBP in amputee population ranges between %52-%84 (2-4,6). LBP is more frequent in above knee amputees than below knee amputees. Thus, LBP may be releated the level of amputation and biomechanical vari-

ables. It is important to investigate possible causes of LBP, such as biomechanical changes secondary to the amputation. These physical characteristics include deficiencies in abdominal and back extensor muscle strength, hamstring and iliopsoas muscle length (3).

In general, specific strength and length variables were selected because muscle imbalances may cause abnormal biomechanics, which may then cause compensatory movements, leading to microtrauma in the pelvis and lumbar spine (3).

The results of the studies carried out on various education and exercise programs showed statistically significant reduction of LBP. In our study this result was observed in both groups (7).

CONCLUSION

According to these results, the education and the exercise program used in this study increased muscular strength, decreased pain perception and muscle shortness.

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ASSESSMENT OF RELATION BETWEEN THE JOINT POSITION SENSE AND PHANTOM LIMB SENSATION AND PHANTOM LIMB PAIN IN TRANS-TIBIAL AMPUTEES

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Abstract

The aim of this study was to compare the joint position sense (JPS) in below knee amputees with and without phantom limb pain (PLP). The study included 25 unilateral trans-tibial amputees and 30 healthy subjects of the same age. For the evaluation of JPS, Laserline was used and the findings obtained at the angles 20°, 40° and 60° were recorded. A significant difference was found to be in the aspect of JPS at the test angles 20° with prosthesis in favor of the subjects with phantom limb sensation (PLS) when the patients with and without PLS was evaluated ($p<0.05$). There was a statistical difference in the aspect of JPS at the test angles 20° and 40° in favor of the subjects with PLP when the subjects with and without PLP were compared ($p<0.05$). There was correlation between JPS and PLS and PLP at the test angles 20°, while it was determined that there was only relation between JPS and PLP at the test angles 40° ($p<0.05$). It can be concluded that the PLP and PLS effect JPS in trans-tibial knee amputees.

INTRODUCTION

Proprioceptive sense provides us to be aware of the position of our extremities and therefore we can protect our balance while we are standing up and during activity. It gives an opportunity to well-arranged writing, jumping and running (1).

There are many questions about proprioceptive neuromuscular control, although it has not any doubts about importance of proprioceptive sense in the literature (2, 3). Receptors of proprioceptive sense exist in the different structures such as skin, muscle, ligament, tendon, and joint. So, if these structures expose to traumas, proprioceptive sense can be effected, negatively (4-6).

There are few studies about how proprioceptive sense is effected in the amputees and how is it working during prosthetic fitting and training program. The aim of this study was to compare the joint position sense in trans-tibial amputees with and without phantom limb pain and to determine if there is a relation between joint position sense and phantom limb pain.

METHODS AND SUBJECTS

The study included 25 unilateral trans-tibial amputees, between the ages of 18-50 years who were using their prosthesis for at least 6 months and 30 healthy subjects of the same age. The subjects were seperated into two groups. The study group was formed of amputees with phantom limb sense-pain and the control group included the subjects without phantom limb sense-pain. The subjects were evaluated in the aspects of age, the time passed after amputation, the duration of prosthetic utilization, the number of prosthesis used, the weight of prosthesis in addition to weight distribution and joint position sense.

It were not included that the patients had muscle weakness in hip and knee, muscle shortness, contractures, joint limitations, cooperation problems, nerve system patologies were known, vestibular and neuromuscular defects, history of knee injuries, cronic knee pain was evaluated by visual anolog scale.

Conventional prosthesis with patellar tendon bearing sockets and supra condyler suspension was used in prosthetic applications.

For the evaluation of joint position sense, Laserline was used and the findings obtained at the angles 20°, 40° and 60° were recorded.

RESULTS:

It was determined that 72% of the subjects who had phantom sense, while 36% of the subjects complained about phantom pain (Table I).

Table 1: *The phantom sense and pain of the subjects*

		n (%)
Phantom sense	Yes	18 (72)
	No	7 (28)
Phantom pain	Yes	9 (36)
	No	16 (64)

Demographic characteristics and prosthetic components of the subjects who had phantom sense and who had no phantom sense were shown in table II.

Table 2: *Demographic characteristics and prosthetic components of the subjects had phantom sense and no phantom sense*

Parameters		The subjects who had phantom sense (N=18) X±SD	The subjects who had no phantom sense (N=7) X±SD
Age (year)		39.39 ± 9.54	31.43 ± 2.09
Body mass index(kg/m^2)		26.61 ± 2.73	24.71 ± 3.73
Prosthesis usage time(year)		9.83 ± 9.02	17.43 ± 10.67
Weight of prosthesis(kg)		1.74 ± 0.31	1.66 ± 0.48
Length of stump(cm)	Bone tissue	17.19 ± 6.30	17.93 ± 5.67
	Soft tissue	18.56 ± 5.61	18.29 ± 5.89

We found to be a significant difference in the aspect of joint position sense at the test angles 20° with prosthesis in favor of the subjects with phantom limb sensation when the patients with and without phantom limb sensation was compared (p<0.05) (Table III).

Table 3: *Comparison of the values of deviation angle in the subjects who had phantom sense and who had no phantom sense.*

		The subjects who had phantom sense (N=18)	The subjects who had no phantom sense (N=7)		
		X±SD	X±SD	z	p
20°	Intact side	4.21 ± 3.77	5.86 ± 6.08	-0.577	0.564
	Without prosthesis	8.12 ± 5.00	13.43 ± 14.74	-0.485	0.628
	With prosthesis	4.86 ± 4.62	10.19 ± 4.45	-2.274	**0.023***
40°	Intact side	6.43 ± 4.53	6.39 ± 2.03	-0.485	0.628
	Without prosthesis	8.35 ± 5.45	11.34 ± 11.45	-0.03	0.976
	With prosthesis	7.38 ± 5.79	8.47 ± 7.75	-0.061	0.952
60°	Intact side	7.18 ± 4.25	6.29 ± 3.18	-0.303	0.762
	Without prosthesis	7.51 ± 6.60	4.47 ± 4.08	-1.091	0.275
	With prosthesis	5.94 ± 4.34	3.67 ± 2.41	-1.212	0.225

* Mann-Whitney U testi (p<0.05)

Demographic characteristics and prosthetic components of the subjects who had phantom pain and who had no phantom pain was shown in table IV.

Table 4: *Demographic characteristics and prosthetic components of the subjects who had phantom pain and who had no phantom pain*

Parameters		The subjects had phantom pain (N=9) X±SD	The subjects had no phantom pain (N=16) X±SD
Age (year)		36.67 ± 10.40	37.44 ± 11.18
Body mass index(kg/m^2)		24.78 ± 1.99	26.81 ± 3.39
Prosthesis usage time(year)		8.22 ± 8.63	14.06 ± 10.22
Weight of prosthesis(kg)		1.78 ± 0.21	1.69 ± 0.42
Length of stump(cm)	Bone tissue	18.09 ± 5.58	18.09 ± 5.58
	Soft tissue	18.88 ± 5.52	18.88 ± 5.52

There was a statistical difference in joint position sense at the test angles 20° and 40° in favor of the subjects with phantom pain when the subjects with and without phantom pain were compared (p<0.05) (Table V).

Table 5: *Comparison of the values of deviation angle in the subjects who had phantom pain and who had no phantom pain*

		The subjects had phantom pain (N=9)	The subjects had no phantom pain (N=16)		
		X ± SD	X ± SD	z	p
20°	Intact side	2.49 ± 2.87	5.89 ± 4.79	-1.819	0.069
	Without prosthesis	4.87 ± 3.08	12.27 ± 9.93	-2.437	0.015*
	With prosthesis	2.16 ± 2.76	8.71 ± 4.60	-3.120	0.002*
40°	Intact side	6.03 ± 4.90	6.63 ± 3.46	-0.680	0.496
	Without prosthesis	5.04 ± 4.25	11.52 ± 7.96	-2.295	0.022*
	With prosthesis	5.94 ± 3.91	8.67 ± 7.17	-0.595	0.552
60°	Intact side	8.78 ± 4.26	5.89 ± 3.45	-1.503	0.133
	Without prosthesis	5.96 ± 4.94	7.06 ± 6.76	-0.085	0.932
	With prosthesis	7.73 ± 5.12	3.94 ± 2.42	-1.616	0.106

*Mann-Whitney U testi (p<0.05)

A correlation was found between joint position sense and both phantom limb sensation(r:0,492; p:0,037), and pain(r:0,469 ; p:0,037) at the test angles 20° while we determined that there was only relation between joint position sense and phantom limb pain (r:0,458 ; p:0,042) at the test angles 40°(r:0,458 ; p:0,042) (p<0.05).

DISCUSSION

Body protects its balance by proprioceptive sense as it reorganizes the muscles suddenly, towards reactional forces occurred from outside. It has information about its posture, movement, balance and objects which came on position and weight (7).

Proprioceptive sense is related to balance, coordination and agility (8). Rehabilitation program included proprioceptive sense training is used to develop functional abilities as it is understood that importance of the proprioceptive sense on stability of the functional joint is protected and provided (9).

Loss of the proprioceptive sense is vital in the amputees who have limited functional capacity. When it is thought that base on the prosthetic training includes increasing muscle strength, balance, weight bearing and gait training in the amputees who tried to their demands with prosthesis instead of function of the amputated extremities.

When we evaluated the our patients in terms of joint position sense according to phantom sense and phantom pain, we found to be a significant difference in the aspect of joint position sense at the test angles 20° with prosthesis in favor of the subjects with phantom limb sensation when the patients with and without phantom limb sensation was compared, while it was a statistical difference in the aspect of joint position sense at the test angles 20° and 40° in favor of the subjects with phantom pain when the subjects with and without phantom pain were compared.

The deviation obtained from all three measurements increased as its parallel to test angle increased, when deviation angle obtained from intact extremities and amputated extremities with and without prosthesis of amputees had phantom pain were compared each other. This condition shows parallel to data obtained from intact extremity which we accepted normal Proprioceptive sense.

CONCLUSION

It can be concluded that the phantom limb pain and sensation effect joint position sense in trans-tibial amputees. So, evaluation of joint position sense is very important in terms of prosthetic rehabilitation in trans-tibial amputees.

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EFFECTS OF INFRAPATELLAR STRAP ON GAIT AND FOOT PARAMETERS IN PATIENTS WITH PATELLOFEMORAL PAIN SYNDROME

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BACKGROUND

Patellofemoral pain syndrome (PFPS) is defined as "idiopathic pain" arising from the anterior aspect of knee or patellofemoral region. It is reported that abnormal lower-extremity kinematics have been commonly cited as a possible predisposing factor for PFPS.

OBJECTIVE

We aimed to show initial effects of infrapatellar strap on foot and gait parameters using dynamic pedobarography in patients with unilateral PFPS and compare the results with their uninvolved side as a control.

METHODS AND SUBJECTS

18 women diagnosed with unilateral PFPS mean age 44.17 ± 7.44 years with no history of lower limb, spinal or neurological injury or surgery participated in the study. All subjects underwent dynamic plantar pressure measurements on dynamic pedabarography during barefoot with/without infrapatellar strap.

RESULTS

We found significant differences in forefoot surface during gait with or without infrapatellar strap ($p<0.043$). In addition, minimum subtalar angle decreased patients' involved side ($p<0.008$).

CONCLUSION

Our findings suggest that the feet of the patients with PFPS have significant differences compared to uninvolved side. The results of this study can be considered valuable in the light of assessing foot and gait parameters in PFPS during barefoot walking.

TREATMENT WITH AFO IN CASE OF CALCANEUS PATHOLOGICAL FRACTURE

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INTRODUCTION

In severe cases of diabetic foot disorders the destruction of the bones and joints can often be observed showing the typical clinical and radiological image of osteoarthropathy (Charcot-foot). Due to the disorder of bone metabolizm diffuse osteoatrophy is developed, therefore pathological fractures are common after even smaller traumas, as well as dislocation, subluxation in the joints, which all lead to the deformation of the foot.

CASE REPORT

Young male patient with Diabetes Mellitus for decades, receiving insulin therapy. Pathological fracture of the calcaneus without trauma, being treated at his home for a long time. He was taken to medical ward in severe septic condition. An extended abscess and the fracture of the calcaneus was diagnosed there.

Due to the infected bone and soft tissues and the osteoporosis of the bone, the traditional osteosynthesis methods had to be rejected, therefore non-operative fracture treatment was followed, including incision of the abscess, drainage, bed rest, foot up position, plaster immobilisation. As a result, the inflammation diminished, the sceptic condition slowly ceased. Plastic orthoses was then applied in order to splint the fracture therefore to mobilise the patient. X-ray images documented the healing of the bone fracture.

CONCLUSION

The clinical and radiological characteristics and the diagnostic steps of the diabetic neuropathic foot disorders are not widely known, that's why it leads very often to maior amputation. Due to neoropathy, the lack of pain sensation which normally acts as a defence mechanism, these kind of severe foot disorders are recognised too late. The treatment of the infected bone fracture is very difficult, therefore long lasting non-operative treatment, use of orthoses is recommended over osteosynthesis methods.

THE ORTHOTIST ROLE IN DESIGNING CUSTOM WHEELCHAIR SEATING SYSTEMS

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Abstract

The orthotist can play a significant role in the design of specialized custom seating systems for the non ambulatory patient. Custom seating system can be considered full body orthosis. With training in designing orthosis for the limbs, there is a natural evolution for the orthotist to design and fit custom seating systems. A seating team, consisting of a physician, nurse, occupational and physical therapists, orthotist and a wheelchair technician would best benefit the patient. However, with the changing healthcare system, it is difficult getting all members together. In most cases the client is now seen by three healthcare professionals at a time to determine the patient's seating and mobility needs. The presentation will review the seating posture and the biomechanics of sitting. It will review the protocol of evaluating the seating needs of the client, and the casting and fabrication of the seating system. Three case studies will be presented.

INTRODUCTION

The definition of an orthosis is "an orthopaedic appliance or apparatus used to support, align, prevent, or correct deformities or to improve function of moveable parts of the body" (Dorland's Medical Dictionary). There is a variety of seating systems to select from and it is well documented when to utilize custom made systems (1, 2). A custom made seating system is an orthosis for the body for sitting, which is the person's functional position (3). It has been well documented that a well designed seating system improved the wheelchair dependent person's quality of life, making sitting more comfortable, and it allowed them to interact with their environment and others, and it can relieve the work of the primary caregiver, because less time is required to constantly re-position the patient (2, 4).

In Ontario, custom seating systems were originally determined and prescribed necessary by a seating team, often associated with a Hospital. However, with healthcare funding changes, and the role of the hospital changing, the primary funding agency (provincial government) eliminated the need for the seating team. The seating team consisted of: nurse co-ordinator, physician, physical therapist occupational therapist, and orthotist and wheelchair technician. Today, it is mainly the occupational or physical therapist, the orthotist and wheelchair technician who determine the mobility and seating needs of the wheelchair dependent person.

The presentation will review the goals of wheelchair sitting and the principles of proper sitting posture. The seating assessment protocol will be described, highlighting the importance of the pelvis. The process of capturing the most effective and functional sitting position will be outlined. The negative cast rectification will be described briefly.

CASE PRESENTATIONS

Three cases will be presented. The first case is an adult diplegic cerebral palsy patient. Three different seating systems were provided over a 10 year period. Each system was photographed and justification was provided for each new system. The second case is young adult spastic quadriplegic cerebral palsy patient. This patient has been followed for 12 years. He has had 4 custom seating systems and has converted from manual to power wheelchair (Figure 1). The third case is a blind young adult spastic quadriplegic patient who has been followed for 12 years. She has received 4 custom seating systems. The patients had thorough documentation of their physical and functional needs assessments, including photographs of their seating issues, and the fit and function of the seating systems. Recently the patients had pressure mapping done to ensure that the custom seat cushions were performing effectively (Figure 2).

CONCLUSION

Thorough documentation using photographs and pressure mapping (Tek Scan) are effective tools when dealing with complex seating systems for the wheelchair dependent person. These tools provide effective feedback to the clinician and the patient. The photographs are also effective tools to use when requesting the need for funding for new systems.

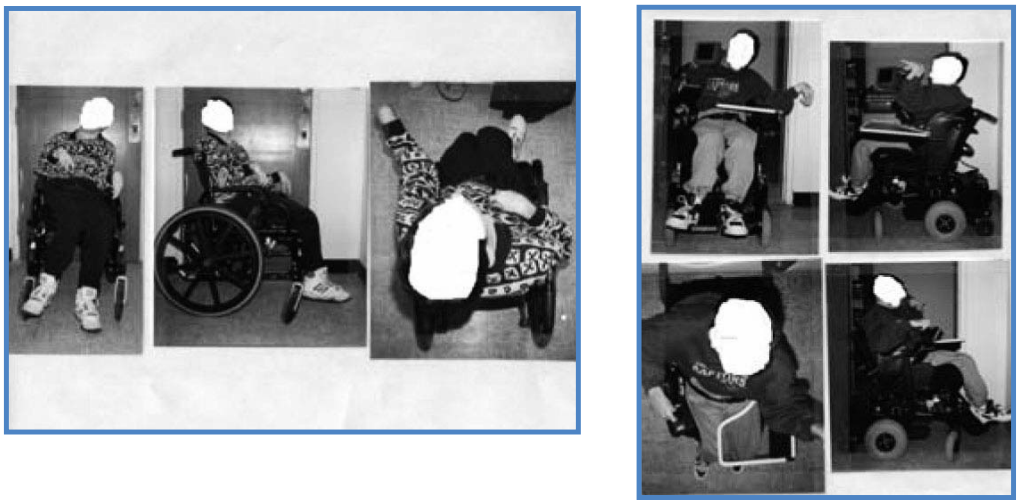

Figure 1: *Example of photographs used in documentation.*

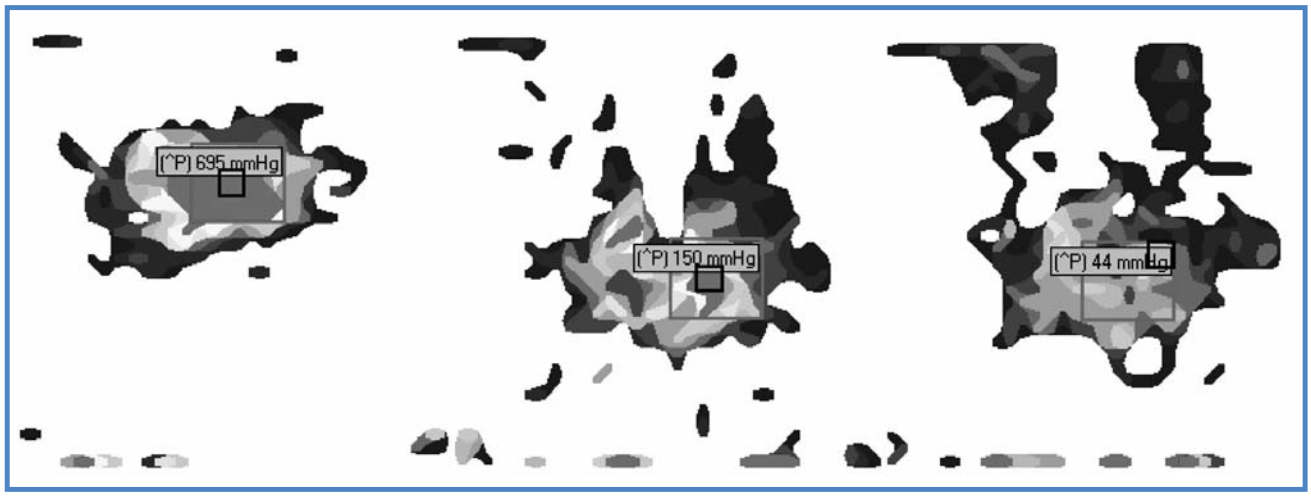

Figure 2: *Example of Tek Scan seat pressure mapping for standard chair, custom seat cushion and modified custom seat cushion.*

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PROBLEMS IN REHABILITATION OF PATIENTS AFTER TRAUMATIC TRANSTIBIAL AMPUTATION

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Abstract

Trauma is the most common cause for lower extremity amputation in the second and third decades of life. The aim of this paper is to indicate the (complex) issues in preprosthetic and prosthtetic phase of transtibial amputatees rehabilitation. Our patient has underwent a transtibial amputation after trauma. After the orthopaedic treatment had finished, a substantial flexion contracture of the knee remained. A lengthy physical treatment combined with the surgical treatment eventually gave a positive effect and the patient was enabled to walk with the prosthesis. The other problem in the prosthetic phase was a prominence of the fibula in the residual limb which represented a painful spot and limited the walk with the prosthesis. This problem was surgically resolved. In order to achieve success, a close cooperation of all of the rehabilitation team members, in all the phases of prosthetic process, is crucial.

INTRODUCTION

Approximately 6% to 10% of acquired lower extremity amputations result from traumatic injuries to the extremities. Trauma is the most common cause for lower extremity amputation in the second and third decades of life. Muscle imbalance and postoperative positioning lead to development of knee flexion contracture in the transtibial residual limb (1).

METHODS AND SUBJECTS

Patient (20 yrs.) acquired a crushing injury of the left foot and a supracondylar fracture of the left thigh bone, in a traffic accident which happened on the 19th of August 2006. A transtibial amputation of the left leg and an external fixation of the left thigh bone were performed. Due to a redislocation of the thigh bone fracture, one month later a new stabilization was undertaken using the external stabilizator according to Hoffman.

Postoperatively, the patient was treated with antibiotic therapy according to the antibiogram, due to necrosis and infection of the postoperative wound. After the infection was solved, the skin defect was covered with plastic surgery according to Tirsch. The consequence of these complications was a left knee flexion contracture after the external fixation was removed on the 11th of January 2007 (flexion 90°, extension -40°, both actively and passively), which persisted even after a two months physical treatment (physical exercise, occupational therapy, thermotherapy). An orthopedic surgeon who was consulted decided to surgically treat the contracture by placing an orthosis in the form of external fixation (18.04.2007). During his second hospitalization, the patient was educated to increase the angle of extension on his own (by turning the screw on the orthosis), the muscle strength of the upper extremities and the right leg was increased (grade 4), while the muscles of the transtibial residual limb were graded 3 according to the MMT. On August, the external fixation was removed. In the prosthetic phase, a reduction of the flexion contracture of the left knee was observed (passive extension -15°, active -35°) which was further improved by intensive physical exercise, hydro, laser and thermotherapeutic procedures (passive extension 0°, active -10°), but a problem of pain and palpatory sensitivity of the lateral part of the postoperative scar just above the bone prominence (fibula) occurred, as well as three skin folds in the medial part. This problem was also surgically solved.

RESULTS

One year after the rehabilitation process first took place, the patient is able to walk with the shank vacuum prosthesis without other walking aids, for longer distances uses one crutch, is without any subjective complaints and has a minimal flexion contracture in the knee (active extension -7°, passive 0).

DISCUSSION

Contractures are serious complications that will interfere with proper prosthetic gait and increase the energy require-

ments of ambulation. Severe knee flexion contractures are virtually impossible to reduce by exercise once they become fixed (2).

CONCLUSION

Medical rehabilitation of patients after amputation of the lower extremities is very complex, especially in cases where complications occur. In order to achieve success, a close cooperation of all of the rehabilitation team members, in all the phases of the prosthetic process, is crucial.

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CONCEPTION OF STUDY ORTHOTIST-PROSTHETIST AT UNIVERSITY OF OSTRAVA, CZECH REPUBLIC

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Bachelor's study programme Orthotist and Prosthetist has been taught at Medico-Social Faculty since the academic year 2006/2007 and has been opened as the first one in the Czech Republic. It has implemented all requirements of the Czech Act No. 96/2004 on non-medical healthcare occupations and related Decree No. 39/2005 regulating minimal study programme requirements for acquiring on professional qualifications for practice of a non-medical healthcare occupation. It has been prepared as the three-year face-to-face full-time study.

The goal of the curriculum is preparation of university educated paramedical professional - orthotist-prosthetist, who will be qualified for designing, manufacturing and repairing orthotic and prosthetic devices in the whole extent within therapeutic and rehabilitative treatment and on the basis of physician's indication.

The study programme respects ISPO recommendations for acquiring international qualification class I and for development on field prosthetics and orthotics in advanced countries abroad.

Graduate's profile is defined in six fields:
- Patient's care
- Control action and professional supervision
- Training and education
- Public beneficial work
- Research and development
- Medical, legislative and ethical requirements

The graduate is after finishing the course specialist in P&O and is able:
- to participate in patient's examination and in designing indication of a device, he is an equal member of the therapeutic team
- to give the patient or his family instructions on principles of using and maintaining of a device
- to record and to process relevant information on patient and his family, incl. specific expectations and needs
- to take part in suggesting medical treatment, to reflect changes in the health condition and also local findings related to application of P&O device and in cooperation with physician and paramedical staff to find adequate solutions, which he can apply during manufacturing, fitting and adjusting of the device and its follow-up evaluation
- to lecture and to train his colleagues and other professionals who are concerned in P&O and also other interested parties
- to contribute professionally and to participate in public beneficial rehabilitative projects

Realization of cooperation with ISPO Czech Republic:
- Teaching of core subjects
- Organization of professional seminaries and lectures in terms of further training of doctors, physiotherapists, prosthetic and orthotic technicians etc.
- Development of international cooperation on field education, science and research with foreign universities and specialized departments
- Preparation of project on building training premises for theoretical and practical education and research laboratories

EDUCATION OF ORTHOTIST AND PROSTHETIST IN SLOVENIA THRU THE VIEW OF BOLOGNA DECLARATION

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Abstract

In 1999 a group of 40 European countries signed a Bologna declaration to combine and unify the common European higher educational system until 2010. With the new credit based system, students and teachers of different universities will gain access to better mobility and comparable studies and diploma levels and quality. Among the countries that signed the declaration is also Slovenia.
Department of Orthotics and Prosthetics on the College of Health Studies at the University of Ljubljana is still on a college level of its study program. We proposed a 3+2 model; 3 years of basic study on primary level and two additional year on secondary »Bologna« level.
The renewed study program of Orthotics and Prosthetics means an update of the study contents, foresees more independent studies of student end work of students (case studies), in encourages active ways of teaching, more specialist practice and chosen cases under the supervision of a mentor and an expert from the practice. The study program can be compared to the programs in Europe.

INTERNATIONALIZATION OF THE EDUCATION

After the signature of the Bologna declaration Slovenia has the obligation, until 2010 to create a unified college study with the credit system of study, better mobility of students and comparable degrees. On the first, undergraduate stage, the binary system is preserved, two types of study programs, university and technical, but the sharp line between them is softened. On the second stage we are preparing a master study that will be technical. The third stage is the doctorate study to achieve the doctor of science title. With this the Bologna declaration defines and encourages studying throughout the whole life (1).

THE RENEWAL OF THE STUDY PROGRAM OF ORTHOTICS AND ROSTHETICS BY BOLOGNA STANDARDS

The department for Orthotic technique of the College of Health Studies of the University of Ljubljana was until now performing the three year study program from the field of orthopedic techniques (2). The base for the renewal of the study is the acknowledgement of the fundamental goals of the Bologna process. The growing tendency to improve the expert knowledge and fundamental and application researches in the field of orthotics and prosthetic will lead to the development of the branch and a competitive position for the graduates with similar profiles in the EU, this guides us to the need of transformation of the current educational study program of Orthopedic technique and the development of the study in the second Bologna stage (3).

The renewed technical study program of Orthotics and Prosthetics means an update of educational contents and also the educational philosophy with implementation of modern educational methods. We foresee more independent studying and work of students, encourage active ways of teaching, examples study, we are introducing more technical practice of the chosen cases with the supervision of expert mentors and experts in the field of orthotics and prosthetics. The content of the study is founded to give the student basic knowledge from the field of natural science, which he applies to the field of orthotics and prosthetics, gins ethical, social, economical and juridical basics, in the field of health science he gains the basics of the functioning of the human body, gets acquainted with the managing of biological and physics agents, which is all upgraded by the knowledge from the field of orthotics and prosthetics (4).

PRESENTATION F A GRADUATE OF ORTHOTIST AND PROSTHETIST

Graduates of Orthotist and prosthetist are workers in the health care field, that perform independently and expertly technical procedures. These can be made directly on a patient namely diagnostically or can perform additional activities

which are planed individualy according to the professional profile with the decree of the ministry of health (7).

Graduates of this section have the suitable basic knowledge from the health studies which enables them a better understanding of the most usual signs, basic pathological processes, which appear in the development stage, with adults in of this age group. The graduates have to have the command of a language of the European Union, in addition to Slovenian, namely the terminology of their field for the exchange of basic information (1).

The need for orthotics and prosthetics in foreign countries show the prospective of this job. In Slovenia it is not asserted, that is why the renewal and promotion of the study is needed. An expert in orthotics and prosthetics can think in the field of health and technicaly approach to solving a problem. In his work he manages to merge the achieved medical technical knowledge and knows how to use it in prevention and in practice and development of technical appliances.

In accordance with the guidelines and goals of the Bologna process the renewal of the study program of orthotics and prosthetics means a great update of educational contents and educational philosophy with the introduction of modern educational methods. Within the renewal we decided to implement the 3-year model because the programs of orthotics and prosthetics in foreign countries are also of 3 years and this will enable the comparison, competitiveness and quality of the study (1).

The fundamental goal of the program is to give the graduate the knowledge, skill and philosophy to work in the prevention field, rehabilitation, making and applying of technical appliances, education, evaluation and research and development of the field (5). This way the main goal, with the development of the technology and increase for the demand to restore the functionality of physically disabled people, is to make the graduate prepared for individual production of orthopedic supports, inclusion in the complex system of the health prevention of the population and contribution as an equal to the rehabilitation tem and this way to contribute to a better quality of life (6).

CONCLUSION

The renewed study program represents new challenges, progress of the profession, more working opportunities, better collaboration with the economy and more work in the research field. For the students it means a better future and later development of the study and a better chance at mobility. All the above mentioned will improve the recognition of Orthotist and prosthetist and its promotion inside and outside the country boarders. We wish to create skilled workers that will have the expert skills for working in different fields, better employment chances and will be able to promote and further develop its own field.

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RESULTS OF EARLY REHABILITATION IN PATIENTS WITH AMPUTATION OF THE LOWER LIMBS

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INTRODUCTION

A number of studies have indicated that beneficial results of early rehabilitation following lower limbs amputation can be done only by experienced team. There are no objective criteria for optimal rehabiltation treatment in these patients.

AIM

The aim of the study was to evaluate results of the rehabilitation of the patients with amputation of the lower limbs.

METHODS

Early rehabilitation was implemented in 46 patients following lower limbs amputation, between 32 and 76 years of age. Thirteen of 46 patients (28%) were of female sex. Follow-up consisted of clinical data during hospitaization, duration of hospitalization, and number and type of complications.

RESULTS

Mean age was 67.5 years. Amputation swere done due to occlusive disease of peripheral arteries and/or diabetic angiopathy. Bilaterla amputation was performed in 7 patients. Above-knee amputation was performed in 71% of patients and below-knee amputation in 29%. A total of 5 (11%) of patients died during hospialization. On th eother hand, 39 (82%) were able to walk successfully with th eaid of cruthes upon discharge. Lenght of hospitalization varied from several days to 5 weeks depending on general health and type of amputation. Upon discharge from our intitution patients were reffered to rehabiltation centers for prosthetic orthopedics where the patients learned how to walk with limb prosthesis.

CONCLUSION

Patients were very enthusiastic for the fast and complete recovery and eagerly participated in rehabilitation program. This is very encouraging for the further work and implementation of new methods in rehabilitation of vascular patients.

SOME CHARACTERISTICS OF PATIENTS WITH LOWER LIMB AMPUTATION ON REHABILITATION IN THE REHABILITATION INSTITUTE IN LJUBLJANA

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Abstract

The article describes some characteristics of patients after lower limb amputation due to atherosclerosis which affects arteries of all human body. The most affected are diabetic patients. The research looked over all hospitalized amputee patients from 2002 to 2007. It showed that 90% of amputee patients lost their lower extremity due to atherosclerosis. Mail population was handicapped frequently than female population. 54% of patients had diabetes.

INTRODUCTION

In Slovenia, as in other countries, the average life expectancy has been rising. The consequences of longer life include chronic diseases affecting human body.

One of the chronic diseases is atherosclerosis. It affects the arteries of the entire human body, including the arteries of lower limbs. About 90% of all lower limb amputations result from poor arterial circulation. Atherosclerosis affects also vital organs which may lead to brain stroke or myocardial infarction as well as to lower limb amputation (1).

In the world, the incidence of amputation is about 30 patients per 100 000 inhabitants per year. In Slovenia, the incidence is about 23 patients per 100 000 inhabitants per year (2).

The Institute for Rehabilitation, Republic of Slovenia, is the main institute in the country providing rehabilitation for patients after disease or trauma. One of its wards is a ward for patients after lower limb amputation. The ward has 31 beds.

The patients are treated by a multidisciplinary team. The main aim is to restore and preserve the patient's maximal functional independence for as long as possible.

Rehabilitation outcome depends on the patient's cooperation as well as on the level of amputation. Appropriate prosthetic fitting also plays an important role.

Patients after amputation of one or both limbs, admitted to the rehabilitation program, differ in a variety of ways: the cause of amputation, the part of Slovenia they come from, their age, sex etc.

The aim of the research was to review and classify the patients admitted for rehabilitation in the period from 2002 to 2007.

METHODS AND SUBJECTS

Methods

A descriptive method was used. Longitudinal study included a sample of patients hospitalized at the Institute for Rehabilitation at the ward for patients after lower limb amputation in the period from January.1, 2002 till December 31, 2007. Structural observation was performed.

The collected data were analyzed with Excel software.

RESULTS

From 2002 to 2007, the number of patients fluctuated from 377 in 2004 to 427 in 2006.

Average stay in Rehabilitation institute (Fig.1) was from 27 to 29 days for first admission. The average stays in Institute for bilateral amputations of lower limb was from 9 to 20 days. It depended if patient has got prosthesis for second amputated limb or not, or if he came only for prescription of other orthopedic devices.

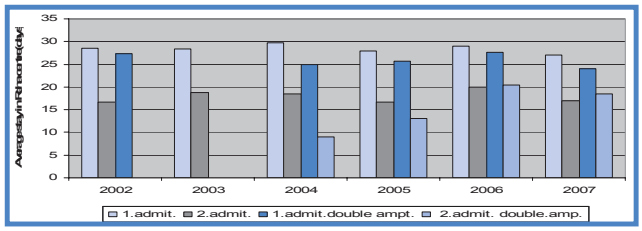

Figure 1: *Average amputee patients stay in Rehabilitation centre from 2002 to 2007 (First admission, Second admission, First admission after double amputation, Second admission after double amputation)*

The most frequent cause for amputation is diabetes (Fig 2). About 55% of patients lost their lower limb because of diabetes.

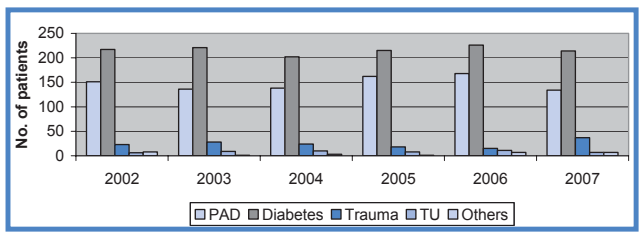

Figure 2: *Causes for lower limb amputation (PAD-peripheral arterial disease, diabetes, trauma, TU-tumors, Others - other causes for amputation*

The most frequent level of amputation in years 2002 to 2007 was transtibial. In years 2006 and 2007 the number of patients with transfemoral amputations increases (Fig.3).

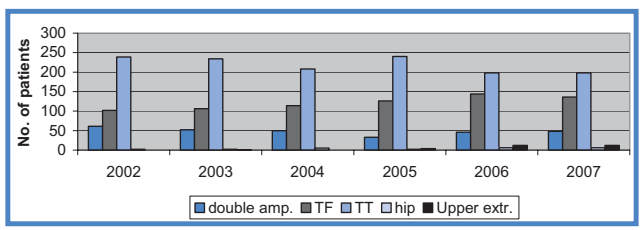

Figure 3: *Levels of amputation from 2002 to 2007 (double amp. -double transfemoral amp.,transfemoral and transtibial amp. and double transtibial amp., TF-transfemoral amp. and knee disarticulation, TT-transtibial amp., hip.- hip disarticulation and hemipelvectomy, upper extremities)*
The percentage of amputee patients who were fitted with prosthesis wariate from 80 to 90%. The number of patients who were not fitted with prosthesis decreased in the last few years.

The relationship between male and female in years 2002 to 2007 was 2:1.

The most frequent age period in which patients were hospitalized was from 70 to 79 years in all years we reviewed. Patients were average 65.5 years old, female were average 71.9 years old and male 65.4 years old.

From 2002 to 2007, the largest number of patients came from the region covered by the Health Insurance Institute Ljubljana and the next region with high percentage of hos-

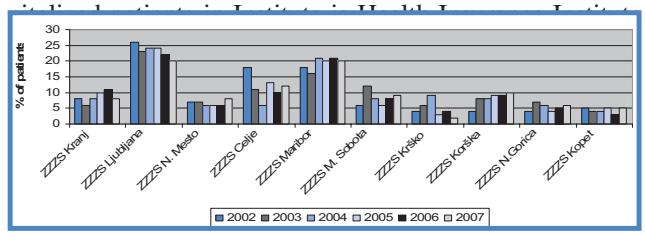

Figure 4: *% of amputee patients from different Slovenian Health Insurance*

DISCUSSION

From 2002 to 2007, the number of patients fluctuated from 377 in 2004 to 427 in 2006.

The average time for first admission was 27 to 29 days and for second admission to be fitted with the final prosthesis was from 17 to 20 days. Some of the patients needed to have the remaining lower limb amputated. Those patients were included into rehabilitation from 24 to 27 days.

If we connect together diabetes and vascular diseases as a cause of lower limb amputation the result is 90% (1). In the recent years, an increasing number of amputations due to various injuries have been observed. The other causes of amputation have stayed at the same level.

The most frequent level of amputation in all years was transtibial amputation, about 60% of hospitalized patients.

The percentage of amputee patients who were fitted with prosthesis wariate from 80 to 90%.

The number of patients who were not fitted with prosthesis decreased in the last few years.

Prešern-Štrukelj (1) speaks about relationship between male and female in 2:1, which is valid also in our research.

Mostly patients were hospitalized in age period from 70 to 79 years. From 2002 to 2007, the largest number of patients came from the region covered by the Health Insurance Institute Ljubljana. There has been a constant increase in the number of patients from the region covered by the Health Insurance Institute Maribor and Ravne. The smallest number

of hospitalized patients was from the region covered by the Health Insurance Institute Koper.

CONCLUSION

In Slovenian Institute for Rehabilitation will be necessary to file still much effort to educate the patients after lower limb amputation. Education should be about bad habits such as smoking or abuse of alcohol and its¨ bad influence on individuals¨ health. Education should have also all diabetic patients after amputation, above all concerning harmful influence of high blood sugar on walls of arteries. It is also necessary to underline the urgency of taking care for the remaining leg. The quality of life of patients that have both legs amputated is vitally worse from patients who are one side amputated.

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MAJOR AMPUTATIONS OF THE LOWER EXTREMITY DURING 25 YEAR. A STUDY ON 430 PATIENTS FROM SIX COHORTS IN THE URBAN CITY OF MALMÖ, SWEDEN

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INTRODUCTION

Major amputation is sometimes unavoidable but the aim is always preserve the patient lower limb. For this purpose many efforts has been made during the past quarter of century in our society. This includes health information and better diabetes care, vascular surgery, treatment of cardiovascular disease, infections, cessation of smoking.

METHODS AND SUBJECTS

In this descriptive study 430 patients from six annual cohorts with major amputations was collected and followed-up after one year postoperatively. All major amputations from 1979 were includes and the same investigator repeated the study every fifth year - 1984, 1989, 1994, 1999 and 2004. All patients alive one year after the operation, was examined as part of a routine follow-up. Included were only major amputations caused by lower limb ischemia from the population of the urban city of Malmö, Sweden. Statistics were made by Jan-Ĺke Nilsson, Malmö.

RESULTS

During 25 years the annual number of amputations at our hospital has more than halved. This means a decrease of the crude incidence to 18 per 100 thousand in 2004. A simultaneous increase of the population with 28 thousands inhabitants has occurred in our city and the proportion of +80 years has more than doubled up to 6 %. Other significant difference compared to 1979 was the increase of the proportion of vascular referrals and surgery, fewer bilateral amputations. Temporary, during the 1990's, more patients were non-ambulant patients before the operation and the quota TT/TF was lower. Only smaller or non-significant changes could be seen regarding the proportion of men, residence, living alone, previous hip fractures, diabetes mellitus, acute ischemic disease, dementia and Parkinsonism. The mean age for men and women were 74 and 80 years respectively during our 25 years. This gives no significant changes except for men between 1979 and 1994/2004. In 2004 the mean age was 80+/-12 (51-95) years.

Postoperative data gave significant shorter mean number of days in hospital but then a decrease in the proportion of patients that returned straight back home. The mortality within one month and one year was significantly lower, especially among those with a TT - not after a TF. During the 1990's we notice a temporary lower proportion of the patients who had a prosthetics and were able to walk. Among the patients treated with a TT we found no significant differences regarding the walking capacity at follow-up, nor regarding higher re-amputation/re-operations.

DISCUSSION

This study gives lower and lower number of amputations for each year which makes it harder to compare the cohorts especially if you want to compare men and women. The selected data was choosen in 1979 and even if more data are collected 2004 this is a comparative study. Even if the age-differences are small some of the results can be influenced by age.

CONCLUSION

From the city of Malmö it is clear that we have a significant decrease in the incidence of amputation when six annual cohorts of major amputations where followed during 25 years. The characteristics of the patients were otherwise similar even if the postoperative mortality has decreased. The preventive measurement from our health care system, in order to avoid major amputations, seems to have been successful. During the 1990's, the patients in our city, temporary could have been composed of a group with more delicate health.

ORTHOTIC MANAGEMENT OF PSEUDOARTHROSIS FEMORIS

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Abstract

Pseudoarthrosis femoris, caused by fractura mallae sanata, is one of the rare complications. It is a consequence of osteomyelitis, poliomyelitis or osteoporosis. Poliomyelitis anterior acuta is an acute disease caused by the poliomyelitis virus. Paralysis, one or more extremities and muscle hypotrophy exist in the infected limb. Also, there are great deformities. When the surgical operation is not possible, the only choice for patient`s verticalization is application of above-knee orthosis.

NTRODUCTION

In order to avoid postoperative complications orthopedic surgeons recommend a conservative treatment. Because of deformities, the patients have great problems in activities of daily living, so they have to choose some orthotic devices.

METHODS AND SUBJECTS

Methods

A team evaluation was performed, to make a decision in which way rehabilitation has to go. Physical treatment and exercises for mobility were included. PNF elements also, have a great influence in patient recovering. We used magnethotherapy, IFS, DD, Bioptron in treatment. Above-knee orthosis connected with low corset was made of thermoplastic material.There is on left side an extremity abbreviation of 5cm.The patient had a hip pain on the same side, without active movement. We want to present an orthotic management of pseudoarthrosis colli femoris after prior poliomyelitis and osteoporosis in this case study.

Subjects

From the group of patients whom, due to pseudoarthrosis, the orthosises were applied in our hospital during 2005/06/07, we chose to present a female, at the age of 52 with fracture colli femoris lat.sin. after accident, pseudoarthrosis, poliomyelitis and osteoporosis. Because of osteoporosis and poliomyelitis a surgical operation was not available. In local status dominated asymmetry of pelvis and lower extremities, abbreviation of left leg of 5cm. Left foot was in supine and without eight bearing after unsuccessful arthrodesis.

RESULTS

Pseudoarthrosis was fixed by applied orthosis, controlling hip movement in sitting and standing position. The patient walked by below-elbow crutches and had a better mobility. The patient had less hip pain.

DISCUSSION

After physical treatment, exercises and with above-knee orthosis the patient was able to walk and continue to work.

CONCLUSION

The patient is verticalizated by above-knee orthosis and below-elbow crutches. A pain was reduced by using orthosis. It is very important to carry out an orthotic rehabilitation according to medical indication.

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GAIT ANALYSIS TO ASSESS THE EFFECTS OF SELECTIVE TRUNK REHABILITATION PROGRAM IN HEMIPARESIS: CASE REPORT

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Abstract

Trunk movement disorders are frequent in patients with hemiplegia, limiting or delaying the recovery of gait and functional independence, and the importance of trunk control to functional rehabilitation has long been underlined in literature. The aim of this study was to evaluate the effects of a selective trunk rehabilitation program on gait, balance and functional activities, in one resident patient affected by hemiparesis, using clinical validated scales and quantitative gait analysis. The results showed improvements after treatment in terms of gait parameters (walking speed, stride length, stance phase and kinematics of the paretic knee and ankle) and clinical scales (walking/balance abilities and functional independence). In accordance with previous studies, this study confirms that trunk performance is still impaired in chronic hemiparetic patients and it suggests that trunk recover must be included in rehabilitation planning.

INTRODUCTION

Trunk control is required to maintain postural control, to remain stable during gait, and to perform daily living activities. Little is known about the stroke effects on trunk muscle activity even if many authors emphasize the role of trunk rehabilitation as key point after stroke. The aim of the study was to investigate the effects of rehabilitative protocol with specific trunk control exercises using quantitative gait analysis (GA) and clinical scales.

METHODS AND SUBJECTS

Methods

Patient was evaluated by quantitative and clinical indexes. Quantitative analysis was performed by means of GA (VICON system, UK) to acquire kinetics and kinematics data, while clinical indexes were measured using clinical scales: Trunk Control Test (TCT), Motricity Index (MI), Functional Ambulatory Category (FAC), Walking test (WT), Berg Scale (BS), and FIM™ to define functional abilities. Rehabilitation Bobath concept treatment one hour daily and thirty minutes specific trunk training were applied for 21 days. All the clinical and instrumental evaluations were performed before and after therapy.

Subjects

The study involved 1 resident female, 38 years old, with right hemiparesis (hemorrhagic stroke occurred after 3 months). The patient gave her written consent and the study was approved by the local ethic committee.

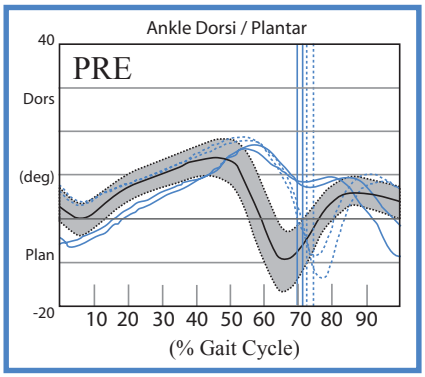
RESULTS

The most important results with regard to quantitative GA were in terms of: incremented walking speed (from 0.48 m/s to 0.56 m/s), stride length (from 0.70 m to 0.76 m) and reduced stance phase in hemiparetic side (from 71% to 67%). The analysis of kinematic data suggested an improved ankle angles at foot strike (Fig1) with reduced equinus of the right foot and reduced hyperextension of the right knee (Fig. 2).

Clinical indexes agree with improvements highlighted by quantitative analysis in terms of MI (right upper extremity from 72/100 to 77/100), FAC (t/10m from 21" to 13"), WT (m/6' from 170 m to 270 m), BS (from 53/56 to 55/56), and FIM (from 99/126 to 109/126).

DISCUSSION

GA results showed that patient is recovering her walking abilities: the increased walking speed and stride length reveal more stable gait, while stance phase suggests more symmet-



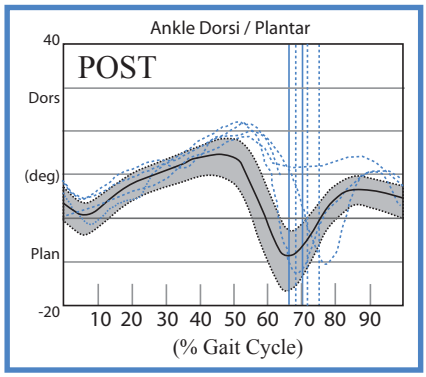
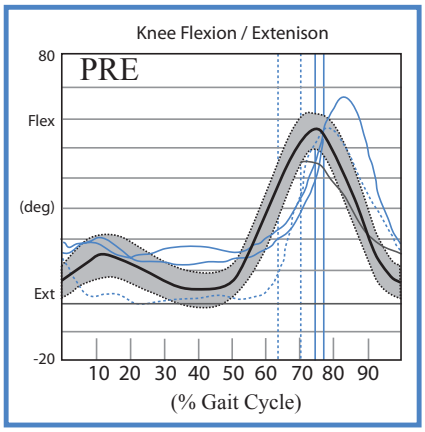


Figure 1: *Ankle angles PRE-POST the treatment (right limb: green, left limb: red).*



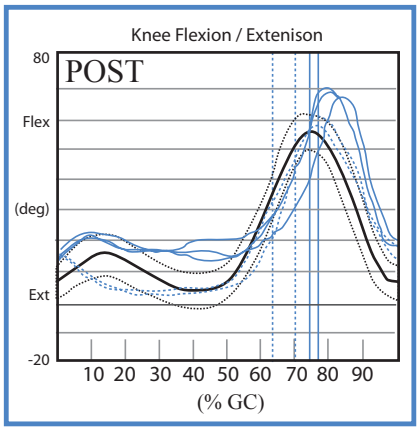


Figure 2: *Knee kinematic PRE-POST the treatment (right limb: green, left limb: red).*

ric walking pattern. Kinematic data at ankle and knee agree with spatio-temporal parameters showing improvements that led towards physiological gait. Concerning about clinical evaluations, improvements are not only related to ambulation (FAC-WT) but also regarding functional performances (e.g. BS, MI and FIM).

CONCLUSION

In the analyzed hemiparetic patient, the selective trunk rehabilitation program is efficiency, providing improvements in walking and functional abilities. Even if GA has been revealed to be more sensitive than clinical scales, thus being able to assess small, but fundamental, improvements induced by treatment, the agreement between clinical and quantitative GA supports and emphasizes obtained results.

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THE ROLE OF GAIT ANALYSIS IN THE CHOICE OF DIFFERENT ORTHOSES: CASE REPORT

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Abstract

Various ankle-foot orthoses have been used to correct gait deviations in children with cerebral palsy and today clinicians need new objective tools to make better recommendation. The aim of this study was to evaluate the best orthoses for one resident patient affected by spastic diparesis, using the quantitative data provided by gait analysis. Five trials of gait analysis were registered into different conditions: with anterior ankle-foot orthoses and with posterior one. Results showed better performances in walking with the anterior orthoses than posterior in terms of walking speed, cadence and kinematics of knee and ankle (bilaterally).
Our findings showed that gait analysis is a sensible tool to evaluate effects induced by different orthoses in a patient with cerebral palsy, thus resulting potentially useful for clinical practice.

INTRODUCTION

A common gait deviation in children with cerebral palsy (CP) is dynamic equinus or excessive ankle plantar flexion during stance in ambulation. To correct these deviations many type of orthoses could aid children to improve their walking ability, independence and quality of life. The aim of this study was to evaluate the best orthoses in one patient affected by CP using quantitative gait analysis (GA) as an objective measurement.

METHODS AND SUBJECTS

Methods

The patient was evaluated by quantitative gait analysis (VICON 460 optoelectronic system with 6 cameras and two Kistler force platforms) in two conditions (always with walker device support): with anterior bilateral AFO (aAFO, Fig.1) and with posterior bilateral AFO (pAFO, Fig.2); kinematic repeatability was verified analyzing 5 gait trials for each condition. Effects of different orthosis were investigated analyzing following parameters: stance time (expressed as % of gait cycle), walking speed, stride length, cadence and kinematics of lower limbs.

Subjects

A 20 years old male, affected by cerebral palsy with a spastic diparesis. Being unable to walk barefoot, he came to our Division to plan his rehabilitation program and to identify proper walking orthoses after a corrective surgical operation on hip and knee (bilateral Achilles' tendon lengthening, bilateral tenotomy of psoas muscles, bilateral femoral rectum lengthening, bilateral longus adductor myotomy, bilateral biceps and semimembranosus lengthening, bilateral gracilis and semimebranosus tenotomy).

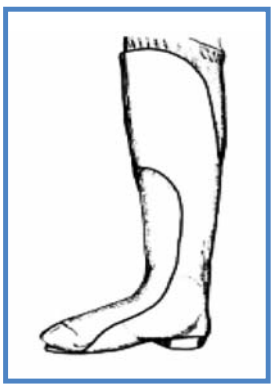

Figure 1: *Anterior ankle-foot orthoses*

Figure 2: *Posterior ankle-foot orthoses*

RESULTS

Spatio-temporal (Tab. 1) resulted influenced by AFO type, as well as kinematics parameters. We observed differences in average pelvic tilt (aAFO: 10°; pAFO: 21°), range of motion of pelvic rotation (aAFO: 10°; pAFO: 26°), and patterns at left hip and right ankle (Fig. 3).

Table 1: *Spatio-temporal parameters*

	pAFO	aAFO
Stride length [m]		
DX	0.83	0.88
SX	0.85	0.96
Walking speed [m/s]		
DX	0.37	0.62
SX	0.38	0.67
Cadence [step/min]	53.8	84.1
Stance [% of cycle]		
DX	81.4	74.1
SX	78.1	68.9

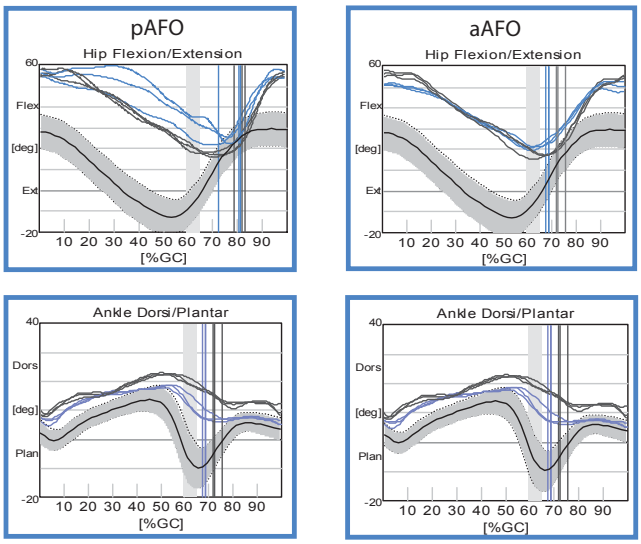

Figure 3: *Effects of orthoses on kinematics of ankles (black: right limb; blue: left limb).*

DISCUSSION

The choice of the best orthoses requires a tailored analysis in order to evaluate the effects that an orthoses has on the specific patient. Presented results suggest that the anterior AFO is the best one for the considered patient: it is confirmed by improvements of all spatio-temporal parameters, with cadence and walking speed over all (Tab.1).Concerning about kinematics, the anterior AFO causes more symmetry between limbs (Fig. 3) and involves many improvements: the reduction of anterior tilt and rotation of pelvis during all gait cycle, the best patterns of left hip flexion, and, bilaterally, the best pattern of plantar-dorsiflexion with reduced dorsiflexion in stance phase.

CONCLUSION

The quantitative data coming from GA let us to identify effects produced by the two different proposed orthoses. This information was used by clinicians in order to identify the best orthoses for analyzed patient. This study suggests the key role of GA to produce relevant information to clinical decision making.

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P15 PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION - CHALLENGE IN ORTHOTICS

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Abstract

Poliomyelitis anterior acuta is an acute disease caused by the poliomyelitis virus. It is characterized by inflammation of the anterior horns of the gray substance of the spinal cord. It is attended with early paralysis, one or more extremities and rapid atrophy muscle groups in the infected limb, often producing permanent deformities. It is a disease so common to childhood that it is more often termed infantile paralysis. Many different terms are used to describe these neuromuscular symptoms for instance post-poliomyelitis progressive muscle atrophy, postpoliomyelitis dysfunction. Eventually, post-poliomyelitis syndrome became the commonly accepted term. Pseudoarthrosis is one of the complications after fracture colli femoris. Osteoporosis has a great impact in rehabilitation of patient.Using proprioceptive neuromuscular facilitation may improve the functionality in activities of daily living with applied orthosis.

INTRODUCTION

Different surgical procedures are recommended in order to solve fracture colli femoris, but sometime there is a risk of operation, because of osteopenia, osteoporosis, or possible postoperative complications. In those cases it is a better decision conservative treatment. If there is a prior poliomyelitis, the patient`s functional status is more complicated. Unilateral paralysis of lower extremity, rapid muscle atrophy in the infected limb, with various deformities, reduce the functionality in activities of daily living. Usually, the patients can`t continue with their professions, interests, hobbies. Besides these aspects influencing the quality of life, the choise of orthotic device and exercises during treatment must also be considered.The great deal in successful recoverment has a team-work, which includes a cooperation between physician (and other specialists), physiotherapist, othotist, nurse, psychologist, social worker and patient and his family.

METHODS AND SUBJECTS

Methods

At the beginning of treatment, a therapeutic evaluation was performed: an extremity abbreviation of 5cm on left side existed, severe hip pain without active movement on the same side, muscle hypotrophy of left leg without weight -bearing. We used anthropometric measurements before treatment, as control tests too, in supine position with hip and knee flexion, quadripedal and kneeling position. We performed different proprioceptive neuromuscular facilitation techniques in supine, prone and other positions during the treatment, which included a phenomenon of irradiation, successive induction, rhythmic stabilization, initiation, agonist reversal, patella mobilization etc. The aims of this case presentation are: application of proprioceptive neuromuscular facilitation, improvement in activities of daily living and increasing stability in different body positions.

Subjects

In our hospital a group of patients with pseudoarthrosis colli femoris and applied aboveknee orthosis were observed during 2005/06/07. The following case report describes the rehabilitation of a female patient at the age of 52 with pseudoarthrosis, after fracture colli femoris on the left side by accident, ipsilateral paralysis of lower limb, due to post-poliomyelitis syndrome. Because of hemipelvic, hip and lower extremities dysplasia on the left side, endoprosthesis was not applicable. A better decision was a conservative treatment. In early youth the patient underwent multistage surgery of extremity elongation. After the team evaluation the patient got above-knee orthosis, made of thermoplastic material connected with low corset.

RESULTS

At the end of treatment the patient has succeeded to achieve control of requested positions with affected limb. Hip pain has been reduced and active movements improved In activities of daily living the patient has improved the functionality, using one below-elbow crutch while walking in short distance, and two in longer.

DISCUSSION

In order to improve patients` functionality using PNF techniques may have a great influence. In different cases may be performed different techniques depending on aims.

CONCLUSION

The variety of PNF techniques may give great opportunities to attain therapeutic goals in different ways.

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THE LENGTH OF RESIDUAL EXTREMITY IN A REHABILITATION PROCESS

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INTRODUCTION

The length of a residual extremity is of utmost importance in a rehabilitation process and it also affects a subjective sensation of a physical handicap. It is possible to influence the length of a residual extremity in an initial operative phase, depending on ethiological factors, while making indications, evalutation of a biological response in a postoperative period or in posterior reconstructive actions. The posterior reconstructive actions can be performed in soft tissues («Z» plastic, creation of slices: connective, transpositional, free microvascular) or on bones of free microvascular bone graft type or made by distractional osteogenesis Ilizarov technique.

GOAL

The goal od our research is to quantify a difference in efficiency of shorter or longer residual extremity from a point of view of a biomechanics, ability for prosthetics and a patient's subjective attitude.

METHOD

A group of patients, with amputation on a lower exteremity in processes of rehabilitation and prosthetics, was analysed. The length of the residual extremity in absolute values was measured, as well as its percentage in relation to a length of a contralateral side and patient's height. The residual extremity strength was also measured acting as a moving lever, and its strength with prosthesis, in relation to other preserved extremity.

DISCUSSION

The benefit of the longer residual extremity was considered, from the point of view of an operative wound healing, quality of the residual extremity, present complications, advantages of a possibility to hold a prosthesis bearing, strength of a prosthetic extremity and its control.

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FIRST EXPERIENCES WITH THE USE OF THE SIGAM-WAP SCORE DURING INPATIENT REHABILITATION AFTER LOWER LIMB AMPUTATION.

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INTRODUCTION

Approximately 3000 major lower limb amputations are performed annually in the Netherlands. About 50% of all amputee patients receive prostheses.

Outcome measurements are of increasing interest for management, patients and insurance companies. Therefore the Dutch **S**pecial **I**nterest **G**roup on **A**mputation **M**edicine (WAP) used the SIGAM-WAP[1] score (SIGAM score[2] Dutch translation) to assess mobility of amputee patients. The score gathers information about mobility of lower limb amputee patients.

Aim of the study

To investigate the feasibility to use the SIGAM-WAP score to assess outcome of inpatient rehabilitation after lower limb amputation.

METHODS

From 1-12-2006 until 31-5-2007 all inpatients admitted after a major lower limb amputation were included in the study. On admission and at discharge mobility of all amputee patients was measured by the SIGAM-WAP score. The score has 6 classes: A: no prosthetic use towards F: fully mobile with prosthesis without aids in all conditions. A Questionnaire of 21 yes/no items scales the activities. An algorithm reveals distinct mobility classes. Mobility score, duration of treatment and patient characteristics were gathered for evaluation.

RESULTS

Data were obtained from 112 patients admitted to 9 different Rehabilitation Centres. This was a good sample of the inpatient rehabilitation population in Dutch Rehabilitation Centres. 99 patients completed their inpatient training in the study period.

Age: Mean 62.0 years (range 25-88 years);
Average admission time: 101 days (Sd 61 days)

Amputation level:
Hemipelvectomy 2%;
Transfemoral 25%;
Through-knee: 10%;
Transtibial: 40%;
Bilateral: 23%.

Table 1: *Sigam-WAP scores*

SIGAM-WAP scores		
Class	Admission	Discharge
A	92	33
B	1	9
C	3	29
D	0	23
E	3	4
F	0	1

DISCUSSION

Most (92 / 99) patients started at SIGAM-WAP score A because they did not use any prosthesis on admission. Seven patients had higher scores on admission because they were already using prostheses. Most patients (66 / 99) learned to walk on prosthesis during inpatient rehabilitation. On average they walked on level ground with use of walking aids, 29 patients walked less than 50 meters (score C) and 23 patients more than 50 meters (score D).

Five patients walked without use of walking aids, while nine patients walked only during therapy or with physical help. On discharge a remarkable number (33) of patients

went home without prosthesis. Most of them learned to walk on prosthesis during outpatient rehabilitation (data not shown).

Pooling of data obtained from various rehabilitation centres was possible because the SIGAM-WAP algorithm makes a clear and reliable distinction between mobility levels.

CONCLUSION

After inpatient rehabilitation 68% of the amputee patients walked with prostheses. All patients were discharged home after inpatient rehabilitation. The SIGAM-WAP score is easy to apply. Use of the SIGAM-WAP score facilitates multicentre pooling of information about prosthetic mobility after rehabilitation treatment.

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