# *IMPROVING WALKING IN PERSONS AFTER TRANS-FEMORAL AMPUTATION BY MEANS OF ELECTRICAL STIMULATION*

# IZBOLJŠANJE HOJE PRI OSEBAH PO NADKOLENSKI AMPUTACIJI Z UPORABO ELEKTRIČNE STIMULACIJE

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## Izvleček

### Izhodišča:
Pogoj za hojo po nadkolenski amputaciji je zmožnost nadzora nadkolenske proteze, za kar oseba potrebuje močne mišice krna. Namen naše študije je bil ugotoviti, ali električna simulacija velike zadnjične mišice na amputirani strani izboljša nadzor kolenske proteze brez zaklepa in hojo pri osebah po nadkolenski amputaciji.

### Metode:
Dvaintrideset moških po nadkloenski amputaciji, ki so bili sprejeti na rehabilitacijo in prej niso nikoli hodili s protezo, smo po naključju razdelili v dve skupini po 16 oseb: skupino, ki je prejela električno stimulacijo (ES) in kontrolno skupino. Pred odpustom smo ocenili zmožnost nadzora kolenske proteze brez zaklepa, prehojeno razdaljo, potrebo po berglah in zmožnost vzpeti se po stopnicah.

### Rezultati:
Ob sprejemu med skupinama ni bilo razlik glede starosti, vzroka amputacije, stanja krna, prehojene razdalje, vzpenjanja po stopnicah in potrebe po berglah. Šest oseb iz skupine z ES in tri iz kontrolne skupine so lahko nadzorovale kolensko protezo brez zaklepa in so zato dobile tovrstno protezo. Osebe iz skupine z ES so ob odpustu v splošnem lahko prehodile daljšo razdaljo in manj jih je za hojo potrebovalo bergle kot osebe iz kontrolne skupine.

## Abstract

### Background:
*A precondition for walking after trans-femoral amputation is successful control of the above-knee prosthesis for which the person needs strong muscles of the stump. The goal of the present study was to determine whether electrical stimulation of the great gluteal muscle on the amputated side improves the control of an unlocked prosthetic knee and walking of persons after trans-femoral amputation.*

### Methods:
*Thirty-two men after trans-femoral amputation who came to their first rehabilitation session and had never walked with a prosthesis before were randomly divided into two groups of 16 persons: a group that received electrical stimulation (ES group) and a control group. Before discharge the ability to control unlocked prosthetic knees, walking distance, need for crutches and ability to climb stairs were evaluated.*

### Results:
*There was no difference between the two groups in age, cause of amputation, condition of the stump, walking distance, climbing of stairs and need for crutches at admission. Six persons who received ES and three from the control group were able to control the unlocked prosthetic knee and therefore received one. The persons from the ES group walked significantly longer before discharge and had less need for crutches while walking than persons from the control group.*

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**Zaključek:**
Električna stimulacije velike zadnjične mišice izboljša nadzor kolenske proteze brez zaklepa in hojo pri osebah po nadkolenski amputaciji.

**Conclusions:**
*Electrical stimulation of the great gluteal muscle improves control of an unlocked prosthetic knee and walking of persons after trans-femoral amputation.*

**Ključne besede:**
nadkolenska amputacija, električna stimulacija, rehabilitacija, hoja

**Key-words:**
*trans-femoral amputation, electrical stimulation, rehabilitation, gait*

## INTRODUCTION

One of the main goals in rehabilitation after lower limb amputation is successful walking (1). A precondition for walking after trans-femoral amputation is successful control of the above-knee prosthesis for which the person needs strong muscles of the stump (2, 3). After a trans-femoral amputation the morphology of the muscles around the hip joint at the amputated side alters and the muscles become weaker (4-6). As a result, it is difficult for these persons to control the prosthesis, especially to stabilise an unlocked prosthetic knee.

For some people after lower limb amputation walking is difficult (7) in spite of modern lightweight and energy-efficient prostheses, which has made prosthetic limb fitting and walking possible for an increasing number of patients (8). To help persons after trans-femoral amputation to control the prosthesis, one tries to improve the strength and endurance of all stump muscles. The techniques used include exercises and electrical stimulation at rest and during walking (9-17).

We believe that for stability and control of an unlocked prosthetic knee in persons after trans-femoral amputation the hip extensors, especially the great gluteal muscle, which remains the only uncut hip extensor, are essential. The goal of the present study was to determine whether electrical stimulation of the great gluteal muscle on the amputated side improves the control of an unlocked prosthetic knee and walking of persons after trans-femoral amputation.

## METHODS

Thirty-two men after trans-femoral amputation who came to their first rehabilitation session and had never walked with a prosthesis before were randomly divided into two groups of 16 persons each, a group that received electrical stimulation (ES group) and a control group. Because of randomisation, there was no significant difference between the two groups in age, cause of amputation, condition of the stump, walking distance, climbing of stairs and need for crutches at admission (Tables 1, 2). These persons also had no other disease that could influence the rehabilitation outcome or limit the prescription of the prosthesis, such as stroke, heart disease, paresis or paralysis.

***Table 1:*** *Characteristics of the control and electrical stimulation (ES) group.*

| Characteristic | Control group | ES group |
|---|---|---|
| Age | 58.5 (11.6) years | 59.5 (9.4) years |
| Time from amputation to admission | 124 (106) days | 118 (126) days |
| Amputation side | | |
| Left / right | 8 / 8 | 9 / 7 |
| Dominant / nondominant | 7 / 9 | 8 / 8 |
| Stump length | 29.1 (7.0) cm | 26.1 ± 6.0 cm |
| Hip flexion contracture at admission | 11.6° (11.4°) | 9.7° (10.1°) |
| Maximal hip flexion | 105.3° (6.4°) | 106.3° (5.5°) |
| Cause of amputation | | |
| Atherosclerosis | 13 | 10 |
| Diabetes mellitus | 3 | 2 |
| Other | 0 | 4 |

Note: numerical variables are reported as mean (standard deviation).

All the persons participated in a standard rehabilitation program (group exercises for stump and general fitness, gait re-education with Femoret temporary prosthesis, occupational therapy, psychological and social counselling). The great gluteal muscle on the amputated side of the patients from the ES group was electrically stimulated 1 hour per day with 6s trains of 30 Hz 0.3 ms width electrical impulses and 8s pause in-between, for a period of 3 weeks. The Grass S 8800 programmable stimulator was used. Two oval self-adhering Pals flex electrodes (9x13 cm) were placed over the origin and insertion of the muscle.

The following variables were evaluated before discharge:
1. the ability to control the unlocked prosthetic knee,
2. daily walking time,
3. need for crutches while walking 10 meters and
4. ability to climb 10 stairs up and down.

Daily walking time was evaluated by interview. Need for crutches and ability to climb stairs were observed by the same person.

Because all outcome variables were categorical, Fisher's exact test was used for group comparisons. The data were analysed using the SPSS for Windows 14 statistical software (SPSS Inc., Chicago, IL, 2005).

## RESULTS

Each person received a prosthesis with a quadrilateral socket. Six persons who received electrical stimulation of the great gluteal muscle and three from the control group were able to control the unlocked prosthetic knee and therefore received one. The others were not able to control the unlocked knee and therefore received a prosthesis with a locked knee (Table 3).

***Table 2:*** *Need for crutches before and after amputation.*

| | Before amputation | | After amputation | |
|---|---|---|---|---|
| Need for crutches | Control group | ES group | Control group | ES group |
| 2 crutches | 1 | 1 | 12 | 4 |
| 1 crutch or cane | 2 | 2 | 3 | 11 |
| none | 13 | 13 | 1 | 1 |
| *p* (Fisher's exact test) | 1.000 | | 0.006 | |

***Table 3:*** *Control of prosthetic knee and ability to climb ten stairs.*

| Prosthetic knee | Control group | ES group | *p* (Fisher's exact test) |
|---|---|---|---|
| Locked | 13 | 10 | 0.433 |
| Unlocked | 3 | 6 | |
| Climbing stairs | | | |
| No | 5 | 0 | 0.043 |
| Yes | 11 | 16 | |

***Table 4:*** *Daily walking time.*

| Daily walking time | Control group | ES group | p (Fisher's exact test) |
|---|---|---|---|
| < 1 hour | 6 | 0 | 0.001 |
| 1 - 2 hours | 8 | 5 | |
| > 2 hours | 2 | 11 | |

The persons from the ES group walked significantly longer before discharge than those from the control group (Table 4). The persons from the ES group also had less need for crutches while walking than persons from the control group (Table 2). All persons from the ES group were able to climb stairs whereas five persons from the control group were not able to climb stairs at discharge (Table 3).

## DISCUSSION

This study shows that electrical stimulation of the great gluteal muscle on the amputated side improves the control of an unlocked prosthetic knee and walking of persons after trans-femoral amputation. In our study, better walking was evident in 16 persons who received electrical stimulation of the great gluteal muscle – their walking time was longer, the need for crutches lesser and the ability to climb stairs better than in the control group.

A longer walking distance, no need for crutches and the ability to climb stairs are all important for independence in daily activities such as shopping and visiting friends, relatives and public places. For example, too short a walking distance may lead to social isolation and dependence on other people. A walking distance of 600 steps a day has been proposed as a minimum that allows a person after lower limb amputation to manage independently in a one-level house or apartment when a moderate amount of help is provided by family or social agencies (18). A number increases to 1100-1450 steps a day to live independently in a one- or two- level dwelling (18). These daily minimums do not include activities outside the home such as shopping. We did not actually count the steps, but the walking time of persons receiving electrical stimulation of the great gluteal muscle was longer, indicating that these persons are able to take more steps.

The need for crutches impedes several daily activities, especially if the person needs two crutches. The person has trouble when carrying things like glasses, plates and books and when shopping, cleaning and cooking. Patients after electrical stimulation needed crutches less and were therefore more independent.

Although not many persons after trans-femoral amputation have got stairs at home, stairs are still sometimes found in public places and institutions (without elevators) and people who are unable to climb stairs have problems accessing such places. Like with crutches, more patients from the group receiving electrical stimulation were able to climb stairs than from the control group.

These improvements in walking may be important not only in the short term but also as the persons get older. With ageing, people acquire more disabilities and some years after the amputation many elderly persons cease to use their prosthesis (19-22). We believe that the better the rehabilitation outcome and walking after the first rehabilitation, the longer a person may be independent. With electrical stimulation of the great gluteal muscle on the amputated side of persons after trans-femoral amputation, we can effectively improve walking in the short term and perhaps also in the long term.

## CONCLUSION

Electrical stimulation of the great gluteal muscle on the amputated side improves the control of an unlocked prosthetic knee and walking of persons after trans-femoral amputation. It is therefore a useful additional therapeutic technique in rehabilitation of such persons. We recommend starting its use immediately after the stitches are removed.

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