The body awareness and the standing stability of amputees

Ph. D. theses

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INTRODUCTION

Approximately 7000 amputations are made annually in Hungary, predominantly on lower limbs with dysvascular indication (arteriosclerosis and angiopathia diabetica, 66%), on male patients over 60. The chance of different illnesses increases by age and the physical activity decreases. The physical condition and the stamina – due to the painful limb, the previous operations, and the concomitant deceases – decrease more by the time of the amputation. Patients often fall, either with prosthesis or without it. On the one hand, it is dangerous because of the vulnerable stump, on the other hand because of the frequent osteoporosis, which increases the chance of hip fractures. One of the main viewpoints of kinesotherapy, following the amputation, is the development of the coordination and balance abilities, with the help of special exercises. During the therapy the patient learns that the perception of the position of the artificial limb, and the ambulation demand a changed proprioception. Furthermore, proper prosthesis usage is inevitable to provide its infiltration into the body scheme. Most patients feel as if their lost limbs existed. This is the phantom phenomenon, which is a well-known example of the difference between body awareness and body scheme. For the more successful rehabilitation of amputated patients, we would like to supply new data in connection with the standing stability of unilateral and bilateral amputees, and to reveal the connection between prosthesis wearing and body consciousness and scheme, and how they change in function during the time elapsed since the amputation.

OBJECTIVES

Our research considers two areas, in which we examined the standing stability, the body scheme and the body awareness of unilateral and bilateral amputees.

The aims of the examination of standing stability:

- Introducing a new static stabilometry variable, namely the radius of the characteristic circle based on the 95% of the sampled points of the stabilogram to characterize the body sway.
- Determining the slope of the regression line to characterize balance strategies.
- Finding out differences between healthy and lower limb amputees on the basis of variables of stabilometry.

- Determining the variables characterizing standing stability, and comparing them in case of first fitted amputees and skilled prosthesis users.
- Comparing unilateral and bilateral amputees.
- Establishing the effects of two weeks of prosthesis usage.
- Determining the significance of visual control onto the variables of standing stability.
- Examining the role of the intact and the amputated leg in standing stability.
- Examining the distribution of body weight between the lower limbs in case of unilateral and bilateral amputees.
- Examining the fine coordination of unilateral and bilateral amputees.

The effects of changing body morphology and prosthesis usage were studied in body scheme and body awareness, the characters of phantom sensations, its intensity, its localization based on the examination of the spatial position of the phantom limb and its expansion.

The aims of the examinations:

- Examining the connection between the volitional movement of the phantom limb and phantom pain.
- Determining the similarity and/or difference between dysvascular and traumatic amputees.
- Determining how time influences prosthesis usage in body awareness, the phantom phenomenon and telescoping.
- Comparing the body awareness of dysvascular and traumatic amputees, and of serious and less serious amputees.

MATERIALS AND METHODS

Participants

The amputees taking part in the examinations were selected randomly. The participation was on voluntary basis, but cooperation was required. The participants received oral and written information about the examinations, and they signed the relevant documents to imply their willingness. The examination was completed with the permission of the

Ethical Committee of National Medical Institute of Rehabilitation and the Saint George Hospital.

Participants of the examination of standing stability and fine coordination:

34 patients with vascular disease who had undergone tibial amputation participated. Eighteen patients had just been amputated, and they started to practice ambulation at the time of examination. Their average age was 61.89±(2.16). Six patients from the latter group were checked before and after the two-week ambulation training. Ten had had an amputation on one side and six had lost their limbs on both sides a long time before. Their average age was 61.13 (±3.33) and 56.5 (±1.88). The average age of fifteen healthy control people was 61.13 (±4.89).

Participants of the examination of the body scheme:

51 limb amputees took part in this examination, 33 unilateral and 18 bilateral, 19 traumatic and 32 dysvascular, 23 skilled prosthesis users and 19 first fitted amputees and 9 amputees, the two latter ones did not wear prosthesis, 30 lower limb and 3 upper limb amputees. Their average age was 58.04(±15.11).

Participants of the examination of body awareness:

44 male, lower limb amputees took part in this examination: 27 unilateral and 17 bilateral, 15 traumatic and 29 dysvascular. 22 skilled prosthesis users and 16 first fitted amputees and 6 amputees, who did not wear prosthesis. Their average age was 56.61(±15.27). The average age of the 43 healthy male control people was 51.69(±14.09).

Methods

Stabilometry

A stabilometer was used to asses the excursion of the centre of pressure. The measuring system consists of a force platform, 3 amplifiers, a microcomputer, a PC, a monitor and special software. The position of the centre of the pressure was measured during while the patient was standing quietly. Then the software calculated the anteroposterior, mediolateral and all excursions, as well as the radius of the body sway.

Two persons were present at the examination, one worked on the PC, and the other gave instruction to the patients and stood nearby for safety reasons. There were 6 tasks for the unilateral amputees, and healthy participants, and 5 tasks for the bilateral amputees, which were the variations of the classic Romberg-test:

- Examining the body sway on two legs, with lowered arms and lifted arms, opened and closed eyes, using prosthesis. The length of examination was 20 s.
- Examining the body sway on one leg, with lowered arms and opened eyes.

The tests in the order of performance:

- Standing on two legs with opened eyes and lowered arms
- Standing on two legs with closed eyes and lowered arms
- Standing on two legs with opened eyes and lifted arms
- Standing on two legs with closed eyes and lifted arms
- Standing on one leg with opened eyes and lowered arms
- Examining the body weight distribution

The process of the examination:

Static stabilometry. We outlined the tasks to the examined persons before starting the examination. During the examination of static balancing ability the persons stood in the middle of the force platform in the posture described beforehand. After the persons had taken the required posture and had been ready for the accomplishment of the test, we started measuring, which lasted 20 s while the data collection was going on as well. The persons did not get feedback from COP motion or any instructions concerning their postures. The persons had to concentrate on one single task. They were asked to stand on the platform without moving while keeping the balance. We did not evaluate the test if the patient was not able to complete the task, that is, they were not able to maintain the given posture for 20 s without clinging. Since most of our patients were not suitable for ambulation without a walker or crutches, to make the approach and the stepping up easier, from safety reasons, the strength platform, and the other platform applied at the symmetry test, were placed between frames, the width of which was 0.7 m.

Examining the body weight distribution. We examined how bodyweight is distributed on the two feet in this test. In the first step, keeping the posture of the measurement the 2NL for 26 s, we measured the patient's bodyweight. We applied two platforms in the second part of measuring: the force platform used at the previous measuring and a platform at the same size, but it did not make any measurements. We put the two platforms 2 cm far from and next to each other, then we asked the patients to take the position like in the 2NL test, with the prosthesis (at a bilateral amputee with the right side) on the force platform, and their intact limb on the other platform. Similarly, we measured the bodyweight load on the force platform, that is, the prosthesis loading, for 26 s. We considered the average of the measured weight a result. At the assessment we considered the difference of the bodyweight load of the two lower limbs, compared to the full bodyweight expressed in percentage (%), so that the bilateral patients' bodyweight can be compared to that of the other groups'.

Determined variables:

Measured variables:

1. Body sway: the total excursion of the center of pressure (mm) (SUM)
2. Antero-posterior sway: the length of the saggital component of the total excursion of the COP (mm) (A-P)
3. Medio-lateral sway: the length of the frontal component of the total excursion of the COP (mm) (M-L)
4. The radius of the body sway: the length (mm) of the circle radius formed by the centre of pressure of the sole; the starting point of the circle is the central point of the supporting surface (based on 95% of the total measured data, i.e. the total excursion of the COP (mm) (R).
5. Body weight distribution between the lower legs

Calculated variables:

1. The visual dependence was considered by Romberg-quotient, which was calculated as the ratio of suitable results of the test with closed eyes and opened eyes (RK_R, RK_{SUM}, RK_{A-P}, RK_{M-L}).
2. The role of the intact leg in standing stability was considered by ½-quotiens, which was calculated as the ratio of the suitable results of the test 2NL and 1NL ($1/2_R$, $1/2_{SUM}$, $1/2_{A-P}$, $1/2_{M-L}$)
3. We calculated the slope of the regression line (α) with second order regression analysis to characterize the direction of the body sway, during standing on both leg with opened eyes.

Examining fine coordination:

To examine fine coordination we used two tests. 1. Moving the center of pressure within a determined area. 2. Moving and keeping the center of pressure to a determined period of time.

The description of the tests:

The patients move the center of pressure within a determined area. The examined persons stood on two feet on the force platform keeping their arms next to the body. In front of the persons two meters away, at their eyes' level, we placed a monitor, on which we displayed a square. The patient had to move his COP, which was displayed on the monitor as a pen, and shade the largest possible area of the square without stepping out of it, for 20 s.

Moving and keeping the center of pressure to a determined period of time. The examined persons stood, as explained earlier, on the force platform, in front of the monitor. On the monitor, a vertical and a horizontal line, which crossed each other in the middle and a square, could be seen. The square, which indicated NKP motion, was to lead to the crossing point of the lines and to keep there for 10s.

Determined variables:

1. The size of the shaded area of the square, expressed in percentage, compared to the full area of the square (NKA)
2. The time spent inside the square (NKT) expressed as the proportion of the total time (20 s) in percentage.
3. The time of keeping the COP on the target, expressed as the proportion of the total time (20 s) in percentage (NKP)(%).

The examination of the spatial posture of the phantom limb

In our research we examined the actual manifestation and the change of body image through the spatial position of the phantom limb. We asked the patients, sitting on a chair with eyes closed, to show where they could feel the different parts of the lost limb. In fact, tibial amputees had to show their feet, femoral amputees their knees and feet, forearm amputees their hands, upper arm amputees their elbows and hands. When the patient felt the body part where it should have been located, we concluded that it is not an example of the phenomenon called 'telescoping'. We believe it proves that body change is not followed by body schema change i.e. the extent of the change has not been reflected in the body schema yet. We consider the more proximal perception of the body parts in question as an example for shortening, telescoping i.e. a change in the body schema. When the examined limb did not shorten, but the participant was not able to locate the limb, it was considered to be the beginning of body schema change.

Examining body awareness based on a Body Focus Questionnaire

The aim of the questionnaire is to find out how people share attention between different body areas. While filling in the questionnaire, the participants had to choose from the limbs, written on the paper in pairs, which they could imagine more clearly. The original version of the questionnaire contained 108 questions, 8 (8 scales) of which related to the body: Arms, Front/Back Side, Right/Left Side, Head, Eyes, Mouth, Stomach and Heart Scale. The Hungarian version of the questionnaire uses an additional ninth scale: Legs, but without any changes or alternations. The Legs Scale was divided into 4 subscales: thigh, knee, shank, ankle + foot. That is, we pointed out the four connecting items from the Legs Scale without changing the original scale.

The result of the test is simply a number that indicates how much clearer and more imaginable the opposite limb is considered to be.

A questionnaire on anamnesis and prosthesis wearing habits

The patients answered the questions of a questionnaire we compiled. The questions in the questionnaire were connected to anamnesis (age, sex, cause and date of amputation), prosthesis wearing habits and the localization and characteristics of phantom sensations and their cause.

Measuring scales of self-sufficiency and activity

We applied the Barthel-index to characterize the examined persons' self-sufficiency, and the Amputee Mobility Predictor (AMP) to determine their activity level while using prosthesis.

Statistical analysis

Mean and standard deviation (±SD) was calculated for age, anthropometrical and stabilometry variables. Median and modus was calculated for the body awareness and body schema data. The normality of the data was checked with Shapiro Wilk's W-test. Nonparametric statistical calculation was applied using Mann-Whitney U-test, Wilcoxon-test and Spearman correlation of Statistica X.0 version (Statsoft. Inc., USA). Significant differences were accepted at $p<0.05$.

RESULTS

The results of the measuring scales

Results of the Barthel-index

• Barthel-index is the lowest in case of first fitted amputees, differs from the one of not users' and the skilled prosthesis users'. Skilled prosthesis users' Barthel-index is higher than that of first fitted prosthesis users and non-users.

• We did not manifest a difference between the unilateral one and the bilateral amputees. The average age of the serious bilateral amputees is higher, and the Barthel-index is lower than those of the other amputee group.

The results of Amputee Mobility Predictor at the lower limb amputees

• 2 patients from group K0 have not been provided prosthesis fitting yet, 4 persons are bilateral above-knee amputees, 3 of them are traumatic ones, 1 is a vein amputee.

• Groups K1 and 2 include unilateral tibial, and femoral and bilateral amputees. Group K3 consists of traumatic amputees, two bilateral tibial, and one femoral-tibial amputee.

• One tibial, young amputee who plays table-tennis was in group K4.

The results of the examination of standing stability and fine coordination

Standing stability on two legs

The results of the examination, with opened eyes, lowered arms, on two legs

The test was performed by all the examined participants

• The radius of the body sway of the three amputee groups was larger than that of the control group. The body sway of first fitted amputees was larger than those of unilateral and bilateral skilled prosthesis users.

• In case of full body sway the difference cannot be experienced between the control group and the skilled prosthesis users. At the same time the total excursion of COP of first fitted prosthesis users was larger than that in the control group and that of bilateral skilled prosthesis users.

• In case of A-P sway only first fitted amputees differed from the control group.

• In case of first fitted amputees, who participated in two measuring processes, the radius of body sway did not change, but the total excursion of COP and M-L sway increased.

The results of the examination, with closed eyes, lowered arms, on two legs and the RK rates

• Similarly to the previous test, the radius of body sway of the control group is lower than that of the amputees. All measured rates of this test in case of first fitted amputees were larger than at the control group, furthermore the total excursion of COP of unilateral skilled prosthesis users was larger than that of the control group. The total excursion, A-P, and the M-L sway of bilateral amputees did not differ from the control group.

• All measured variables of this test at every person were larger than that of the test with opened eyes.

• The RK was calculated as the ratio of the suitable variables of the test with closed eyes and opened eyes. The RK_R of the control group is larger than that of the amputees. The RK_{SUM} differed only between bilateral amputees and the control group.

• RK_{A-P} did not differ between groups. At the same time RK_{M-L} did not differ between the control group and first fitted amputees, but in case of the group of skilled unilateral amputees was larger. RK_{SUM} is larger than RK_{M-L} in the control group and in the group of first fitted amputees.

The results of the examination, with opened eyes, lifted arms, on two legs

• The radius of body sway in the control group was smaller than in the groups of amputees. Furthermore, in case of skilled prosthesis users it was smaller than that of the first fitted amputees.

• We found a difference between unilateral and the bilateral skilled prosthesis users, the body sway of bilateral amputees was larger than that of the unilateral skilled prosthesis users.

• The rates of this test were larger than in case of the test with closed eyes.

• The lifting of arms yielded change in the control group, the whole excursion and A-P sway was increased.

Results of the examination, with opened eyes, lifted arms, on one leg and the values of 1/2K

• The radius of the body sway was lower in the control group than the one in the groups of unilateral amputees.

• At the same time in contrast with the test on two legs, the body sway of the first fitted amputees was smaller than that of skilled prosthesis users.

• The whole excursion of COP was the smallest for first fitted amputees, smaller than in the control group and the group of skilled prosthesis users.

• The A-P sway did not differ.

• The M-L sway was smaller at first fitted amputees than that of the control group, but did not differ from skilled amputees.

• There was no difference compared to the test on one leg and on two legs at first fitted amputees, but the total excursion of COP, the A-P and the M-L sway were larger in the test on two legs than on one leg.

• The values of the test on two legs were smaller than in the test on one leg.

• We can compare the role of visual control in the standing stability, in the given groups, with the help of the 1/2K. The 1/2K rates were smaller in the group of first fitted amputees than in the control group, and the $1/2K_R$ and the $1/2K_{A\text{-}P}$ in the groups of skilled prosthesis users.

Slope of the regression line

• The regression line trends from the prostheses heel towards the intact sole, so it seems to be opposite in left and right side amputees.

• We observed relatively small α in both groups, suggesting predominantly mediolateral COP movements produced by hip strategy.

The results of the examination of the fine coordination

• Moving the COP within the determined area was more successful than in the groups of amputees. There was no difference between amputee groups. The time spent inside the square did not differ between the control group and the skilled prosthesis users, but the result of first fitted amputees was worse than the one of the control group.

• The results of the test, moving and keeping the center of pressure to a determined point, did not differ between the control group and the amputees. But the results of the bilateral amputees were better than that of the first fitted amputees, and the control group.

The results of measuring body weight distribution

• Skilled prosthesis users showed symmetrical loading image, while that of first fitted amputees was asymmetrical. Due to two weeks of training there was significant increase in the loading of the prosthesis.

The results of the examination of body scheme

Among people amputated due to a vascular disease, three persons (one tibial, one bilateral tibial, one bilateral femoral, time passed since amputation is 0.5-5 years) and one traumatic, unilateral, tibial amputee (time passed since amputation is one week) did not feel his lost limb. 47 of our patients reported phantom sensations. Patients amputated earlier did not remember when the first phantom sensations appeared after the amputation. Out of 22 acute amputees, 17 could feel his/her lost limb immediately after awakening. Two patients could feel it two weeks later.

The character of the phantom feeling and its localization

• The patients reported various sensations. Most of them felt pain and numbness in the area of the phantom. Most of the dysvascular amputees reported pain (60%), and smaller part numbness. Numbness was the main symptom (76%), pain (35%) and itching (35%) were frequent. Itching in case of the dysvascular amputees was similar (36%). 15% of the traumatic amputees and 18% of the dysvascular amputees indicated volitional phantom limb feeling.

• The pain was described in different ways: spasm, pang, pulsation, electrifying, squeezing and sting. The power of the pain was indicated on a wide scale, however nobody reported unbearable pain. 18% of the dysvascular amputees did not feel the phantom pain, 30% felt medium, 27% strong and 12% a very strong pain. At the same time 38% of the traumatic patients did not feel any phantom pains, 12% felt weak, 27% medium, 23% a strong pain. The dysvascular patients rather felt weak and medium intensity pain as opposed to traumatic patients.

• The memories remained at the location of the sensations. More dysvascular amputees felt the pain where they had the wound and a traumatic amputee on the place of injury. The phantom sensation came frequently on the places which had bigger cortical representation. All lower limb amputees, feeling a phantom sensation, reported that they could feel their feet, ankle, sole and heel. Additionally, it was observed that the patients who had a problem in this area before the operation could feel the shank. Upper limb amputees (N=43) reported palm and hand sensations. The sensation of the distal limb parts, with bigger cortical representation occurred, but the proximal limb parts had smaller importance, or their sensation was sometimes missing.

The cause

- Considering the root of the causes dysvascular and traumatic amputees showed differences. Dysvascular amputees experienced that the movement of phantom limb did not cause pain, but in some cases, in the group of traumatic amputees, did.
- It was the dysvascular patients who explained the phantom sensations by tiredness or dream activity.
- The change in the weather, as a root cause, was experienced in both cases.
- 70% of dysvascular and 43% of traumatic amputees were not able to explain what may have induced sensations.
- From the examined patients 22 persons move their phantom limb. A bigger part of the patients do not move their phantom limb and did not hear about the phantom gymnastics. The motion, the gymnastics and the connection between the phantom pains are different from time to time.

Telescoping and modifying the body scheme

- Two patients, who did not wear prosthesis because of the short time passed since the amputation, and 16 first fitted prosthesis users did not show telescoping. Furthermore, amputated patients who had an operation long before and wore the prosthesis regularly did not show telescoping either.
- We could observe the initial process of the reorganization of the body scheme in the cases of four patients who were beginner prosthesis users.
- According to our experiences the process of the body scheme reorganization may be very different. Its more outstanding modification needs more time (our present examination took 4 years).
- In case of patients who were amputated a long time ago, and did not wear prosthesis (N=6), we experienced shortening in all cases (time passed since an amputation: 7-55 years). At a femoral amputee the shank and the thigh, at a forearm amputee the forearm, at an upper arm amputee the upper arm and the forearm shortened. At the

same time the ankle-, the foot-, the knee-, the hand palm- and the elbow sensation remained.

The results of the examination of the body awareness

• The number of answers given to the scale of Legs was between 0 and18. One dysvascular amputee indicated some awareness about his limb lost two years earlier.

• The awareness of legs was significantly higher in group 6- than in group 6+. There was no difference in the awareness of legs between the control group and in group 6-, but the leg awareness in group 6+ was lower than in the control group.

• In case of other scales, there was no difference. There was a weak correlation between Legs scales and the time elapsed since the amputation.

• The awareness of legs and arms did not differ between the prosthesis users and not users, and the patients amputated more than 6 months earlier.

• There was no significant difference between any parts of the lower limb at the bilateral tibial amputees. We did not experience that awareness of the supporting area of the prosthesis (the knee) and the other parts were different, so the leg awareness was not influenced by prosthesis wearing.

• Concerning leg awareness we did not manage to establish a significant difference between the dysvascular and the traumatic amputees. At the same time, the awareness of arms was higher in cases of traumatic amputees than in the cases of dysvascular amputees, and in the control group. Furthermore, the dysvascular amputees had stronger awareness of stomach, than the traumatic amputees or the control group.

• Those who had more serious body deficiencies (they lost two of their lower limbs) had higher awareness of arms than the persons losing one limb and the control group. In case of Legs scale, the control group had higher awareness than bilateral amputees.

• Unilateral amputees and the control group did not differ in case of the Arms and the Legs scales.

CONCLUSIONS

The radius of the body sway of dysvascular amputees was significantly larger than that of the control group. In case of the less active, first fitted unilateral amputees all four stabilometrical variables (R, SUM, A-P and M-L) were larger than in the control group. It was the R average only in case of the more active skilled prosthesis users that was larger than that of the control group, the rest of the variables (SUM, A-P and M-L) did not differ. We may establish, based on the facts mentioned above, that **the standing stability of amputees is weaker than that of healthy participants**, but **the standing stability of skilled prosthesis users was similar to healthy participants** rather than to first fitted amputees. Practicing with the prosthesis increases standing stability. The excursion of the COP does not refer to the differences of standing stability. Determining the radius of body sway is suitable to do so, because it shows how much the pressure centre approaches the edges of the supporting surface. When its rate is bigger, the off-balance is more likely. Its length concerning a time unit for the motion of the pressure centre shows the speed of body sway and how quickly the compensation of the evasion occurs. The velocity of the response expresses, onto the shift of a desirable pressure centre, the short radius and relatively longer body sway. The mediolateral sway reflects the learning process of the bodyweight load on the prosthesis. The determined stabilometrical variables, as **the radius of the characteristic circle, the total body sway, the anteroposterior sway, the mediolateral sway and the slope of regression line give information about standing stability in a complex way.**

- The stabilometrical variables, fine coordination and bodyweight distribution between the lower limbs were similar in case of unilateral and bilateral amputees. The weaker rehabilitative results which can be experienced at bilateral amputees cannot be caused by the ability of holding static balance.
- The way of standing balance development is illustrated by the fact that after two weeks of walking training the radius of body sway did not decrease, but the total excursion and the mediolateral sway increased. The fact that the bodyweight load of the two lower limbs became more symmetric is connected with this. **The adaptation to prosthesis wearing is reflected by the organization of movements becoming more sensitive**, which caused the increase of total excursion and mediolateral sway.
- RK showed a larger rate in the organization of movements in the control group, but between the amputee groups it did not differ. Visual control has central significance in the balance keeping after more years of prosthesis usages, too. It has a role in the prosthesis loading by controlling mediolateral sway, in case of unilateral skilled prosthesis users.

• The body sway of unilateral amputees, on one leg is larger than at the control group, and that one is larger at the skilled prosthetic users than at first fitted unilateral amputees. The rate of $1/2K_R$, which indirectly reflects the participation of the intact leg in standing stability, was the lowest at the first fitted amputees. Furthermore the radius of body sway did not differ in the test on two and one leg at first fitted amputees. **We may establish that the intact foot plays a central role in balance keeping in case of first fitted amputees.**

• The weight loading of the two lower limbs at first fitted amputees showed big asymmetry, which became more symmetrical by the influence of the walking training, and also the mediolateral sway became more sensitive.

• The amputees performed more weakly than the control group in the fine coordination tests. As a result of the incomplete afferentation and the incomplete function of the limb, and the rigid ankle foot the postural answer is late because, the patients are able to move the COP within a smaller support surface only. Consequently, **the amputees' ability of fine coordination is limited.**

• **The second order regression analysis is sensitive tool to characterize balance strategies in amputees.**

• The phantom pain of dysvascular and traumatic amputees did not show significant difference, but it is typical that the dysvascular patients rather felt the weak and medium intensity more frequently, opposed to the traumatic patients. In case of the other phantom sensations most dysvascular amputees reported pain and fewer of them about numbness. While numbness was the main symptom at traumatic amputees, pain and squeezing were frequent. There was no correlation between volitional movement and phantom pain. As a result, **phantom gymnastics is recommended in both indication groups.**

• **Memories before amputation played role in the localization of phantom sensations, they became frequent on the distal part of the phantom limb, but their main cause was not determined.**

• **The lack of prosthesis wearing caused telescoping, but the regular usage of the prosthesis provides to maintain a similar body scheme.**

• **Lower limb amputees had leg awareness, but it was influenced by the time elapsed since the amputation.** The leg awareness of the patients amputated for more than six months was similar to that of the healthy participants, but this one in case of the patients, amputated earlier, decreased. **The extent of cortical representation does not influence the body awareness, but the body scheme and the phantom sensations do.**

• **The leg awareness of dysvascular and traumatic amputees, and unilateral and bilateral amputees did not differ. At the same time, the arm awareness is lower at the traumatic patients, and bilateral amputees, reflecting that the functional role of the arms, in the latter groups of the less active walker, is greater.**

SUMMARY

Due to the amputation changes the morphology of the body, which causes many other changes. The organization of movements changes and a discrepancy becomes between body awareness and the body scheme. We studied the standing stability with stabilometry, the spatial localization of the phantom limb with a special test, and the body awareness with Body Focus Questionnaire. We introduced a new static stabilometry variable, namely the radius of the characteristic circle based on the 95% of the sampled points of the stabilogram to characterize the body sway, and determined the slope of the regression line to characterize balance strategies.

The prosthesis does not make a possibility to reach a standing stability alike this one of healthy people, due to incomplete somatosensory information, and the poorer physical ability. The standing stability of the first fitted amputees is poorer, than this one of the skilled prosthesis users, but this one not differ between unilateral and bilateral skilled prosthesis users. The visual control plays an important role in the standing stability, particularly in reduction the mediolateral sway at the skilled unilateral amputees. The role of the intact foot is outstanding at the acute amputees in the balance keeping, which decreases by the passing of longer time. We observed that the hip strategy is typically used in balance of unilateral amputees. The planning suitable rehabilitation program, which includes exercises developing the intact and the amputated leg, and exercises taking aim the reduction of visual dependence, may be expedient. The phantom phenomenon is the example of the difference of a body scheme and the body awareness when the amputee feels his absent limb although he knows that he lost it. We knew to justify about the body scheme only, that his spatial position relevantly

possible the maintenance of a normal state, which condition of is the usage of the prosthesis. Opposite this, independently of a prosthesis usage, the lower extremity of amputees is being built from the body awareness, and the awareness of the arms, which grew with their functional significance, grows.

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