DOI: https://doi.org/10.2298/SARH171121010B
UDC: 616.718-089.873:616.379-008.64-056.24

PRELIMINARY REPORT / ПРЕТХОДНО САОПШТЕЊЕ

Does diabetes affect stability in people with unilateral transtibial amputation?

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SUMMARY

Introduction/Objective Currently, analysis of the stability of amputees with diabetes is lacking. The aim of this case study was to examine the effects of unilateral transtibial amputation on the stability and balance confidence of patients with below-knee amputation caused by trauma and diabetes.

Methods Seventeen subjects, 12 males and five females, with the average age of 51.47 ± 12.12 years, who use a unilateral transtibial prosthesis, were examined. The balance of 10 traumatic amputees (TTA) and seven diabetic amputees (TDA) was assessed by Activities-Specific Balance Confidence (ABC) scale, Timed Up and Go (TUG) test, and One-Legged Stance Test (OLST). Plantar pressure distribution was recorded using Gaitview AFA-50.

Results For 10 TTA and one TDA, ABC scores were > 80%, the mean value of the TUG test was 11 (range: 8.08–23 seconds). All the subjects could stand on the healthy leg, two women with diabetes were unable to stand on the prosthetic leg. The distribution of load between the healthy and the prosthetic leg showed higher overload on the healthy leg (average: 56.62%).

Conclusion The data from this case series describe stability problems of people with transtibial amputation. Plantar pressure distribution has the potential to provide information about the properties of stability in the amputees who use prosthesis.

Keywords: amputee; balance; diabetes; plantar pressure

INTRODUCTION

For people with lower limb amputation, the ability to balance is an important condition for gait training and has a significant role in their new movement patterns.

Postural stability may be decreased under the impact of several factors: by biomechanical changes, somatosensory and motoric impairment in people with amputation. Due to the structural deficit and the lack of muscle mass, as well as the lack of proprioceptive activity, amputees face the problem of maintaining stability. Stability problems cause falls and fear of falling, identified as negative factors in prosthetic rehabilitation [1]. For lower leg amputees, where the cause of amputation is vascular pathology associated with diabetes, diabetes-induced changes are expected to occur in all structures, e.g. sensory nervous system, tendons, soft tissues, peripheral vascular system, etc., which can have an impact on the stability [2, 3]. In amputees with diabetes, changes in walking, falls, lack of protective foot sensitivity and other complications of diabetes, have been recorded and these changes can contribute to stability problems [4–7]. It is reasonable to think that diabetes-related amputations cause greater problems in terms of balance confidence when compared to people with a traumatic amputation. It is believed that postural control and balance confidence assessment provide important information about the stability and fear of falling in patients with lower limb amputations. In general, better understanding of imbalance is important for the rehabilitation program [8–11]. These patients face challenges in fulfilling everyday tasks and the ability to maintain balance is required for tasks to be fulfilled. Estimation of stability through the determination of the pressure center provides useful information and although the plantar pressure research has high potentials, its clinical assessment is not sufficient [12, 13, 14]. By reviewing the literature, pedobarography was used for foot-deformity tests, diabetic polyneuropathy, knee osteoarthritis, orthosis, etc. The purpose of this case series is to describe the effects of unilateral transtibial amputation on the stability and balance confidence of patients with below-knee amputation caused by trauma and diabetes. Furthermore, we hypothesize that the examination of plantar pressure distribution has potential future benefits in the rehabilitation of amputees.

METHODS

Descriptive study of the type series of cases included 17 subjects with transtibial amputation who have been using prostheses for at least 6

Received • Примљено: November 21, 2017
Revised • Ревизија: January 22, 2018
Accepted • Прихваћено: January 23, 2018
Online first: February 6, 2018

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Table 1. Patients' characteristics and the balance assessment outcome

Case	Amputation cause	Sex	Age	Height	Weight	DM (years)	Prosthesis (years)	ABC	TUG	OLST	OLST p
1	Trauma	M	25	184	70		12	88.75	10.61	22	4
2	Trauma	M	30	178	70		5	85	8.08	23	3
3	Trauma	M	43	172	95		6	83.75	8.09	24	4
4	Trauma	M	53	192	92		5	85	9.22	8	3
5	Trauma	M	61	178	97		20	84.37	11.72	25	4
6	Trauma	M	55	178	78		20	80.62	11	35	6
7	Trauma	M	36	178	65		9	93.75	10.61	28	6
8	Trauma	M	47	186	96		20	91.25	10	30	5
9	Trauma	M	56	180	82		19	88.2	8.56	29	4
10	Trauma	F	50	170	68		10	88.12	11	27	4
11	Diabetes	F	66	167	70	20	1.5	65.62	23	5	0
12	Diabetes	M	62	188	100	5	4	70	14	5	2
13	Diabetes	F	49	175	75	22	6	82.5	11.75	5	0
14	Diabetes	M	66	187	105	10	10	71.87	11.96	15	1
15	Diabetes	M	60	181	80	8	4	65	16	9	1
16	Diabetes	F	54	171	69	8	4	74.37	14	19	3
17	Diabetes	F	62	168	67	14	5	79.37	15	17	2
Average			51.47	178.41	81.12	12.43	9.44	81.03	12.04	19.18	3.06
St. Dev.			12.12	7.36	13.49	6.48	6.46	8.76	3.66	9.8	1.85
Median			54	178	78	10	6	83.75	11	22	3
Min.			25	167	65	5	1.5	65	8.08	5	0
Max.			66	192	105	22	20	93.75	23	35	6

M – male; F – female; ABC – Activities-Specific Balance Confidence scale; TUG – Timed Up and Go test; OLST – Timed One-Legged Stance Test; OLST p – Timed One-Legged Stance Test on the prosthetic leg

months after discharge from the Regional Rehabilitation Centre. The study population was made up of twelve males and five females with the mean age of 54 (range: 25–66 years). The study was prepared at the Clinical Centre of Montenegro and the examination was carried out in Rudo Montenegro Orthopaedic Company in Podgorica. Amputees were invited to participate in the study based on the patient files of the Orthopaedic Company. The primary factor influencing participant selection was the cause of amputation. The study was approved by the Medical Ethics Committee of the Clinical Centre of Montenegro. Data on the cause and the time when the amputation was performed, duration of diabetes, and the presence of comorbidities were taken from the patients' medical records. Excluding factors for participation in the study were the following: neurological diseases that can lead to balance damage, unregulated glycaemia, sight problems, diabetic foot, and musculoskeletal disorders of the contralateral leg.

Assessment procedure

Activities-Specific Balance Confidence (ABC) scale is a 16-item questionnaire in which patients were asked to rate their confidence in terms of whether they will lose their balance while performing a set of activities [15]. Each item describes a specific activity that requires progressively increased balance control. Participants were asked to rate their level of confidence on a scale between 0% and 100% when performing a variety of activities, such as climbing stairs, reaching above the head, and walking on different surfaces. Responses were added and then divided by 16 to provide an overall mean balance confidence score. Greater scores indicate higher balance confidence. The ABC scale has psychometric evidence supporting its use with individuals with lower-limb amputations [16].

Walking and balance were assessed using the Timed Up and Go (TUG) test [17]. The TUG test – a performance-based measure of many of the components of basic mobility – includes balance, transfers, walking, and turning while walking.

In the Timed One-Legged Stance Test (OLST) for the amputees, the subjects were standing first on the contralateral leg, then on the prosthetic leg [18].

Static and dynamic plantar pressure were measured during standing and walking in shoes using the Gaitview AFA-50 system (alFOOTs, Seoul, Republic of Korea), which includes a 700 × 500 × 45 mm active area, consisting of a 3 mm thick floor mat, comprising 2,304 (48 × 48) force-sensitive sensors; test time: changeable; maximum pressure: 100 N/cm^2; acquisition frequency: ≤ 86 images per second. In previous studies, this system demonstrated good to moderate reliability [19, 20]. We used the two-step method. Participants repeated walking on a 3 m long tape twice.

Table 2. Plantar pressure distribution

Case	P ratio %	P ratio p %	F/F ratio %	F/F ratio p %	R/F ratio %	R/F ratio p %	DP ratio %	DP ratio p %	Gait time	Gait time p
1	63.29	36.8	25.05	22.42	38.14	14.38	51.01	48.99	0.92	0.98
2	65.34	34.35	25.56	22.71	39.98	11.74	52.73	47.27	0.87	0.81
3	50.88	49.12	23.98	13.54	26.9	35.58	45.49	54.51	0.92	0.87
4	51.31	48.69	22.87	18.2	28.44	30.69	40.42	59.58	0.98	1.04
5	61.26	38.74	18.35	34.09	42.5	4.65	50.74	49.26	1.21	1.1
6	60.06	39.4	20.23	23.67	36.33	14.35	52.45	45.65	0.99	0.96
7	64	36	24.12	13.02	33	35.46	52.01	47.88	0.91	0.9
8	60.32	39.68	25.05	22.89	37.11	20.78	47.89	52.11	1.00	0.96
9	54.5	45.5	28.3	19.79	33.24	20.76	51.88	48.12	0.95	0.91
10	57.25	42.75	25.56	22.71	35.4	19.00	51.01	48.99	1.15	1
11	60.2	39.8	24.85	30.48	35.35	9.31	47.65	52.35	1.56	1.62
12	47.16	52.84	19.41	29.37	27.75	23.48	51.36	48.64	0.92	0.98
13	53.01	46.99	20.21	22.62	32.8	24.27	51.48	48.52	1.27	0.98
14	47.21	52.79	28.65	38.52	18.56	14.27	54.19	45.81	1.1	1.15
15	58.1	41.99	19.28	20.98	38.7	21.1	39.18	60.82	0.92	0.87
16	55.48	44.52	17.99	24.99	37.49	19.93	49.36	50.64	1.04	1.15
17	53.1	46.95	22.56	24.38	30.35	26.16	51.05	49.88	1.02	1.14
Average	56.62	43.35	23.06	23.79	33.65	20.35	49.41	50.53	1.04	1.02
St. Dev.	5.63	5.68	3.32	6.54	5.87	8.59	4.18	4.28	0.17	0.18
Median	57.25	42.75	23.98	22.71	35.35	20.76	51.01	48.99	0.99	0.98
Min.	47.16	34.35	17.99	13.02	18.56	4.65	39.18	45.65	0.87	0.81
Max.	65.34	52.84	28.65	38.52	42.5	35.58	54.19	60.82	1.56	1.62

P ratio – pressure ratio; P ratio p – prosthetic foot pressure ratio; F/F ratio – forefoot ratio load percentage; F/F ratio p – prosthetic foot forefoot ratio load percentage; R/F ratio – rearfoot ratio load percentage; R/F ratio p – prosthetic foot rearfoot ratio load percentage; DP ratio – dynamic pressure ratio; DP ratio p – prosthetic foot dynamic pressure ratio

Statistical analysis

The data was analyzed in PASW Statistics for Windows, Version 18.0 (SPSS Inc., Chicago, IL, USA) and R software environment for statistical computing and graphics (R Foundation for Statistical Computing). Statistical analysis comprised descriptive methods.

RESULTS

Table 1 illustrates the descriptive statistics of the amputees involved in the study. The most common reason for amputation was trauma. Seven subjects have had diabetes of average duration 12.43 ± 6.48 years. All traumatic amputees demonstrated higher balance confidence, ABC score > 80%, but the respondents with amputations due to diabetes problems had lower balance confidence, ABC score < 75%. For 12 amputees, the TUG test was < 12, but amputees with diabetes had high amplitudes in the scores (23, 14, 11.76...). For nine subjects with traumatic amputation, scores for time spent for standing on the healthy leg were > 20 seconds. Only one man could stand for 8 seconds (subject 4). Amputees with diabetes had a shorter standing time – two women with diabetes were unable to stand on the prosthetic foot (subjects 11 and 13). Static and dynamic pedobarography test results were as follows: the distribution of the load between the healthy and the prosthetic leg showed higher overload on the healthy leg (the average of 56.62%); the percentage of the load between the forefoot and the rearfoot on the healthy leg showed greater posterior overload (forefoot 23.06%, rearfoot 33.65%) and greater anterior overload on the prosthesis leg (forefoot 23.79%, rearfoot 20.35%).

DISCUSSION

The decrease of balance and balance confidence in amputees can be associated with the level of amputation and its cause [1]. By measuring these factors, related to the cause of amputation, in this study we have presented variations in the results of stability. Diabetic amputees, with their mean age of 54 years, have the ABC score of less than 80% (72.67), and are at risk of falling. In a study by Myers et al. [21], elderly people in good health had the ABC score higher than 88%. We used the TUG to show physical function and mobility with the below-knee amputees. Regarding the TUG, traumatic amputees had been using prosthesis for more than four years and have had good physical mobility, but diabetic amputees needed more time to perform the test. It is important to mention that the diabetic amputees in this study were older and had been using the prosthesis for a shorter time, which means that it can take longer for

them to perform the TUG test. Although we cannot make a definitive conclusion, these outcomes are interesting for future research. Christiansen et al. [22] indicate the predictive role of the TUG test for the risk of falls in patients with dysvascular lower extremity amputation. Dite et al. [23] found that the TUG score of 19 seconds or more is associated with an increased risk of having multiple falls in transtibial amputees. The OLST test provided useful information about the static stability of below-knee amputees. Hermodsson et al. [18], in their comprehensive analysis, reported results similar to those in the present study. The standing balance capacity of the traumatic amputees is good. The results for plantar pressure assessment showed a difference in standing pressure distribution based on the asymmetrical weight distribution between the normal and prosthetic feet. It is desirable to develop a typical profile for transtibial amputees while standing, as other authors suggest [24, 25]. We believe that the collection of data regarding the forefoot and rearfoot pressure ratio may be useful information for the treatments aimed at correcting load imbalance. Several studies examined the effect of different types of prosthetic feet on the pattern of plantar pressure in the group of diabetic transtibial amputees [26]. The participants in this study had the same prosthetic foot. This study presents the use of plantar pressure assessment as an additional tool, and data collected in the present case series investigation support this hypothesis. Several limitations were present in this study: small number of participants, results of pedobarography excluded other surfaces and prosthesis characteristics. Further research is required to show significance across a larger amputee population.

CONCLUSION

Data presented in this case series suggest the importance of the balance assessment of unilateral below-knee amputees of a different etiology.

REFERENCES

1. Miller WC, Speechley M, Deathe AB. The prevalence and risk factors of falling and fear of falling among lower extremity amputees. Arch Phys Med Rehabil. 2001; 82(8):1031–7.
2. Kolarova B, Janura M, Svoboda Z, Elfmark M. Limits of stability in persons with transtibial amputation with respect to prosthetic alignment alterations. Arch Phys Med Rehabil. 2013; 94(11):2234–40.
3. Wong KL, Nather A, Liang S, Chang Z, Wong TT, Lim CT. Clinical outcomes of below knee amputations in diabetic foot patients. Ann Acad Med Singapore. 2013; 42(8):388–94.
4. Allet L, Armand S, De Bie RA, Golay A, Monnin D, Aminian K, et al. The gait and balance of patients with diabetes can be improved: a randomized controlled trial. Diabetologia. 2010; 53(3):458–66.
5. Hewston P, Deshpande N. Falls and balance impairments in older adults with type 2 diabetes: thinking beyond diabetic peripheral neuropathy. Can J Diabetes. 2016; 40(1):6–9.
6. Akbari M, Jafari H, Moshashaee A, Forugh B. Do diabetic neuropathy patients benefit from balance training? JRRD. 2010; 49(2):333–8.
7. Timar B, Timar R, Gaiță L, Oancea C, Levai C, Lungeanu D. The impact of diabetic neuropathy on balance and on the risk of falls in patients with type 2 diabetes mellitus: a cross-sectional study. PLoS ONE. 2016; 11(4):1–11.
8. Miller WC, Speechley M, Deathe B. Balance confidence among people with lower limb amputation. Phys Ther. 2002; 82(9):856–65.
9. Lajoie Y, Gallagher SP. Predicting falls within the elderly community: comparison of postural sway, reaction time, the Berg balance scale and the Activities-specific Balance Confidence (ABC) scale for comparing fallers and non-fallers. Arch Gerontol Geriatr. 2004; 38(1):11–26.
10. Sjodahl C, Jarnlo GB, Persson BM. Gait improvement in unilateral transfemoral amputees by a combined psychological and physiotherapeutic treatment. J Rehab Med. 2001; 33(3):114–8.
11. Franchignoni F, Giordano A, Ronconi G, Rabini A, Ferriero G. Rasch validation of the Activities-specific Balance Confidence Scale and its short versions in patients with Parkinson's disease. J Rehabil Med. 2014; 46(6):532–9.
12. Brown SJ, Handsaker JC, Bowling FL, Boulton AJM, Reeves ND. Diabetic Peripheral Neuropathy Compromises Balance During Daily Activities. Diabetes Care. 2015; 38(6):1116–22.
13. Lugade V, Kaufman K. Center of pressure trajectory during gait: a comparison of four foot positions. Gait Posture. 2014; 40(1):252–4.
14. Giacomozzi C. Potentialities and criticalities of plantar pressure measurements in the study of foot Biomechanics: devices, methodologies and applications. Chapter 11: In: Vaclav K (Ed.). Biomechanics in applications. In Tech Publication, 2011.
15. Powell LE, Myers AM. The Activities-specific Balance confidence (ABC) scale. J Gerontol A Biol Sci Med Sci. 1995; 50A(1): M28–34.
16. Sakakibara BM, Miller WC, Backman CL. Rasch analyses of the Activities-specific Balance Confidence Scale with individuals 50 years and older with lower-limb amputations. Arch Phys Med Rehabil. 2011; 92(8):1257–63.
17. Schoppen T, Boonstra A, Groothoff JW, de Vries J, Göeken LN, Eisma WH. The Timed "up and go" test: reliability and validity in persons with unilateral lower limb amputation. Arch Phys Med Rehabil. 1999; 80(7):825–8.
18. Hermodsson Y, Ekdahl C, Persson BM, Roxendal G. Standing balance in trans-tibial amputees following vascular disease or trauma: a comparative study with healthy subjects. Prosthet Orthot Int. 1994; 18(3):150–8.
19. Lee JS, Kim KB, Jeong JO, Kwon NY, Jeong SM. Correlation of foot posture index with plantar pressure and radiographic measurements in pediatric flatfoot. Ann Rehabil Med. 2015; 39(1):10–7.
20. Kim YT, Lee JS. Normal pressures and reliability of the Gaitview® system in healthy adults. Prosthet Orthot Int. 2012; 36(2):159–64.
21. Myers AM, Powell LE, Maki BE, et al. Psychological indicators of balance confidence: relationship to actual and perceived abilities. J Gerontol A Biol Sci Med Sci. 1996; 51(1):M37–43.
22. Christiansen C, Fields T, Lev G, Stephenson RO, Stevens-Lapsley JE. Functional outcomes following the prosthetic training phase of rehabilitation after dysvascular lower extremity amputation. PM R. 2015; 7(11):1118–26.
23. Dite W, Connor HJ, Curtis HC. Clinical identification of multiple fall risk early after unilateral transtibial amputation. Arch Phys Med Rehabil. 2007; 88(1):109–14.
24. Engsberg JR, Allinger TL, Harder JA. Standing pressure distribution for normal and below-knee amputee children. Prosthet Orthot Int. 1989; 13(3):152–5.
25. De Cerqueira Soares ASO, Yamaguti EY, Mochizuki L, AmadioAC, Serrão JC. Biomechanical parameters of gait among transtibial amputees: a review. Sao Paulo Med J. 2009; 5(127):302–9.
26. Arifin N, Abu Osman NA, Ali S, Gholizadeh H, Wan Abas WA. Postural stability characteristics of transtibial amputees wearing different prosthetic foot types when standing on various support surfaces. Scientific World Journal. 2014; 2014:856279.

Да ли дијабетес утиче на стабилност код особа са једностраном транстибијалном ампутацијом?

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САЖЕТАК

Увод/Циљ Тренутно недостају анализе стабилности код особа са ампутацијама узрокованих дијабетесом.
Циљ ове студије је био да се процени утицај дијабетеса на стабилност и да се утврди корелација између расподеле плантарног притиска и нестабилности код особа са ампутацијом испод колена.

Методе У опсервациону студију пресека укључено је 17 болесника – 12 мушкараца и пет жена, старости 51,47 ± 12,12 година. Подељени су у две групе: контролна група, 10 транстибијалних трауматских ампутација (ТТА) и седам транстибијалних ампутација услед дијабетеса (ТАД).
Баланс је процењен Скалом самопоуздања за одређене активности (ССА), тестом устани и крени (ТУК) и тестом стајања на једној нози (ТСЈН). Расподела плантарног притиска забележена је помоћу *Gaitview AFA*-50.

Резултати За десет ТТА и један ТАД, ССА резултати су били > 80%, средња вредност ТУК теста је била 11 (опсег: 8,08–23 секунди). Сви испитаници су могли да стоје на здравој нози, две жене са дијабетесом нису могле да стоје на протетској нози. Расподела оптерећења између здраве и протетске ноге показала је веће оптерећење на здравој нози (просечно: 56,62%).

Закључак Ово испитивање указује на проблеме са стабилношћу код људи са транстибијалном ампутацијом и дијабетесом. Дистрибуција плантарног притиска може да пружи информације о стабилности код људи са ампутацијом који користе протезу.

Кључне речи: ампутација; равнотежа; дијабетес; плантарни притисак