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Original Article

Factors affecting activities of daily living, physical balance, and prosthesis adjustment in non-traumatic lower limb amputees

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ABSTRACT

Objectives: This study aims to identify the factors affecting the activities of daily living, balance, and prosthesis satisfaction in patients with non-traumatic lower limb amputation (LLA).

Patients and methods: This cross-sectional study included a total of 195 patients (120 males, 75 females; mean age 65.9±11.6 years; range, 40 to 90 years) who underwent LLA between January 2009 and April 2017. All patients were evaluated in terms of age, sex, amputation etiology, side, level, comorbidity, length of hospital stay, prosthesis adjustment, ambulation level, functional outcome, and complications. Prosthesis adjustment, physical balance ability, and daily living activities were assessed using the Turkish versions of the Trinity Amputation and Prosthesis Experience Scales (TAPES), Berg Balance Scale (BBS), and Nottingham Extended Activities of Daily Living Scale (NEADLS), respectively.

Results: There was no significant difference between male and female patients in terms of prosthesis and amputation adaptation, physical balance, and activities of daily living. The BBS, TAPES, and NEADLS scores were lower in the patients aged over 65 years ($p<0.001$, $p<0.001$, and $p<0.001$, respectively). Prosthesis and amputation adaptation, physical balance, and daily living activities were also worse in this age group. Transfemoral amputees had lower BBS, TAPES, and NEADLS scores than the transtibial amputees ($p=0.009$, $p=0.020$, and $p=0.004$, respectively). Prosthesis and amputation adaptation, physical balance, and daily living activities were worse in the transfemoral amputees.

Conclusion: Age and amputation level affect physical balance, prosthesis satisfaction, and daily living activities after non-traumatic LLA. Therefore, orthopedic surgeons and physical therapists should conduct a multidisciplinary evaluation, particularly in patients aged over 65 years and in transfemoral amputees to improve outcomes.

Keywords: Activities of daily living, amputation adaptation, lower limb amputation, physical balance, prosthesis satisfaction.

Lower limb amputation (LLA) is a common condition affecting the activities of daily living and balance adversely, resulting in social, economic, psychological, and occupational burdens.[1-6] Thanks to the wide use of prosthesis and improved rehabilitation methods, it is possible to improve the quality of life of patients and make them able to return to social life and return to former or a new job by reducing the functional limitations.[7] As the amputees regain the functional independence with the prosthesis, their self-esteem increases, and social adjustment and quality of life are positively affected. However, various factors such as the cause and level of amputation, duration of prosthesis use, prosthetic design, stump pain, phantom limb sensation, phantom limb pain and psychosocial status can affect prosthesis adjustment and rehabilitation success.[8] Therefore, identifying the factors affecting functional status, balance, and

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activities of daily living in patients with LLA is of paramount importance.

Among the factors affecting prosthetic walking ability after amputation, balance disorder is the main factor which limits prosthetic walking.[9] In addition, advanced age and more proximal amputation may lead to a decrease in the prosthetic functional ability.[10] Both physical abilities and psychosocial characteristics can affect the prognosis of prosthetic use and performance on functionality.[11]

In the light of these data, we aimed to identify the factors affecting the activities of daily living, physical balance, and prosthesis adjustment in patients with non-traumatic LLA.

PATIENTS AND METHODS

This cross-sectional study was conducted at Bakırköy Dr. Sadi Konuk Training and Research Hospital between January 2009 and April 2017. Patients aged 18 years and older, and patients with unilateral LLA without cognitive and mental problems, and neurological problems, and those with actively using the prosthesis for at least one year were included in the study. Patients aged under 18 years old, having upper limb amputations, bilateral amputations, amputations due to congenital or neoplastic reasons, or amputations due to trauma, those with inadequate cognitive function, having muscle weakness and comorbidities affecting the walking ability before LLA were excluded. Finally, a total of 195 patients (120 males, 75 females; mean age 65.9±11.6 years; range, 40 to 90 years) who underwent LLA were enrolled. A written informed consent was obtained from each patient. The study protocol was approved by the Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (Approval Date: May 29, 2017, No: 2017/04-12). The study was conducted in accordance with the principles of the Declaration of Helsinki.

All patients were evaluated in terms of age, sex, amputation etiology, side, level, body mass index (BMI), smoking habit, comorbidity, length of hospital stay, prosthesis adjustment, ambulation level, functional outcome, and complications. The causes of amputation were identified as diabetes mellitus (DM) and other peripheral vascular disease (PVD) such as Buerger's disease. The patients were divided into two subgroups as transtibial (TT) and transfemoral (TF) amputations. The TF amputation was performed from an average of 12 cm distal to the trochanter major, and the TT amputation was performed at an average of 15-cm distal to the knee joint level. The patients were also classified according to age as ≥65 years and <65 years. Prosthesis adjustment, physical balance ability, and daily life functionality were performed with the Turkish versions of the Trinity Amputation and Prosthesis Experience Scales (TAPES), Berg Balance Scale (BBS), and Nottingham Extended Activities of Daily Living Scale (NEADLS), respectively. The scales were evaluated by a senior physiotherapist who had more than 10 years of experience and was blinded to study.

Outcome measures

The Turkish version of the BBS was used to measure physical balance ability. It is a measure with 14 items, each with a score of 0-4, observing the patient's performance for each item. The patient is given 0 points in cases he/she has never been able to do the activity, while 4 points are given when the patient completes the activity independently. The highest score is 56, indicating the presence of balance of 0-20 points, an acceptable balance of 21-40 points, and a good balance of 41-56 points. The BBS has been shown to be a valid balance function for patients with lower limb loss, when they are not using an assistive device. The inter- and intra-rater reliability of the BBS is excellent for those with lower limb loss.[12]

The Turkish version of the TAPES was used to measure amputation and prosthesis adaptation.[8] It evaluates adaptation to prostheses using subscales including psychosocial adjustment, activity restriction, prosthesis satisfaction, stump pain, phantom pain, and other medical problems.[13] Psychosocial adjustment is assessed on a five-point scale, consisting of a total of 15 items, each ranging from 1 to 5. The activity restriction is assessed on a scale of three points each and a total of 12 items. Prosthetic satisfaction is assessed on a five-point scale of 10 items, each ranging from 1 to 5. Higher scores on these subscales indicate greater prosthesis satisfaction.

The Turkish version of the NEADLS was used to evaluate the functions of the amputees in daily life.[14] Originally developed for stroke patients, it is also used for orthopedic diseases such as amputation and total hip replacement.[15] The NEADLS consists of four subdomains; mobility (6 items), kitchen (5 items), housework (5 items), and leisure activities (6 items). It is a scale with 0-3 points for the answers to the questions. The NEADLS score is the sum of all the points. The total score ranges from 0 to 66 points. Higher scores indicate a better level of daily activity.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency. After checking the normal distribution of the variables, the Kolmogorov-Smirnov test and Mann-Whitney U test were used to compare numeric variables between the groups. The chi-square test was used for the analysis of categorical variables. For regression analyses, five variables were stratified according to sex and a linear regression analysis was performed. The Functional Independence Scale (FIM) was determined as the dependent variable, while the TAPES, BBS, length of hospital stay, and BMI were determined as the independent variables. The latest step according to the backward method was tabulated and the initial variables were added to the bottom of the table. A p value of <0.05 was considered statistically significant.

RESULTS

Baseline demographic and clinical characteristics of the patients are shown in Table 1. Amputation side,

TABLE 1
Baseline demographic and clinical characteristics of patients

Variables	n	%	Mean±SD	Median	Min-Max
Age (year)			65.9±11.6	66	40-90
Sex					
Female	75	38.5			
Male	120	61.5			
Body mass index (kg/m^2)			23.6±2.8	23	18-29
Hospitalization (day)			15.6±11.7	15	1-60
Follow-up (month)			26.2±3.2	25	24-37
Berg Balance Scale score			17.6±14.8	18	0-52
TAPES score			30.5±26.8	25	0-115
NEADLS score			19.9±16.5	18	0-56
Amputation level					
Transtibial	102	52.3			
Transfemoral	93	47.7			
Amputation side					
Right	70	35.9			
Left	125	64.1			
Amputation etiology					
Diabetes mellitus	88	45.1			
Peripheral vascular disease	107	54.9			
Smoking habit					
Still smoker	52	26.7			
Left smoking	100	51.3			
Non-smoker	43	22.1			
Ambulation level					
Dependent at home	28	14.4			
Dependent outside	62	31.8			
Independent	105	53.8			
Comorbidity					
Hypertension	180	92.3			
Diabetes mellitus	152	77.9			
Coronary artery disease	155	79.5			
Heart failure	34	17.4			
Complication					
Stump revision	32	16.4			
Stump infection	36	18.5			
Phantom limb pain	73	37.4			
Residual limb pain	27	13.8			

SD: Standard deviation; Min: Minimum; Max: Maximum; TAPES: Trinity Amputation and Prosthesis Experience Scales; NEADLS: Nottingham Extended Activities of Daily Living Scale

TABLE 2
Assessment of characteristics of patients, physical balance, prosthesis satisfaction, and daily living activities according to age and sex groups

	Female				Male					Age ≤65				Age >65				
	n	%	Mean±SD	Median	n	%	Mean±SD	Median	*p*	n	%	Mean±SD	Median	n	%	Mean±SD	Median	*p*
Hospitalization (day)			15.5±12.9	10.0			15.7±10.9	15.0	0.470*			14.5±12.1	10.0			16.8±11.2	15.0	0.041*
BBS score			16.5±15.9	11.0			18.3±14.2	18.0	0.255*			21.5±14.8	22.0			13.8±13.9	11.0	0.000*
TAPES score			28.6±29.7	18.0			31.8±24.8	27.0	0.124*			38.4±28.0	41.0			22.8±23.2	19.5	0.000*
NEADLS score			18.2±17.6	13.0			21.0±15.7	18.0	0.143*			24.9±16.6	26.0			14.9±14.9	13.0	0.000*
Amputation side									0.550†									0.724†
Right	25	33.3			45	37.5				36	37.1			34	34.7			
Left	50	66.7			75	62.5				61	62.9			64	65.3			
Amputation etiology									0.000†									0.097†
Diabetes mellitus	62	82.7			26	21.7				38	39.2			50	51.0			
PVD	13	17.3			94	78.3				59	60.8			48	49.0			
Smoking habit									0.000†									0.004†
Still smoker	9	12.0			43	35.8				36	37.1			16	16.3			
Give up smoking	27	36.0			73	60.8				44	45.4			56	57.1			
Non-smoker	39	52.0			4	3.3				17	17.5			26	26.5			
Ambulation level									0.610†									0.007†
Dependent at home	13	17.3			15	12.5				17	17.3			11	11.3			
Dependent outside	22	29.3			40	33.3				21	21.4			41	42.3			
Independent	40	53.3			65	54.2				60	61.2			45	46.4			
Comorbidity																		
Hypertension									0.074†									0.057†
-	9	12.0			6	5.0				11	11.3			4	4.1			
+	66	88.0			114	95.0				86	88.7			94	95.9			
Diabetes mellitus									0.049†									0.000†
-	11	14.7			32	26.7				33	34.0			10	10.2			
+	64	85.3			88	73.3				64	66.0			88	89.8			
CAD									0.000†									0.012†
-	25	33.3			15	12.5				27	27.8			13	13.3			
+	50	66.7			105	87.5				70	72.2			85	86.7			
Heart failure									0.056†									0.470†
-	57	76.0			104	86.7				82	84.5			79	80.6			
+	18	24.0			16	13.3				15	15.5			19	19.4			
Complication																		
Stump revision									0.501†									0.421†
-	61	81.3			102	85.0				79	81.4			84	85.7			
+	14	18.7			18	15.0				18	18.6			14	14.3			
Stump infection									0.002†									0.060†
-	53	70.7			106	88.3				74	76.3			85	86.7			
+	22	29.3			14	11.7				23	23.7			13	13.3			
Phantom limb pain									0.233†									0.023†
-	43	57.3			79	65.8				53	54.6			69	70.4			
+	32	42.7			41	34.2				44	45.4			29	29.6			
Residual limb pain									0.003†									0.553†
-	58	77.3			110	91.7				85	87.6			83	84.7			
+	17	22.7			10	8.3				12	12.4			15	15.3			

SD: Standard deviation; BBS: Berg Balance Scale; TAPES: Trinity Amputation and Prosthesis Experience Scales; NEADLS: Nottingham Extended Activities of Daily Living Scale; PVD: Peripheral vascular disease; CAD: Coronary artery disease; * Mann-Whitney U test; † Chi-square test.

TABLE 3
Assessment of characteristics of patients, physical balance, prosthesis satisfaction, and daily living activities according to amputation level

	Transtibial				Transfemoral				
	n	%	Mean±SD	Median	n	%	Mean±SD	Median	*p*
Age (year)			67.0±11.8	67.5			64.7±11.3	65.0	0.222
Age group (year)									0.174†
≤65	46	45.1			51	50.0			
>65	56	54.9			42	41.2			
Sex									0.160†
Female	44	43.1			31	30.4			
Male	58	56.9			62	60.8			
Body mass index (kg/m^2)			23.7±2.6	23.0			23.6±2.9	24.0	0.988*
Hospitalization (days)			14.8±8.1	15.0			16.5±14.7	14.0	0.518*
BBS			20.1±14.6	22.0			15.0±14.7	12.0	0.009*
TAPES			34.5±26.1	38.0			26.2±26.9	19.0	0.020*
NEADLS			22.9±16.6	24.0			16.7±15.8	13.0	0.004*
Amputation side									0.190†
Right	41	40.2			29	31.2			
Left	61	59.8			64	68.8			
Amputation etiology									0.085†
Diabetes mellitus	52	51.0			36	38.7			
PVD	50	49.0			57	61.3			
Smoking habit									0.849†
Still smoker	26	25.5			26	28.0			
Give up smoking	52	51.0			48	51.6			
Non-smoker	24	23.5			19	20.4			
Ambulation level									0.031†
Dependent at home	20	19.6			8	8.6			
Dependent outside	35	34.3			27	29.0			
Independent	47	46.1			58	62.4			
Comorbidity									
Hypertension									0.535†
-	9	8.8			6	6.5			
+	93	91.2			87	93.5			
Diabetes mellitus									0.865†
-	22	21.6			21	22.6			
+	80	78.4			72	77.4			
Coronary artery disease									0.000†
-	32	31.4			8	8.6			
+	70	68.6			85	91.4			
Heart failure									0.010†
-	91	89.2			70	75.3			
+	11	10.8			23	24.7			
Complication									
Stump revision									0.289†
-	88	86.3			75	80.6			
+	14	13.7			18	19.4			
Stump infection									0.296†
-	86	84.3			73	78.5			
+	16	15.7			20	21.5			
Phantom limb pain									0.591†
-	62	60.8			60	64.5			
+	40	39.2			33	35.5			
Residual limb pain									0.436†
-	86	84.3			82	88.2			
+	16	15.7			11	11.8			

SD: Standard deviation; BBS: Berg Balance Scale; TAPES: Trinity Amputation and Prosthesis Experience Scales; NEADLS: Nottingham Extended Activities of Daily Living Scale; PVD: Peripheral vascular disease; * Mann-Whitney U test; † Chi-square test.

TABLE 4
Regression analysis results

	Berg Balance Scale		TAPES		NEADLS	
Variables	Correlation (R)	R Square (R^2)	Correlation (R)	R Square (R^2)	Correlation (R)	R Square (R^2)
Age	0.3440	0.1183	0.3710	0.1376	0.3880	0.1506
Sex	0.0506	0.0025	0.0918	0.0084	0.1047	0.0109
Amputation level	0.3214	0.1033	0.2740	0.0750	0.3312	0.1097

TAPES: The Trinity Amputation and Prosthesis Experience Scales; NEADLS: Nottingham Extended Activities of Daily Living Scale.

length of hospital stay, BBS, TAPES, NEADLS scores, and ambulation level were similar in both sexes (p>0.05). There was no significant difference between male and female patients in terms of prosthesis and amputation adaptation, physical balance, and activities of daily living. However, amputation due to DM was higher in women, whereas amputation due to PVD was higher in men (p<0.001). Smoking and coronary artery disease (CAD) were more frequent in males (p<0.001 and p<0.001, respectively). Stump revision and phantom limb pain did not significantly differ in both sexes (p>0.05). However, stump infections and residual limb pain were found to be higher in women (p=0.002 and p=0.003, respectively) (Table 2).

In the ≥65 years age group, the length of hospital stay, DM and CAD were higher (p=0.041, p<0.001, and p=0.012, respectively). In addition, the BBS, TAPES and NEADLS scores were lower in this age group (p<0.001, p<0.001, and p<0.001, respectively). Prosthesis and amputation adaptation, physical balance, and daily living activities were also worse in these patients. Similarly, the independent ambulation in the ≥65 years age group was significantly lower than the <65 years age group (p=0.007). Stump revision, stump infection, and residual limb pain were similar in both age groups (p>0.05). However, smoking and phantom pain were higher in the <65 years age group (p=0.004 and p=0.023, respectively) (Table 2).

Age, sex, BMI, amputation side, etiology, smoking, and length of hospital stay were similar between both groups (p>0.05). There was a significant difference between the TF and TT amputation groups according to the ambulation level (p=0.031). The TF amputees had lower BBS, TAPES, and NEADLS scores than the TT amputees (p=0.009, p=0.020, and p=0.004, respectively). Prosthesis and amputation adaptation, physical balance, and daily living activities were also worse in the TF amputees. Coronary artery disease and heart failure (HF) were less common in the TT amputees (p<0.001 and p=0.010, respectively). Stump revision, stump infection, phantom limb pain, and residual limb pain did not significantly differ between the TF and TT amputation groups (p>0.05) (Table 3).

In male patients, each unit increase of the TAPES score increased the functional independence scale by 0.336 units (95% CI: 0.245-0.427). Each unit increase of the BBS score increased the functional independence scale by 0.473 units (95% CI: 0.314-0.631). Each unit increase in the length of hospital stay increased the functional independence scale by 0.080 units (95% CI: 0.010-0.151) and each unit increase of BMI increased the functional independence scale by 0.554 units (95% CI: 0.224-0.885). In female patients, the increase of the TAPES score by one unit increased the functional independence scale by 0.226 units (95% CI: 0.119-0.333) and each unit increase of the BBS score increased the functional independence scale by 0.664 units (95% CI: 0.464-0.864) (Table 4).

DISCUSSION

Although amputation is a protective surgery, it disrupts the body image and causes major changes in the life of patients. A large number of factors are known to cause difficulties in mobility, personal care, and overall quality of life.[16] In addition, LLA remarkably affects the professional performance and other events by changing the patient's psychosocial status. Preoperative factors associated with the inability to wear prostheses for mobility include the presence of DM, inability to walk before amputation, TF amputation, and age above 60 years.[11] The most affected function is walking, particularly in different terrains and slopes.[6] Therefore, the main goal after LLA is to restore the independent prosthetic walking and to ensure that the patients return to their former activities with optimal efficiency and comfort.[17] The most important findings of this study are that adaptation to prosthesis and amputation, physical balance, and daily living activities are worse in the ≥65 years age group and TF amputees.

Lower limb amputations are common in males and in those aged 50 to 70 years.[18] In the current study, amputations were more frequent in males and after the sixth decade of life. Singh et al.[19] reported that prosthetic rehabilitation rarely succeeded in women compared to men, while Frlan-Vrgoč et al.[20] found no significant difference in walking ability between males and females. Although the ambulation level was higher in males in our study, there was no statistically significant difference between two sexes. Amputation level, stump length, and age of the patient directly affect the outcomes.[21] Knežević et al.[6] found that the overall health and physical function subscale scores of the Short Form-36 (SF-36) were significantly higher in TT amputees than in TF amputees. This difference is due to the fact that, in the TT amputees, prosthetic walking energy transfer is lower than TF amputees. Therefore, TT amputees are much more mobile than TF amputees.[22] In our study, it is noteworthy that independent ambulation was worse in TF amputees and patients over 65 years old. Since the stump length was unable to be assessed in the present study, no interest was found in the results. In their study, Gailey et al.[23] found that the prosthesis satisfaction increased, as age decreased. Yilmaz et al.[24] also found a significant relationship between age and prosthesis satisfaction and that prosthesis satisfaction decreased with increasing age. In older amputees, frequent comorbidities such as DM or cardiopulmonary disease may affect the prosthesis adjustment.[24]

In a previous study, only physical balance ability was found to be a significant predictor of prosthetic use and walking ability.[22] Balance disorders play an important role in these factors which limit prosthesis walking. Indeed, LLA causes a deficit in proprioceptive information that normally interacts with the vestibular, visual, and somatosensory regulation systems.[17] In our study, there was no significant correlation between the physical balance and sex in amputees. However, physical balance scores, prosthesis satisfaction, and daily living activities were significantly better in patients under 65 years and TT amputees. Not only physical balance ability, but also age, amputation level, and comorbidities are influential in walking ability. Hogg et al.[25] attributed the cause of poor scores of the SF-36 questionnaire to the limitations arising from comorbid diseases in the LLAs. In our study, there was a significant difference between age, sex, amputation level, and comorbid diseases, although the relationship between the physical balance score, prosthesis satisfaction, daily living activities and comorbid diseases was not investigated. However, CAD was significantly higher in men, in the ≥65 years age group, and in TF amputees, while DM was significantly higher in women and in the ≥65 years age group and HF was significantly higher in the TF amputees. On the other hand, Hirsh et al.[26] found no significant difference in pain severity between the two sexes. However, in the current study, both residual limb pain and stump infection were significantly higher in women. Although the physical balance score, prosthesis satisfaction, and daily living activities were better in the <65 age group, the phantom limb pain was significantly higher than the ≥65 years age group. There was no significant relationship between the amputation level and complications.

Limitations of the present study include the lack of analysis of the effects of complications on outcomes and the wide age range. The strengths of the study are the analysis of the subgroups with homogeneous demographic characteristics, and synchronous evaluation of three parameters; i.e., physical balance, prosthesis satisfaction, and daily living activities.

In conclusion, our study results showed that the age and amputation level had an effect on physical balance, prosthesis satisfaction, and daily living activities after the non-traumatic LLA, although sex did not significantly affect these parameters. Based on these results, orthopedic surgeons and physiatrists should conduct a multidisciplinary evaluation, particularly in patients aged 65 years and TF amputees to improve outcomes.

Declaration of conflicting interests

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