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Treadmill versus overground gait training in patients with lower limb burn injury: A matched control study

Özden Özkal [a,*], Kemal Kısmet [b], Ali Konan [c], Mutlu Hayran [d], Semra Topuz [e]

[a] Bursa Uludağ University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Bursa, Turkey
[b] Selçuk University, Faculty of Nursing, Konya, Turkey
[c] Hacettepe University School of Medicine, Department of General Surgery, Clinic of Burn, Ankara, Turkey
[d] Hacettepe University Cancer Institute, Department of Preventive Oncology, Ankara, Turkey
[e] Hacettepe University, Faculty of Physical Therapy and Rehabilitation, Ankara, Turkey

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ABSTRACT

Introduction: Gait impairment is commonly seen in patients with a lower limb burn injury (LLBI). Therefore, the aim of this study was to investigate the effects of two different gait training modes on gait symmetry, functional mobility and kinesiophobia in patients with LLBI.
Methods: This matched control study was conducted between January 2017 and August 2018. Patients with LLBI (n=28) were allocated to 2 different groups by matching according to burn localization, age, and gender. Group 1 (overground group: n=14) received overground gait training in addition to standard burn rehabilitation, and Group 2 (treadmill group: n=14) received treadmill gait training in addition to standard burn rehabilitation. The rehabilitation program and gait training were started when the patient was admitted to the hospital and ended on discharge. These physical therapy interventions were performed 5 days per week. The gait training intensity, including walking speed and duration, was determined according to patient tolerance. Gait parameters, functional mobility, kinesiophobia and pain values were evaluated with GAITRite, the timed up-and-go test (TUG), Tampa Kinesiophobia Scale and Visual Analogue Scale, respectively. These evaluations were made twice; on admission and immediately prior to discharge. Gait symmetry was calculated using the Symmetry Index.
Results: The baseline characteristics of the groups and initial outcome values were similar. In the comparison of the differences between the overground and treadmill groups, the change in kinesiophobia and TUG values were significantly higher in the treadmill group (p=0.01, p=0.02, respectively). The intragroup comparisons showed significant differences in SI in respect of step length (p=0.004), swing (p=0.006), stance (p=0.008) and velocity (p=0.001), cadence (p=0.001), TUG (p=0.001), kinesiophobia (p=0.001) and pain (p=0.001) in the overground group. Statistically significant differences were determined in step length (p=0.01), swing (p=0.01), stance (p=0.02) and velocity (p=0.001), cadence (p=0.001), TUG (p=0.001), kinesiophobia (p=0.001) and pain (p=0.001) in the treadmill group, when pre and post-training values were compared.

* *Corresponding author at*: Bursa Uludağ University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, 16059 Bursa, Turkey.
E-mail address: ozdenozkal@gmail.com (Ö. Özkal).
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Conclusions: The results of this study have shown that treadmill gait training was more effective in the improvement of functional mobility and reduction in kinesiophobia levels of patients with LLBI compared to overground gait training. Both overground and treadmill gait training also provide greater improvements in the velocity and cadence, and gait symmetry for step length, swing and stance in patients with LLBI.
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1. Introduction

Severe pain, limited lower limb joint range of motion (ROM), muscle loss and fear of movement generally occur following a lower limb burn injury (LLBI) [1,2]. These clinical complications of the LLBI may cause impairments in gait parameters such as velocity/cadence, step length, and stance time [1,2]. Patients with LLBI have been reported to have slower gait speed, wider base support, and decreased stance time on the burned side and decreased step length compared to healthy subjects because of pain and kinesiophobia [3]. For those LLBI patients, early rehabilitation programs involving gait training focus on restoration of walking ability and improving balance, and functional mobility in daily living tasks [4]. There is also a consensus that gait symmetry is one of the main goals after injuries involving the lower limbs, as gait asymmetry may lead to further injury caused by extreme dynamic loading on the unaffected side or misalignment [5].

A few studies investigated the effectiveness of different treatment modalities on gait parameters and functional outcomes for adults or children with burn injuries [6,7]. Ebid et al. evaluated the efficacy of isokinetic training on gait parameteres in pediatric burns and demonstrated that isokinetic training had a positive effect on step length, stride length, velocity and cadence [6]. Joo et al. demonstrated that robot-assisted gait training is an effective tool to improve muscle strength compared to conventional training in cases with severe burns [7]. Previous studies which have generally been conducted on neurological conditions have compared the efficacy of overground and treadmill training [8–10]. Those studies reported a significant enhancement in gait speed, stride length and dynamic balance in the treadmill training group [8–10]. Although gait training with treadmill has been shown to provide significant improvements in gait parameters in different conditions [8–10], its effect on gait symmetry, functional mobility and kinesiophobia in isolated LLBI is still unknown. In addition, a few studies that have evaluated robot-assisted gait or isokinetic training after healing or epithelialization have included patients who did not have isolated LLBI. Considering the fact that early rehabilitation programs have increasingly placed emphasis on burns, there have not been sufficient studies investigating the effectiveness of specialized gait training designed for patients with isolated LLBI in the early period of the burn injury.

Therefore, the aim of this study was to demonstrate the effects of overground or treadmill training in addition to the standard burn rehabilitation program, on gait symmetry, functional mobility, kinesiophobia and pain in patients with LLBI in the early period. It was hypothesized that treadmill gait training would lead to similar improvements in gait symmetry and functional mobility and a reduction in kinesiophobia and pain compared with an overground gait training program in patients with LLBI.

2. Methods

This matched control study was conducted in the Burn Care Unit between January 2017 and August 2018. The study protocol was approved by the Research Ethics Committee. All the participants were informed about the study procedure and signed an informed consent form.

2.1. *Participants*

The study included 28 patients, aged 18–50 years, who were admitted to the hospital within 5 days of unilateral or bilateral LLBI and were treated as an inpatient or outpatient. The exclusion criteria were the presence of upper extremity or trunk burn injury, diabetes, pulmonary or cardiac system disorders, a history of lower extremity surgery, or any musculoskeletal, orthopedic or neurological disorders that affected the gait, balance and physical functions.

2.2. *Intervention*

The patients were assigned to an overground group (OG) or treadmill group (TG), with the groups matched according to burn localization, age and gender. In the matching according to the burn localization, the injury area was evaluated in detail. The presence of foot burn, joint involvement of burn injury, the presence of lower or upper leg burn injury, bilateral or unilateral leg burn injury were determined as the criteria of the primary method of assignment to the study treatment groups. In addition to the burn areas, age and gender were taken into consideration when matching the patients. The matching criteria for age was determined as ±5 years. For example, a 27-year-old female with unilateral ankle and foot burn injury was assigned to the OG, while a 30-year-old woman with unilateral ankle and foot burn injury was assigned to the TG.

All participants received a standard burn rehabilitation program comprising ROM exercises, stretching, functional mobility, balance training, mobilization, and daily living activities. The total duration of each session was approximately 45 to 50 min, with the program consisting of 15–20 min of ROM and stretching exercises, 30 min of mobility exercises (functional mobility, mobilization and daily living activities) and balance training. All the patients had a 10–15 min break before the gait training. In addition to the standard burn rehabilitation program, the patients received gait training overground or on the treadmill. These physical therapy interventions were started when the individual was admitted to the hospital and terminated on discharge. All patients were evaluated on admission and discharge. The discharge criteria determined by the physician for all patients were the completion of epithelialization. The standard rehabilitation program and different gait training programs were performed by the same physiotherapist 5 days per week. The personalized overground or treadmill gait training program was planned following gait assessment. The main goal of this gait training program was to rehabilitate gait deviations and to obtain a symmetrical walking pattern. Therefore, individualized verbal commands were given to each patient to restore gait problems and deviations. In the OG, the patients received the training in a 20 m straight corridor. In the TG, patients were trained on the treadmill (Voit Medical 340, 2015 China). Patients in the TG were trained at a speed selected by the patient, which remained fixed throughout each session. In the OG, the patients were trained in a corridor at a self-selected speed during the session. All the patients were encouraged to maintain their walking speed. Walking speed and duration were gradually increased according to patient tolerance at each subsequent session for both groups. Patient tolerance was evaluated with the Modified Borg Scale. When a score of ≥5 on this scale was reached, the gait training was terminated. The duration of gait training and speed of the treadmill were recorded in each session and the number of training sessions was also recorded for each patient.

2.3. *Outcome measures*

Demographic information and burn characteristics including age, gender, weight, height, body mass index (BMI), cause of burn injury, depth of burn, burn localization and total body surface area (TBSA) (TBSA *defined using the palm surface area*) were recorded.

2.4. *Primary outcome measures*

The primary outcome measure was changes in gait symmetry. Gait assessment was made using the GAITRite system (CIR System INC. Clifton, NJ, USA, 07012), which is a portable electronic walkway containing 18,432 pressure-active sensors that record the footprint and calculate the spatiotemporal characteristics of gait [11]. All patients experienced walking on the GAITRite electronic walkway before the assessment. After the trial test, each patient was instructed to walk on the electronic walkway at a self-selected walking speed without shoes or aids. The spatiotemporal parameters obtained using the GAITRite system were as follows: right/left step length, right/left stride length, right/left swing (% gait cycle), right/left stance (% gait cycle), velocity and cadence. The SI was calculated for all bilateral gait parameters.

The following formula was used to calculate the SI:

$$Symmetry\,Index\,(SI) = \frac{|\mathrm{Xburned} - \mathrm{Xintact}|}{0.5 * |\mathrm{Xburned} + \mathrm{Xintact}|} * 100$$

The value of SI=0 equals full symmetry [12]. A 10% cut-off value of SI was accepted as the criterion of pathological gait asymmetry [13]. An acceptable error for SI is 5% in healthy adults [14].

In addition to the GAITRite system, observational gait analysis was applied by the physiotherapist. Patients were asked to walk with their natural gait in a 20 m corridor. Each patient was observed from both the anterior-posterior and lateral sides. Gait deviations were recorded for each patient.

2.5. *Secondary outcome measures*

Secondary outcome measures were changes in functional mobility, kinesiophobia and pain values. Functional mobility was assessed with the timed up-and-go test (TUG). In the TUG test, the time is recorded that the subject takes to stand up from a chair, walk 3 m, return and sit down on the chair again [15]. The TUG test has been previously validated for use with burn injury patients [16]. Kinesiophobia was evaluated with the Turkish version of the Tampa Scale for Kinesiophobia (TSK) [17]. The TSK is a 17-item self-reported questionnaire that measures the fear of re-injury because of movement. Items are scored on a 4-point Likert scale ranging from 1 “strongly disagree” to 4 “strongly agree”. The total scores for TSK range from 17 to 68 [17,18]. The TSK has been validated for use with burn injury patients [19]. Pain intensity was assessed with a visual analogue scale (VAS), ranging from 0 “no pain” to 10 “worst imaginable pain”. The VAS is known to be a reliable tool for the measurement of acute pain [20].

2.6. *Data analysis*

Bilateral gait parameters were recorded as “burned side” and “intact side” according to the burn localization in unilateral LLBI. In cases with bilateral lower limb burns, the limb with the higher burn surface area was recorded as the burned side, and the limb with less burn surface area as the intact side. A burn injury involving a joint was defined as only the burned skin across the joint.

Statistical analysis was performed using IBM SPSS 21.0 software. With the exception of physical characteristics and treatment data, outcomes were presented as median and 25% −75% interquartile range values. Histogram and normality tests were used to determine whether values conformed to normal distribution. The Mann−Whitney *U* test was used for the comparisons of the groups in respect of physical characteristics and treatment data, and pre-post values and the differences between groups. The Wilcoxon signed-rank test was used for comparisons between the limbs for both pre and post-training values and for comparisons of pre-post training values within the groups. A value of $p < 0.05$ was accepted as statistically significant.

Power analysis of the study was calculated Post-Hoc using G*Power Version 3.1.9.6 (Germany) software. First, the impact factors were calculated using group means, standard deviations and population standard deviations. According to this, the power of the study was found to be <80% with the total of 28 participants in the parameters of SI step length, SI stride length, SI swing, SI stance, velocity, cadence and pain, and in the calculations of TUG and kinesiophobia results, the power was >80%. The level of error was determined as $p<0.05$.

3. Results

The OG ($n=14$) and TG ($n=14$) were similar in respect of age, height, weight, BMI, gender and total TBSA. There was no significant difference between the groups in respect of the number of training sessions, duration of gait training in the first and last sessions and total duration of gait training ($p>0.05$) (Table 1). Information about the burn characteristics is shown in Table 1. All patients had 2nd degree deep and superficial burn injury.

When cadence, velocity, SI for step length, stride length, swing and stance, and kinesiophobia level, pain severity and TUG score were compared between OG and TG, there was no statistically significant difference in the pre-training results ($p>0.05$). In the comparisons within the groups of the pre and post-training values, a significant improvement was determined in SI (step length, swing and stance), i.e. reduction in gait asymmetry and increased velocity and cadence in both OG and TG ($p<0.05$). When the secondary outcomes were analysed, both OG and TG showed increased functional mobility (decreased TUG score), and a reduction in kinesiophobia level and pain severity ($p<0.05$) (Tables 2 and 4).

In the comparisons of the actual mean differences of primary gait outcomes (cadence, velocity and gait symmetry for step length, stride length, swing and stance) between OG and TG, the changes in these parameters were similar ($p>0.05$). In terms of the changes in secondary outcomes, the TG had increased functional mobility (decreased TUG score) and decreased kinesiophobia level compared to the OG ($p<0.05$) (Table 3).

When the pre- training outcomes were compared according to burn localization, patients with joint involvement of burn injury had greater gait asymmetry for step length, swing and stance than the patients without joint involvement of burn injury ($p<0.05$) (Table 3).

The number of patients who had asymmetric gait for pre and post training values according to the cut-off value (%10) of pathological gait [13] in terms of SI are presented in Table 5. When the individual pre-training values were examined, most of the patients in both OG and TG had gait asymmetry for step length, swing and stance. The most striking result according to the individual post-training values was that 5 patients in the OG had gait asymmetry for step length, and all the patients in the TG had optimal gait symmetry for step length and stance.

The pre-training observational gait analysis showed that all the patients had slower gait speed. According to the lateral side analysis, the step length of the burned side was longer than that of the intact side. This difference in step length was observed more prominently in 15 patients with unilateral LLBI than in those with bilateral LLBI. In 9 patients with ankle joint

Table 1 – Physical, burn injury characteristics and treatment data of the patients.

		Mean±SD (Minimum–Maximum)		p
		OGN=14	TGN=14	
Physical characteristics	Age (years)	37.00±11.16 (18–50)	33.64±12.39 (18–50)	0.46
	Height (cm)	164.92±12.17 (143–190)	165.71±6.94 (157–179)	0.83
	Weight (kg)	74.14±20.44 (48–122)	67.07±8.09 (55–85)	0.33
	BMI (kg/m^2)	26.93±5.13 (19.49–38.57)	24.37±1.97 (21.48–27.59)	0.10
	Gender (F/M)	10/4	9/5	0.69
Treatment data	Training Session (days)	17.85±9.14 (4–39)	15.71±4.87 (10–27)	0.67
	Duration of gait training in the first session (min)	3.89±1.05 (2–6)	4.08±1.57 (1.15–6)	0.48
	Duration of gait training in the last session (min)	16.75±2.77 (12–20)	16.92±1.84 (15–20)	0.74
	Duration of total gait training (min)	217.21±141.62 (40–557)	170.28±70.08 (101–348)	0.59
	Speed of gait training in the first session (km/h)	–	1.12±0.30 (0.3–1.5)	
	Speed of gait training in the last session (km/h)	–	3.33±0.23 (3.0–3.7)	
Burn injury characteristics	TBSA (%)	4.78±2.57 (2–10)	4.42±2.73 (2–12)	0.64
Cause of burn injury (*n*)	Scald	13	13	
	Chemical	1	1	
Affected extremity (*n*)	Unilateral	7	8	
	Bilateral	7	6	
Affected joint (*n*)	Ankle joint	4	5	
	Knee joint	2	2	

OG: Overground Group, TG: Treadmill Group, TBSA: Total Burn Surface Area, SD: Standard Deviation, BMI: Body-mass index, *n*: number of participants.

Table 2 – Pre-post training spatiotemporal gait parameters and symmetry indexes of the groups.

	Pre-training gait parameters Median (25%–75% IQR)				Symmetry index for gait parameters Pre-training		
	OG		TG		Median (25%-75% IQR)		
	Burned side	Intact side	Burned side	Intact side	OG	TG	*p*
Step Length (cm)	39.31 (27.40–52.07)	32.59 (13.83–45.19)	46.12 (37.44–53.42)	43.09 (31.16–47.09)	24.84 (7.79–81.52)	8.70 (2.85–18.81)	0.06
Stride Length (cm)	70.31 (46.06–99.43)	68.91 (47.02–100.60)	87.64 (75.67–102.18)	85.52 (75.16–99.94)	1.47 (0.29–2.14)	1.34 (0.58–2.30)	0.89
Swing (%)	33.70 (31.20–36.90)	30.90 (20.32–35.32)	37.55 (36.25–40.27)	31.95 (29.15–36.87)	8.60 (4.46–60.83)	17.09 (3.24–22.10)	0.96
Stance (%)	66.30 (63.10–68.80)	69.10(64.67–79.75)	62.80 (59.72–64.00)	68.80 (63.20–70.85)	4.92 (1.68–20.62)	8.34 (1.83–11.42)	0.71
Post-training							p^1 / p^2
Step Length (cm)	53.79 (49.34–57.21)	49.31 (45.85–54.05)	58.79 (55.29–64.43)	58.76 (56.93–64.18)	7.87 (2.05–16.20)	3.69 (1.45–5.58)	0.004* / 0.01*
Stride Length (cm)	105.04 (97.41–111.10)	103.89 (96.73–111.33)	118.24 (112.53–127.69)	116.84 (11.80–128.15)	1.75 (0.71–2.02)	1.13 (0.44–1.84)	0.59 / 0.51
Swing (%)	36.25 (34.37–37.82)	35.40 (34.27–36.62)	38.10 (36.77–38.32)	37.55 (36.05–38.80)	6.48 (2.55–9.68)	3.02 (1.04–5.88)	0.006* / 0.01*
Stance (%)	63.80 (62.17–65.62)	64.60 (63.37–65.72)	61.90 (61.70–63.10)	62.45 (61.20–63.95)	3.65 (1.35–4.92)	1.94 (0.75–3.83)	0.008* / 0.02*

OG: Overground Group, TG: Treadmill Group, IQR: Interquartile Range, *p*: comparison of pre-training symmetry index between OG and TG; p^1: comparison of pre-post training symmetry index in OG; p^2: comparison of pre-post training symmetry index in TG.
* $p<0.05$.

burns, insufficient toe-off was observed which may have resulted from decreased dorsi/plantar flexion. Inadequate/ decreased knee flexion was also determined in the swing phase of the gait cycle, especially in 4 patients with knee joint burn injury. According to the anterior-posterior side observational analysis, it seemed that almost all the patients had increased step widths. A few patients with burn injury involving the medial parts of the upper legs had increased hip abduction when walking. According to the post-training observational gait analysis, all the patients had increased gait speed. The step lengths of the burned and intact limbs were observed to be quite similar to each other. All the patients had decreased step widths. The patients with knee joint injury had knee flexion/extension momentum within normal ranges.

4. Discussion

This is the first study to have investigated the effects of overground versus treadmill gait training in addition to a standard rehabilitation program on gait symmetry, functional mobility, kinesiophobia and pain in patients with LLBI. The results of the study demonstrated that both gait training methods (overground or treadmill) contributed to a symmetrical gait pattern by producing similar improvements in SI of step length, stride length, swing and stance. Both treadmill and overground gait training also showed a similar increase in velocity, cadence and reduction in pain severity. However, treadmill training had the additional benefit of significantly improving functional mobility and reducing kinesiophobia compared with overground training in patients with LLBI. Therefore, the hypothesis of the present study, which was formed to prevent bias, was substantially supported.

The results of several studies that have compared the effects of overground versus treadmill training on gait parameters, and balance or functional outcomes in different diseases have been inconsistent [9,21,22]. Bello et al. demonstrated that treadmill training highlighted a specific effect on the enhancement of balance and stride length in Parkinson's disease [9]. Similarly, Grecco et al. stated that treadmill training was a more effective tool to improve functional balance than overground training in children with cerebral palsy [22]. However, a few studies have reported that treadmill training provided similar improvements in gait parameters (step length, gait speed, stance time), and balance, to those of overground training in different neurological conditions, in line with the results of the present study [10,21]. The use of treadmill training for the restoration of gait pattern has recently increased [10,22]. It has been thought that the rhythmic stimulation, constant speed and moving surface of treadmill training may have contributed to improvements in motor tasks and balance that require specific activation of agonist-antagonist muscles together with antigravity muscles [22]. Treadmill training activates central pattern generators that play a role in ensuring motor patterns, postural control and balance [22]. In a study showing the effectiveness of treadmill training compared to overground training, treadmill training was performed at 50–80% maximal gait speed [22]. However, both the overground and treadmill training used throughout all the sessions in the current study were performed at a low intensity and at an incremental speed

Table 3 – Actual mean differences of main outcomes and pre-training values according to burn localization.

Outcomes	Actual mean difference Median (25%–75% IQR)			Pre-trainingMedian (25%–75% IQR)		
	OG	TG	*p*	Burn injury involving joint	Non-joint burn injury	*p*
SI Step Length	13.87 (4.05–56.51)	3.71 (1.03–16.32)	0.12	25.01 (11.89–59.31)	7.83 (3.69–24.67)	0.03*
SI Stride Length	−0.26 (−1.60 to 1.09)	0.25 (−0.86 to 1.14)	0.46	1.71 (0.70–3.02)	0.67 (0.34–1.60)	0.06
SI Swing	3.48 (1.12–33.21)	8.58 (−0.26 to 18.43)	0.96	19.97 (8.60–76.87)	4.94 (2.19–19.19)	0.01*
SI Stance	1.84 (0.46–11.52)	3.63 (−0.21 to 10.11)	0.96	10.39 (4.92–25.37)	3.12 (1.25–9.15)	0.02*
Velocity (cm/s)	18.87 (8.30–50.60)	40.90 (31.37–67.20)	0.16	66.80 (15.77–74.90)	58.50 (38.10–84.40)	0.38
Cadence (step/min)	11.70 (3.56–35.54)	211.75 (8.92–36.42)	0.43	93.60 (55.80–100.10)	83.70 (66.00–95.70)	0.98
TUG	6.45 (4.57–8.35)	8.05 (6.95–11.00)	0.02*	15.60 (13.45–18.10)	16.90 (14.70–18.90)	0.40
Kinesiophobia	8.00 (5.75–10.00)	13.50 (9.00–20.00)	0.01*	42.00 (36.50–43.50)	43.00 (39.00–46.00)	0.24
Pain	5.50 (5–6.22)	5.75 (5.27–6.40)	0.46	5.30 (5.05–6.25)	5.80 (5.20–6.40)	0.32

OG: Overground Group, TG: Treadmill Group, IQR: Interquartile Range, SI: Symmetry Index, TUG: Timed up and go test.
* $p < 0.05$.

Table 4 – Pre-post training results of velocity, cadence and secondary outcomes.

Outcomes	Pre-training Median (25%–75% IQR)			Post-trainingMedian (25%–75% IQR)			
	OG	TG	*p*	OG	TG	P1	P2
Velocity (cm/s)	40.95 (16.42–77.80)	73.95 (43.72–84.37)	0.19	83.40 (67.25–89.37)	109.70 (101.02–115.62)	0.001*	0.001*
Cadence (step/min)	73.80 (45.30–95.55)	91.75 (73.97–101.82)	0.13	96.10 (85.37–99.27)	110.40 (107.60–113.55)	0.001*	0.001*
TUG	16.35 (14.32–18.47)	15.15 (14.07–18.52)	0.76	9.85 (9.30–10.55)	8.30 (7.87–8.70)	0.001*	0.001*
Kinesiophobia	42.50 (39.25–45.25)	42.00 (38.00–44.50)	0.66	34.00 (26.00–38.00)	26.00 (25.75–28.25)	0.001*	0.001*
Pain	5.50 (5.00–6.22)	5.75 (5.27–6.40)	0.46	0 (0–0)	0 (0–0)	0.001*	0.001*

OG: Overground Group, TG: Treadmill Group, IQR: Interquartile Range, TUG: Timed up and go test, p1: comparison of outcomes in OG, p2: comparison of outcomes in TG.
* $p < 0.05$.

Table 5 – Individual results of gait asymmetry according to cut-off value.

Symmetry index	Pre-training (*n*)		Post-training (*n*)	
	OG	TG	OG	TG
Step length	9	6	5	–
Swing	6	9	3	2
Stance	5	6	1	–

OG: Overground Group, TG: Treadmill Group, *n*: number of patients.

determined by patient tolerance. It would not have been possible to provide the same intensity gait training program for both groups because of the individual differences in pain, kinesiophobia level and burn localization. This may explain the similarity in velocity, cadence and SI of gait parameters between TG and OG. Nevertheless, low intensity treadmill or overground training seems to be sufficient to provide a significant improvement in gait symmetry. Considering the fact that there are burn rehabilitation units without treadmill equipment, the results of this study, which showed that both gait training methods are efficient in obtaining a symmetrical gait pattern in the early period of injury, are important for burn clinicians.

The results of this study also showed that treadmill training was an efficient method to improve functional mobility and reduce kinesiophobia, which can be triggered by pain after a burn injury. Previous studies have emphasized that treadmill training is an effective form of task-oriented training [23,24]. In the current study, the significant improvement in functional mobility in the TG compared to the OG may have resulted from the repetitive practice and gait rhythm which are part of treadmill training. It was also observed that gait training on a treadmill can encourage the patient to resume walking, potentially by improving motivation and mood. Therefore, the kinesiophobia level was positively affected by treadmill training in the present study. In addition, the level of reduction in pain severity was similar in both training groups. The use of analgesic drugs, especially in the early period of injury, may have been a confounding factor in demonstrating the effectiveness of the gait training.

According to the individual results of post-training gait symmetry, all the TG patients had a symmetrical gait pattern in terms of step length, while 5 patients had high SI of step length (>10% for SI is asymmetric [13]). There are known to be some differences between overground and treadmill gait training. On a treadmill, there is less space for walking, repeated steps can be observed more easily and the walking speed can be controlled [25]. According to the current study, the individual difference of SI for step length could have resulted from the width of the walking area of the treadmill, the moving surface and constant speed of the treadmill. Most of the current study patients had step length asymmetry at baseline. Step length is an important part of the gait pattern since a more symmetrical step length leads to reduced energy cost of walking [26]. Therefore, the contribution of treadmill training to the development of step length symmetry is clinically important, although it was based solely on individual results.

According to the pre-training values of the present study, increased step length of the burned side was observed compared to the intact side in both groups. In addition, the patients spent less time in stance phase and more time in swing phase on the burned side. Kinesiophobia resulting from pain can cause patients to avoid putting weight on the affected limb. Silverberg et al. noted that fear of falling, and pain contributed to decreased step length, and stance phase after burn injury [3]. The current study pre-training gait parameters were consistent with the findings of recent studies of orthopedic or neurological disorders affecting unilateral lower limbs in terms of step length, stance and swing phase [21,27]. Pre- training cadence and velocity values have been shown to be different from those of healthy subjects [28]. Pain and kinesiophobia may contribute to decreased velocity and cadence. In addition to pain and kinesiophobia, burn localization is an important factor for gait parameters. Previous studies have reported that when the burn injury included a joint, the gait parameters and physical functions were affected by restricted movements of the joint [3,29]. Similarly in the current study, patients with joint involvement of LLBI had more asymmetric walking for step length, stance and swing phase than the patients without joint involvement of LLBI. Therefore, in the current study, it was important that the number of patients with LLBI involving a joint was similar in both groups to be able to demonstrate the effectiveness of the different gait training methods.

The major limitation of this study was the differences in number and duration of gait training sessions between the groups, which may have affected the results. The criterion for termination of treatment in both groups was defined as the formation of epithelialization. If a standard rehabilitation program (e.g., 4 weeks) had been performed, the wounds of some of the patients would have healed and some could not have healed. Another limitation was the relatively small sample size although comparative studies which have focused on different gait trainings have had similar sample size. It can be considered that a larger sample size is needed to generalize the gait symmetry results observed to be statistically similar between the groups. However, the results of the study showed that it has provided generalizable power results regarding the effectiveness of treadmill training in TUG and kinesophobia values. It can be recommended that future studies of major burn injuries should use a standardized gait training program in terms of intensity.

5. Conclusion

In conclusion, gait training should be included in the rehabilitation program in the early period because gait and functional mobility are affected by lower extremity burns. The current study has shown that both gait training modalities were effective for patients with LLBI as they provided improved gait symmetry and functional mobility in these patients. As there were differences in training time (days, minutes per session), it is not possible to say exactly which gait training is more effective. A treadmill is not available in every burns unit, so overground gait training is an easy and useful method that can be applied to obtain a more symmetrical gait pattern.

Conflict of interest statement

The authors declare no conflicts of interest.

Ethical approval

Hacettepe University Non-interventional Clinical Research Ethics Board. Decision number: GO 16/786-02.

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