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Energy expenditure of transfemoral amputees during floor and treadmill walking with different speeds

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Abstract

Background: Walking energy expenditure (EE), calculated as the percent utilization of the maximal aerobic capacity is little investigated in transfemoral amputees (TFA).

Objectives: Compare the EE of healthy participants (CON) and TFA walking with their respective preferred walking speeds on the Treadmill (T_{PWS}) and on Floor (F_{PWS}).

Study design: Randomized cross-over study.

*Methods: Ox*ygen uptake (VO_2) was measured when walking with the F_{PWS} and T_{PWS}. VO_2max was measured by an incremental treadmill test.

Results: Mean±SD VO_2max of the TFA and CON were 30.6±8.7 and 49.0±14.4 mL kg^{-1} min^{-1} ($p < 0.05$). T_{PWS} for the TFA and CON was 0.89±0.2 and 1.33±0.3 m sec^{-1} ($p < 0.01$). F_{PWS} was 1.22±0.2 and 1.52±0.1 m sec^{-1} ($p < 0.01$). Walking on floor with the F_{PWS}, the EE of the TFA and CON was 54 and 31 % of VO_2max, respectively ($p < 0.01$). Walking on the treadmill with the T_{PWS}, the EE of the TFA and CON was 42 and 29 % of the VO_2max, respectively ($p < 0.05$).

Conclusions: EE is higher for the TFA than the CON, regardless of walking surface. There are minimal differences in EE between treadmill and floor walking for the CON, but large differences for the TFA.

WORD COUNT: 200

Clinical relevance:

During walking, the TFA expend a larger percentage of their maximal aerobic capacity than healthy participants. With a low VO_2max, ordinary activities like walking becomes physically more challenging for the TFA than the CON and this may in turn have a negative effect on the walking range of the TFA.

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Background

Measurements of oxygen uptake and calculations of the energy cost of walking (C_w) is widely used as a tool for evaluating the energy expenditure of prosthetic ambulation [1-5]. Investigating healthy participants, Parvataneni et al.[6] found that at comparable walking speeds, oxygen uptake was higher during treadmill walking compared to floor walking. In contrast, Pearce et al.[7] found that the oxygen uptake of healthy persons during floor walking was higher than during treadmill walking. Other studies [5,10] , however, have found no differences in oxygen uptake when comparing treadmill and floor walking. Thus, the literature is not always in agreement regarding the energy expenditure (EE) of treadmill and floor walking[5,6,7,8]. Treadmill walking is often used during rehabilitation of prosthetic walkers[4], but the question is if this type of walking provides a realistic environment for evaluating prosthetic walking on other surfaces. Thus, it is important to measure the EE of prosthetic ambulation on different surfaces to clarify the usability of treadmills in a therapeutic setting. To our knowledge, only one previous study has actually compared the EE of prosthetic users during both treadmill and floor walking[5]. The unilateral transfemoral amputees in the study of Traballesi et al.[5] were amputated because of vascular diseases, and had in average used their prosthesis for only two months. Thus, their preferred walking speeds on the treadmill and floor were very slow. It is also demonstrated that vascular amputees walk at a substantially higher relative aerobic load (percent of VO_2max) than people amputated because of trauma [9], and consequently, the findings of Traballesi et al.[5] may not be representative for prosthetic users amputated for other reasons than vascular diseases and with long experience as prosthetic walkers. In addition, there is little information about the prosthetic users' subjective rating of physical effort when walking on different surfaces, and how the perception of exertion correspond to the physiological measurements of EE. Consequently, the main objectives of the present study was to investigate the EE of experienced prosthetic walkers and healthy controls walking with their treadmill and floor preferred walking speeds on both the treadmill and the floor. In addition we investigated the association between EE and subjective ratings of perceived exertion in these walking situations.

Methods

Participants

Eight (four females and four males) nonsmoking unilateral transfemoral amputees (TFA) and eight (four females and four males) non-smoking healthy adults (CON), were recruited to the present study. The respective mean ± SD age (yrs.), height (cm), weight (kg) and self-reported physical fitness (1-5 scale) of the TFA and CON group, were: 37.0 ± 10.9 and 39.0 ± 12.3 yrs., 175.5 ± 4.6 and 170.0 ± 7.4 cm, 73.6 ± 10.4 and 72.7 ± 14.2 kg, 2.6 ± 0.5 and 2.6 ± 0.5. The weight of the TFA is including their prosthesis. There were no significant differences in physical characteristics between the TFA and CON group. Characteristics of the TFA participants is given in Table 1.

Inclusion criteria of TFA participants were age between 20 and 60 years, to have a unilateral transfemoral amputation for at least two years for reasons other than vascular diseases. In average, the TFA participants had used their prosthesis for a period of 15.8 years (range 3-39 years). Inclusion criteria of the CON group were to have no orthopedic problems and to have similar weight, height, age, and self-reported physical fitness (SPF) as the TFA. The SPF was evaluated by a five-point Lickert scale (1 = very good, 3 = average, 5 = very poor). Exclusion criteria for both groups was use of medication that could affect heart rate or energy expenditure. All participants were accustomed to treadmill walking. Written informed consent was obtained from all participants, and the study was approved by the Regional Committee for Medical Research Ethics in Norway.

Study design and walking experiments

In the present study, TFA and CON participants walked with their treadmill preferred walking speed (T_{PWS}) and their floor preferred walking speed (F_{PWS}) on both the treadmill and on the floor. In addition to the walking tests, a VO_{2max} test was also conducted. Details on the sequence of the different tests are shown in Table 2. On each testing occasion, the participants were instructed to report to the laboratory in the morning, two hours after eating a standardized low fat breakfast (bread, jam, sliced ham, juice, low fat milk, no coffee or tea) and to avoid exercise and alcohol 24 hours prior to testing.

The floor walking tests were performed with the participants walking along a 40 meter indoor track, while the treadmill walking tests was performed on a calibrated Woodway ELG70 treadmill (Woodway, Weil am Rhein, Germany). On the floor, the walking speed was monitored by an optical gait analysis system (OptoGait, Microgate, Bolzano-Bozen, Italy) to keep the actual walking speed as close as possible to the determined T_{PWS} and F_{PWS}. Verbal instructions like: "walk a little slower/walk a little faster", was given when the participants needed to adjust their walking speed during floor trials. On the treadmill, walking speeds were set by the control display on the treadmill, and all participants walked on the treadmill without any aids and with minimal and only occasional support from the handrails.

$\dot{V}O_{2max}$ testing

The maximal oxygen uptake ($\dot{V}O_{2max}$) test of the TFA group was performed according to a walking protocol with constant speed, but progressively increasing inclinations of the treadmill [8]. During $\dot{V}O_{2max}$ testing, the TFA participants were allowed to have one hand resting lightly on the handrail to assist in keeping balance. The $\dot{V}O_{2max}$ of the CON group was tested with a treadmill running protocol with constant inclination, but progressively increasing treadmill speed [8]. The $\dot{V}O_2$ measurements were considered maximal when the oxygen uptake did not increase > 2 $mL \cdot kg^{-1} \cdot min^{-1}$ (plateau in $\dot{V}O_2$) despite increasing workload and with respiratory exchange ratio (RER) values > 1.05 [10].

Physiological measurements

During both treadmill and floor testing, the participants used a portable breath-by-breath oxygen analyzer (Cortex Metamax 3B, Cortex Biophysik, Germany). Oxygen uptake ($\dot{V}O_2$), lung ventilation (VE), respiratory exchange ratio (RER) and heart rate (HR) was continuously monitored by telemetry in real-time to verify steady state conditions. Each walking interval lasted seven minutes to enable the participants to reach steady state conditions[5] and data reported on physiological measurements are average values over the last two minutes of each walking interval. The oxygen analyzer was calibrated for barometric pressure, gas and volume according to the manufacturer's instructions.

Statistics

Normal distribution of the data was investigated by the Kolomogorov-Smirnov test. Within-group comparisons was analyzed with student t-tests while between group comparisons was analyzed by independent t-tests. The association between the F_{PWS} determined prior to floor and treadmill experiments and the actual floor walking speeds measured by the OptoGait system, were investigated by Pearson's correlation test. The significance level was set at $p < 0.05$. The data were analyzed by the SPSS version 20. Results are presented as means ± standard deviations.

Results

$\dot{V}O_{2max}$

The mean ± SD maximal oxygen uptake of the CON group was 3.58 ± 1.2 L min^{-1} (49.0 ± 14.4 mL kg^{-1} min^{-1}), and significantly higher ($p < 0.05$) than for the TFA group (2.27 ± 0.79 L min^{-1}, 30.6 ± 8.7 mL kg^{-1} min^{-1}).

Percent $\dot{V}O_{2max}$ during walking (Figure 1)

For both the TFA and the CON, the percent utilization of the maximal aerobic capacity (% $\dot{V}O_{2max}$) when walking with the F_{PWS} on the floor was comparable to when walking on the treadmill with the F_{PWS}. Similarly, the % $\dot{V}O_{2max}$ when the TFA and CON were walking with their T_{PWS} on the floor was similar to when walking on the treadmill with this walking speed. Walking on the floor with their F_{PWS}, the TFA utilized a higher percentage of their $\dot{V}O_{2max}$ compared to when walking on the floor with the T_{PWS}, ($p < 0.01$), while for the CON there was a *trend* for higher percentage utilization of the $\dot{V}O_{2max}$ ($p = 0.08$) for the same comparison. Walking on the treadmill with the F_{PWS}, both the TFA and the CON had a higher % $\dot{V}O_{2max}$ compared to treadmill walking with the T_{PWS} (TFA; $p < 0.01$, CON; $p < 0.05$). When walking with the F_{PWS}, the % $\dot{V}O_{2max}$ of the TFA group was increased compared to the CON, both when walking on the floor ($p < 0.01$) and when walking on the treadmill ($p < 0.01$). Correspondingly, when walking with the T_{PWS}, the TFA also had an increased percentage utilization of the VO_2max compared to the CON, both on the treadmill ($p < 0.05$) and on the floor surface ($p < 0.01$). In general, the TFA used about 53 % of their $\dot{V}O_{2max}$ when walking with the F_{PWS}, and about 42 % of their $\dot{V}O_{2max}$ when walking with the T_{PWS-} For the CON, the corresponding values were about 31 % and 27 % of $\dot{V}O_{2max}$, thus a less pronounced difference than for the TFA. When walking at similar walking speeds, different walking surfaces had no effect on the % $\dot{V}O_{2max}$ for either group.

Walking speeds (Table 3)

In average, the TFA T_{PWS} was about 73 % of their F_{PWS}, while for the CON, their T_{PWS} was about 88 % of their F_{PWS}. There was a close correlation between the OptoGait measurements of the F_{PWS} during floor walking and the F_{PWS} determined prior to the floor and treadmill walking experiments (both groups collectively; $r = 0.994$, $p < 0.0001$). In addition, there was a close correlation between the OptoGait measurements of the T_{PWS} when using this speed on the floor and the T_{PWS} set by the treadmill control panel during treadmill walking ($r = 0.998$, $p < 0.001$).

Oxygen uptake during walking (Table 3)

TFA and CON oxygen uptakes was similar when walking at the same absolute speeds on treadmill and floor, hence type of walking surface do not influence energy expenditure when walking speeds are comparable. The oxygen uptake (mL kg^{-1} min^{-1}) of both the TFA and CON was, however, higher when walking on the floor with the F_{PWS} compared to floor walking with the T_{PWS} (TFA; $p < 0.01$, CON; $p < 0.05$). Similarly, when walking on the treadmill, the TFA and CON oxygen uptake was also higher when walking with the F_{PWS} compared to oxygen uptake during treadmill walking with the T_{PWS} (TFA; $p < 0.01$, CON; $p < 0.05$).

Walking economy (Table 3)

The C_w ($mLO_2 \cdot kg^{-1} \cdot m^{-1}$) of the TFA and CON when walking on the floor with their F_{PWS} was similar to the C_w during floor walking with the respective T_{PWS}. For the TFA, when walking on the treadmill with their T_{PWS}, the C_w was higher than when walking on the treadmill with their F_{PWS} ($p < 0.05$). . Compared to the CON, the C_w of the TFA was higher when walking with their F_{PWS} on the floor and on the treadmill (both comparisons; $p < 0.001$). Correspondingly, the TFA also had a higher C_w than the CON when walking with their T_{PWS} the treadmill and the floor (both comparisons; $p < 0.001$). In general, the TFA walking economy was 120-150 % of the CON walking economy.

Ratings of perceived exertion (Table 3)

When walking with the F_{PWS} on the floor, the TFA had a higher rating of perceived exertion (RPE) compared to floor walking with the T_{PWS} ($p < 0.05$). Similarly, during treadmill walking, the TFA had a higher RPE score when walking with the F_{PWS} compared to when walking with the T_{PWS} ($p < 0.05$).

For the CON, the RPE scores were similar both during T_{PWS} and F_{PWS} walking, and in general, the RPE scores of the CON group was little affected by either walking speed or type of surface. When walking with their $F_{PWS,}$ the TFA group had a higher RPE score than the CON group both on floor ($p < 0.01$) and on the treadmill ($p < 0.01$). Similarly, when walking with their T_{PWS}, the TFA also had higher RPE scores than the CON group on floor ($p < 0.05$) and treadmill ($p < 0.05$).

Discussion

Recently, we have documented similar oxygen uptakes of transfemoral amputees and healthy controls when walking on the treadmill with the T_{PWS}[8]. The present results extend these findings, and when walking with the same relative speed (T_{PWS} and F_{PWS}), the TFA and CON had similar oxygen uptakes both during floor and treadmill walking. The $\dot{V}O_2$ of the TFA and CON when walking with their T_{PWS} was about 12-13 mL kg^{-1} min^{-1}, and about 15-16 mL kg^{-1} min^{-1}, when walking with their F_{PWS}. The type of walking surface (floor and treadmill) did not influence $\dot{V}O_2$ measurements. In normal walking the rate of oxygen uptake is dependent on the walking speed [2], and the curve of the energy–speed relation is approximately linear below walking speeds of 1.67 m per second [1]. Thus, the higher $\dot{V}O_2$ of both groups during F_{PWS} walking in the present study, is the result of the faster walking speeds. Relating to this, results from our lab (data not shown) demonstrate that when TFA individuals walk with the same T_{PWS} and F_{PWS} as the CON (i.e. 1.33 and 1.52 m sec^{-1}), the mean ± SD oxygen uptake of the TFA during floor walking increased to 17.8 ± 3.6 and 21.7 ± 6.4 mL kg^{-1} min^{-1}, respectively. Hence, at the same absolute walking speeds as the CON, the oxygen uptake of the TFA is considerably higher than the CON oxygen uptake. In line with this, many studies have shown that prosthetic walkers select a slower preferred walking speed than healthy persons [8,9], even though it is possible for prosthetic walkers to walk at quite fast speeds [11]. Why prosthetic walkers have a slower PWS than able bodied individuals, is less clear, but it is suggested that individuals adopts a "natural" speed of walking that corresponds to a minimal value of the energy expenditure [12], and we are currently investigating this in a follow-up study.

While the rate of oxygen uptake per minute is a common index of the energy expenditure of a physical activity, the walking economy (C_w) is widely used for evaluating the walking *efficiency* during prosthetic ambulation [2,3,5,13,14]. Studies have, however, demonstrated similar oxygen uptake values of lower limb amputees when walking on different surfaces, but with comparable (relative) walking speeds [5,8]. Since the C_w is calculated as the relative oxygen uptake divided by the walking speed, a slow treadmill PWS will ultimately cause a higher oxygen cost value (C_w) on the treadmill compared to floor walking with a faster walking speed [9]. To put this in perspective, if the TFA walked faster than their predetermined PWS, the C_w would probably decline despite an increase in the relative oxygen uptake, and one could then argue that the effort exerted was lower during the faster walking speed. This can be clearly demonstrated by inspecting Table 3. For example, the C_w of the TFA is 0.23 mL kg^{-1} m^{-1} when walking on the treadmill with the T_{PWS}. Walking on the same surface, but with a faster speed (i.e. the F_{PWS}), the oxygen uptake increases, but there is a significant decrease in the C_w from 0.23 to 0.21 ml kg^{-1} m^{-1}, i.e. a better walking economy. Normally, one would conclude that improvements in the walking efficiency would result in less fatigue and less physical exertion. By inspecting the ratings of perceived exertion (RPE) following treadmill and floor walking, it is evident that this is not the case. The faster walking speeds are associated with the higher RPE ratings, but the lower C_w values. For the TFA, walking was rated significantly harder when walking on the treadmill with the F_{PWS} (RPE = 3.0, C_w = 0.21) compared to treadmill walking with the T_{PWS} (RPE = 1.8, C_w = 0.23).

In summary, it may not be correct to judge the physical burden of prosthetic ambulation based on the C_w alone. In our opinion, the C_w is probably best suited for comparing the energy cost of walking before and after an exercise rehabilitation intervention.

Consequently, it is necessary to use other indicators than the C_w for judging the physical effort of prosthetic ambulation, especially if one is to make meaningful comparisons to able bodied people. One way of doing this, is by measuring the maximal aerobic capacity ($\dot{V}O_{2max}$) of the individuals in question, and based on this, one can then calculate the energy expenditure during e.g. walking in percent of the individuals' maximal aerobic capacity (% $\dot{V}O_{2max}$). The $\dot{V}O_{2max}$ is widely accepted as the single best measure of cardiovascular fitness [15], hence using the % $\dot{V}O_{2max}$ as an indicator of the physical burden of ambulation is physiologically speaking, a more meaningful measure of physical effort than the C_w.

Recent studies show that lower limb amputees adapt to a more sedentary lifestyle following the amputation [16], and consequently their aerobic capacity becomes gradually reduced and lower than comparable able bodied individuals [8]. The consequences of physical deconditioning, is that activities like walking becomes physically more challenging as the TFA have to use a larger percentage of their maximal aerobic capacity than healthy persons to perform normal activities of daily life. This is clearly demonstrated by data from the present study. When walking with their T_{PWS}, the TFA used about 42 per cent of their VO_2max (both surfaces), compared to about 54 per cent, when walking with their F_{PWS} (figure 1). In comparison, the CON used only about 27 and 32 % of their $\dot{V}O_{2max}$ when walking at the same relative speeds. Thus, walking with the F_{PWS} is substantially harder for the TFA compared to the CON, even though the CON walk at a faster absolute speed than the TFA. Relating to this, Wezenberg et al.[9] recently measured the VO_2max of both healthy controls, traumatic and vascular lower limb amputees and calculated the participants % $\dot{V}O_{2max}$ during treadmill walking. Wezenberg et al.[9] observed that traumatic lower limb amputees used about 50 % of their $\dot{V}O_{2max}$ during treadmill walking, but since this study did not differentiate between transtibial and transfemoral amputees, we speculate that this figure would be even higher for the transfemoral amputees alone.

The literature is otherwise somewhat limited on this topic, and earlier studies have merely calculated the participants VO_2max based on prediction equations[13,17,18]. Only a few studies have used a graded exercise test to assess the relative aerobic load of prosthetic walking in relation to transfemoral amputees $\dot{V}O_{2max}$ [8,19]. Collectively, the existing literature indicate that healthy above knee amputees in utilize close to 50 percent of their $\dot{V}O_{2max}$ (mean 46 %) during normal walking[8,13,17,18,19, present study], while healthy controls use about 30 per cent of their $\dot{V}O_{2max}$ at comparable walking speeds [8,17,18, present study]. In summary, it is safe to say that transfemoral amputees, tax a larger proportion of their maximal aerobic capacity during ordinary walking than able bodied individuals and this may in turn, have a negative effect on the development of fatigue during sustained walking periods.

Relating to this, it is argued that lower limb amputees need to tolerate an exercise intensity greater than 50 % of their $\dot{V}O_{2max}$ for successful prosthetic ambulation [20]. Since the TFA in the present study used about 54 % of their $\dot{V}O_{2max}$ when walking with their F_{PWS} (1.22 m sec^{-1}), this speed may be close to what can be maintained for longer periods of time. Walking with about the same F_{PWS} as the CON (1.52 m sec^{-1}), the oxygen uptake of the TFA increased to about 22 ml kg^{-1} min^{-1} as previously described (unpublished data). This is equivalent to 73 % of their $\dot{V}O_{2max}$, which probably is well above the lactate threshold of most sedentary transfemoral amputees[17,21,22]. Consequently, traumatic transfemoral amputees have the capacity to walk just as fast as healthy controls, but a walking speed above the lactate threshold of the TFA, would probably not be a sustainable walking speed.

Limitations of the study

One limitation of this study may be that data are collected from a homogenous and relatively small group of healthy transfemoral amputees with no vascular or other diseases, thus the present results may not be representative for other groups of lower limb amputees which is less fit than our sample. As shown by Wezenberg et al.[9] vascular transfemoral amputees may have substantially lower $\dot{V}O_{2max}$ values than the TFA group in this study and TFAs amputated for vascular reasons use an even greater percentage of their $\dot{V}O_{2max}$ during ordinary walking than traumatic lower limb amputees. It remains also to investigate if TFAs with less sophisticated knee components is able change walking speeds as comfortably as the participants in the present study.

Conclusions

The present study has demonstrated that the rate of oxygen uptake, C_w and % $\dot{V}O_{2max}$ is similar for both TFA and CON participants when walking with the same speed on different surfaces. Thus, walking surface *per se* do not influence EE of the CON and TFA when walking with similar relative speeds. Because of faster walking speeds, overground walking is more physically challenging than walking on the treadmill and this must be considered when choosing the model for rehabilitation for lower limb amputees. In addition, the consequences of low $\dot{V}O_{2max}$ is that activities like walking becomes physically more challenging as the TFA have to use a larger percentage of their maximal aerobic capacity than healthy participants to perform normal activities of daily life. Classifying the EE of TFA by calculating the percent utilization of their $\dot{V}O_{2max}$ during walking is a suitable method for judging the physical effort of prosthetic walking.

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Declaration of conflicting interests

The authors declares that there is no conflicts of interest.

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Table 1. Technical aspects of the prostheses and prosthetic use (n = number)

Characteristics	**n**
Left side amputation	5
Right side amputation	3
Microprocessor knee	5
Advanced hydraulic knee	3
ICS or MAS socket	7
Quadrilateral socket	1
Carbon foot	7
Prosthetic foot with hydraulic ankle joint	1

Table 2. Study design

Time, min	**Test day 1**	**Test day 2**
20	Determination of preferred walking speeds (PWS) on treadmill and on floor	-
10	Resting on a chair	Resting on a chair
7	Walking on the treadmill with the T_{PWS}	Walking on floor with the F_{PWS}
2	Resting on a chair	Resting on a chair
7	Walking on the treadmill with the F_{PWS}	Walking on the floor with the T_{PWS}
30	Resting on a chair	-
20	VO_{2max} testing on the treadmill	-

Legend Table 2.

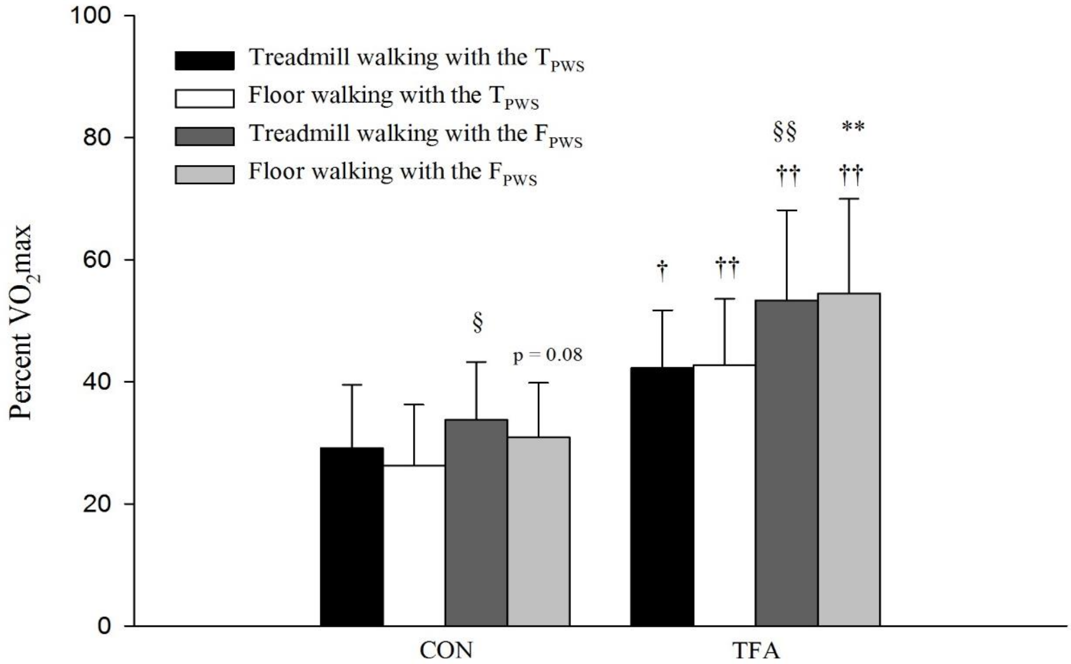
T_{PWS} = preferred walking speed on the treadmill. F_{PWS} = preferred walking speed on the floor. Time (min) = duration of an activity. The sequence of treadmill and floor testing and the sequence of walking speeds within each test day were randomized. For the TFA and CON, the mean time (± SD) between tests were 10 ± 7 and 8 ± 3 days, respectively. The participants were blinded for the actual walking speeds and no verbal feedback of walking speeds was given to the participants during testing.

Table 3. Walking speed, oxygen uptake, walking economy and ratings of perceived exertion during floor and treadmill walking

Speed	**Surface**	**Walking speed** m sec^{-1}		**VO_2** ml kg^{-1} min^{-1}		**Cw** ml kg^{-1} m^{-1}		**RPE** scale 0-10	
		CON	TFA	CON	TFA	CON	TFA	CON	TFA
F_{PWS}	Floor	1.52±0.1	1.22±0.2 ††	14.6±1.9	15.8±3.5	0.15±0.01	0.21±0.04 †††	0.4±0.5	2.2±1.3 ††
	Treadmill	1.52±0.1	1.22±0.2 ††	15.5±2.6	15.6±2.8	0.17±0.02	0.21±0.02 †††	1.1±0.3	3.0±1.4 ††
T_{PWS}	Floor	1.33±0.2 *	0.90±0.2 ***,††	13.2±4.0 *	12.4±1.5 **	0.16±0.02	0.23±0.04 †††	0.4±0.5	1.5±1.2 *,†
	Treadmill	1.33±0.3 §	0.89±0.2 §§§,††	13.4±4.4 §	12.4±2.1	0.17±0.02	0.23±0.03 §, †††	0.5±0.8	1.8±1.3 §, †

Legend Table 3.

Values are means ± SD. PWS = preferred walking speed. T_{PWS} = PWS when walking on the treadmill. F_{PWS} = PWS when walking on the floor. TFA = transfemoral amputees (n = 8), CON = control participants (n = 8). VO_2 = oxygen uptake, C_w = walking economy, RPE = ratings of perceived exertion. RPE were scored immediately at the termination of each walking interval. The reported values of F_{PWS} and T_{PWS} (m sec^{-1}) when walking on the floor are the actual measured values by the OptoGait system, while the F_{PWS} and T_{PWS} values reported during treadmill walking are the values set by the control panel on the treadmill. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$; F_{PWS} on the floor vs. T_{PWS} on the floor. § $p < 0.05$, §§§ $p < 0.001$; F_{PWS} on the treadmill vs. T_{PWS} on the treadmill. $^{†}p < 0.05$, $^{††}p < 0.01$, ††† $p < 0.001$; TFA vs. CON.



Legend Figure 1.

Values are means ± SD. PWS = preferred walking speed. F_{PWS} = PWS when walking on the floor, T_{PWS} = PWS when walking on the treadmill. TFA = transfemoral amputees (n = 8), CON = control participants (n = 8). $^{**}p < 0.01$; F_{PWS} on the floor vs. T_{PWS} on the floor. § $p < 0.05$, §§ $p < 0.01$; F_{PWS} on the treadmill vs. T_{PWS} on the treadmill. TFA vs. CON; $^{†}p < 0.05$, $^{††}p < 0.01$. For the CON, there was a was a *trend* for higher percentage utilization of the VO_2max during floor walking with the FPWS compared to floor walking with the T_{PWS} ($p = 0.08$).