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RESEARCH ARTICLE

Gait Imbalances of Middle-Aged Sedentary Populations

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Abstract

Walking is the first locomotor movement developed by humans after reflexive movements and balancing processes. This study aimed to evaluate walking patterns of middle-aged individuals who lead a sedentary life and to compare gait parameters in terms of gender and body mass index. This study contained eighty-four voluntarily participants (30.00±6.94 years; 74.02±15.44 kg; 170.23±8.94 cm). All participants were sedentary individuals who had not undergone any lower extremity surgery, did not use any movement system medication. Height was assessed by using a wall-mounted stadiometer. Weight was assesed by using Tanita TBF-300. Gait Analysis were performed by Microgate Optogait. All tests were carried out in the same air-conditioned lab which was set to 20°C and 1890 m altitude. Gait parameters were directly provided from Microgate Optogait. The differences between women and men, fat and normal weight were determined using an analysis of variance with Independent T test. All the data were shown as mean and standard deviation. In statistical analysis, the level of significance was chosen as $p<0.05$. There was no significantly difference, when gait parameters values was compared according to gender and BMI ($p>0.05$) in all parameters. There was just significantly difference contact phase and propulsive phase according to gender and double support phase according to BMI. There was also bilaterally difference contact phase, the overweights had more imbalance and interestingly in favor of the non-dominant limb. The mean values of the gait values obtained were similarly the norm values of healthy middle-aged individuals.

Keywords
Walking, Adults, Imbalance

INTRODUCTION

Walking is the first locomotor movement developed by humans after reflexive movements and balancing processes (Viswakumar et al., 2019). Generally, walking forms the basis of many other movements (Baker et al., 2016). All voluntary movements, including walking, are the result of a complex process involving the brain, spinal cord, peripheral nerves, muscles, bones, and joints (Chambers and Sutherland, 2002).

Walking is a movement in which many joints work in a complex way, especially the hip, knee and ankle joints. Therefore, it is very important to establish and use the correct walking form (Chambers and Sutherland, 2002). In gait analysis, the gait cycle and its stages are used (Silva and Stergiou, 2020; Stergiou, 2020). The walking cycle starts with the first touch of one foot to the ground and ends with the second touch of the same foot to the ground (Viswakumar et al., 2019). In other words, two steps are considered as a walking cycle (Baker et al., 2009). The walking cycle consists of eight phases. Five of these eight phases are stance/support and three are swing phases (Whittle,

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2014). The stance includes the initial contact, loading response, mid-stance, terminal stance and pre-swing phases. The stance phases generates 62% of the gait cycle. The swing phase includes initial swing, mid-swing, and terminal-swing phases. The swing phases generates 38% of the walking cycle. When this eight-phase cycle is completed, the walking cycle is completed (Chambers and Sutherland, 2002; Silva and Stergiou, 2020; Whittle, 2014).

Gait analysis has been researched by scientists since the late 20th century. Much more information and analysis methods have been developed in the last years, especially depending on technological developments (Bahureksa et al., 2016; Buckley et al., 2019; Chen et al., 2016). With these analyzes, gait kinematics and kinetics became much more evident (Rozumalski and Schwartz, 2011). Screening for excessive atypical movement patterns during walking can help facilitate effective clinical interventions and prevent injury. On the other hand, energy efficiency can be achieved with gait analysis. At the same time, since walking is the basis of all motor movements, it can directly affect the performance of other movements. The study of gait analysis aims to quantify the factors that the functionality of the lower limbs (Khera and Kumar, 2020). This is crucial for detecting gait abnormalities, recognizing postural imbalances, and evaluating clinical interventions and rehabilitation programs. When the literature is examined, analyzes related to walking have been carried out in many different disease groups and athletes (Buckley et al., 2019; Carter et al., 2017; Chang et al., 2010; Kirmizi et al., 2019). However, studies on sedentary groups are limited. It is known that the sedentary lifestyle weakens the movement systems of people and is among the causes of many chronic fatal diseases (Booth and Chakravarthy, 2002; Carter et al., 2017; Mainous III et al., 2019). When considered from this point of view, it is possible that walking, which is the most basic motor movement, may be a factor that prevents sedentary individuals from moving. It is known that limited walking and/or abnormalities that occur during walking cause different joint and muscle diseases (Brunner & Romkes, 2008). It is also likely that the degrees of physical dysfunction will increase and tend to further restrict walking. For this reason, it is important to perform gait analyzes of sedentary individuals and to reveal abnormalities.

In this context, the aim of the study is to compare gait parameters of middle-aged individuals who lead a sedentary life and to present imbalances. We also purposed to compare gait parameters in terms of gender and body mass index.

MATERIALS AND METHODS

Subjects

This study contained eighty-four voluntarily participants (30.00±6.94 years; 74.02±15.44 kg; 170.23±8.94 cm; 25.47±4.81 kg/m2). All participants were sedentary individuals who had not undergone any lower extremity surgery, did not use any movement system medication. After the participants were determined, we informed the participants about the study. All tests were conducted according to the principles expressed in the Declaration of Helsinki.

Experimental Approach to the Problem

All participants were tested under the same conditions on a flat ground. Participants visited just once laboratuvary for measurement. When participants visited laboratuvary, we informed them about the tests. The height and weight measurements were firstly conducted. Each participant completed a gait analysis protocol. All tests were carried out in the same air-conditioned lab which was set to 20°C and 1890 m altitude in Erzurum. Participants were asked to refrain from physical activity, caffeine and alcohol in the twenty-four hours prior to trials. All participants applied a familiarisation session prior to trials.

Instruments

1. Gait Analysis were performed by Microgate Optogait (Optogait, Microgate, Bolzano, Italy).
2. Height was assessed by using a wall-mounted stadiometer (Seca Stadiometer 282, Seca GmBH & Co Kg, Hamburg, Germany).
3. Weight was assesed by using Tanita TBF-300 (TANITA, Middlesex, UK).

Procedure

All tests were conducted at Ataturk University Sport Sciences Application and Researh Center. Height measurements were performed bare feet on a flat platform in an anatomical position. In body weight measurements, the participants only wore running shorts. Before starting to walk, participants were asked to walk at a normal walking pace. The gait analysis with optogait was performed with walking shoes on the flat ground. The ten-meter optogait was used for walking. Participants performed gait analysis measurement, starting with the right foot.

Statistical Analyses

Optogait data were sampled at 1000 Hz and processed into 1D footfall patterns using dedicated software (Optogait Next, Version 1.3.20.0, Microgate, Bolzano, Italy). The Statistical Package for the Social Sciences version 25.0 (IBM Corp, Chicago, IL, USA) was used to analyze the obtained datas. Normality and sphericity tests were done using Kolmogorov-Smirnov and Mauchly's test, respectively. Descriptive statistics include mean ($\bar{X}$) and SDs. Independent t-test was used for pairwise comparisons. In all analyzes of the data, the significance level was accepted as $p<0.05$.

RESULTS

In this section, the results obtained from the research are shown in tables. Comparisons were made according to the participants' gender and body mass index.

Table 1. Gait parameters averages and bilateral differences of all participants

	Min.	Max.	$\bar{X}$	SDs.
TCont_Avg	0.53	0.96	0.72	0.07
TCont_L_R	-16.90	10.90	-2.21	3.06
Speed_Avg	0.72	1.97	1.25	0.18
Speed_L_R	-2.10	2.90	0.81	0.86
Step_Avg	53.10	83.20	69.16	6.05
Step_L_R	-4.60	6.60	0.53	2.58
Stride_Avg	106.50	167.20	138.81	12.12
Stride_L_R	-2.10	0.80	-0.45	0.62
DoubleSup_Avg	0.17	0.46	0.30	0.06
DoubleSup_L_R	-2.00	17.40	1.60	2.19
StepTime_Avg	0.31	0.75	0.56	0.05
StepTime_L_R	-4.50	26.10	2.49	3.67
ContactPhase_Avg	0.04	0.94	0.09	0.09
ContactPhase_L_R	-107.90	58.00	-3.78	30.90
Footflat_Avg	0.25	0.63	0.42	0.07
Footflat_L_R	-24.10	20.10	-3.27	9.84
PropulsivePhase_Avg	0.15	0.35	0.21	0.03
PropulsivePhase_L_R	-58.60	24.00	-3.07	15.14

Table 2. and Table 3. show comparisons of gait parameters in terms of gender and body mass index. When gait parameters were evaluated in terms of gender, it was determined that there was a significant difference in two parameters. When evaluated in terms of body mass index, it was determined that there was a significant difference between the groups in one parameter.

Table 4. and Table 5. show comparisons of bilateral differences of gait parameters in terms of gender and body mass index. When bilateral differences were evaluated in terms of gender, it was determined that there was no a significant difference in parameters. When evaluated in terms of body mass index, it was determined that there was a significant difference between the groups in one parameter.

Table 2. Gait parameter differences according to gender

Gender (W:40 M:44)		X̄± SDs.	t	p
TCont_Avg (sn)	*W*	0.71±0.07	-1.548	0.12
	M	0.73±0.07		
Speed_Avg (sn)	*W*	1.26±0.18	0.127	0.89
	M	1.25±0.18		
Step Avg (cm)	*W*	68.47±5.75	-0.991	0.32
	M	69.78±6.31		
Stride_Avg (cm)	*W*	137.40±11.51	-1.015	0.31
	M	140.09±12.64		
DoubleSup_Avg (sn)	*W*	0.29±0.05	-2.328	**0.02***
	M	0.32±0.06		
StepTime_Avg (sn)	*W*	0.55±0.06	-1.636	0.10
	M	0.57±0.04		
ContactPhase_Avg (sn)	*W*	0.10±0.13	1.045	0.22
	M	0.08±0.02		
Footflat_Avg (sn)	*W*	0.42±0.07	-0.368	0.71
	M	0.42±0.07		
PropulsivePhase_Avg (sn)	*W*	0.20±0.03	-2.402	**0.01***
	M	0.22±0.04		

*there was difference between the men and women p<0.05 W: Women; M: Men

Table 3. Gait parameter differences according to BMI

BMI (OW: 42 NW: 42)		X̄±SDs.	t	p
TCont_Avg (sn)	*OW*	0.73±0.06	1.414	0.16
	NW	0.71±0.07		
Speed_Avg (sn)	*OW*	1.23±0.15	-.983	0.32
	NW	1.27±0.20		
Step_Avg (cm)	*OW*	68.70±5.34	-0.693	0.49
	NW	69.62±6.72		
Stride_Avg (cm)	*OW*	137.86±10.64	-0.719	0.47
	NW	139.76±13.50		
DoubleSup_Avg (sn)	*OW*	0.32±0.05	2.520	**0.01***
	NW	0.29±0.06		
StepTime_Avg (sn)	*OW*	0.57±0.04	1.036	0.30
	NW	0.55±0.06		
ContactPhase_Avg (sn)	*OW*	0.08±0.02	-1.936	0.57
	NW	0.09±0.13		
Footflat_Avg (sn)	*OW*	0.43±0.07	1.191	0.23
	NW	0.41±0.07		
PropulsivePhase_Avg (sn)	*OW*	0.21±0.03	-0.630	0.53
	NW	0.22±0.04		

*there was difference between the overweight and normal p<0.05. OW: Overweight; NW: Normal Weight.

Table 4. Bilateral differences of gait parameters according to gender

Gender (W:40 M:44)		X̄± SDs.	t	p
TContact	*W*	-2.83±3.13	-1.781	0.79
	M	-1.65±2.92		
Speed	*W*	0.66±0.76	-1.468	0.14
	M	0.94±0.93		
Step	*W*	0.42±2.37	-0.369	0.71
	M	0.63±2.77		
Stride	*W*	-0.38±0.59	0.961	0.33
	M	-0.51±0.64		
Double Sup.	*W*	1.66±1.34	0.258	0.79
	M	1.54±2.76		
StepTime	*W*	2.01±2.67	-1.149	0.25
	M	2.93±4.38		
Contact Phase	*W*	4.26±23.13	1.334	0.22
	M	-11.0±35.26		
Foot flat	*W*	-4.90±10.08	-1.456	0.14
	M	-1.79±9.49		
Propulsive Phase	*W*	-5.25±18.56	-1.261	0.21
	M	-1.09±11.04		

-Negative values mean in favour of left limb

Table 5. Bilateral differences of gait parameters according to BMI

BMI (OW: 42 NW: 42)		X̄±SDs.	t	p
TContact	*OW*	-2.37±2.20	-0.478	0.63
	NW	-2.05±3.75		
Speed	*OW*	0.68±0.88	-1.394	0.16
	NW	0.94±0.83		
Step	*OW*	0.75±2.77	0.772	0.44
	NW	0.31±2.38		
Stride	*OW*	-0.45±0.66	-0.017	0.98
	NW	-0.45±0.58		
Double Sup.	*OW*	1.27±1.36	-1.389	0.16
	NW	1.93±2.77		
StepTime	*OW*	1.79±2.61	-1.766	0.08
	NW	3.19±4.42		
Contact Phase	*OW*	-10.20±33.28	-1.936	**0.04***
	NW	2.64±27.23		
Foot flat	*OW*	-4.39±10.01	-1.043	0.30
	NW	-2.15±9.67		
Propulsive Phase	*OW*	-0.73±14.93	1.426	0.15
	NW	-5.42±15.17		

*there was difference between the overweight and normal p<0.05. -Negative values mean in favour of left limb.

DISCUSSION

The present study conducted to evaluate gait imbalances and to compare gait parameters according to gender and BMI. The nine variables of gait were evaluated in sedentary individuals. We also evaluated gait analysis parameters, bilaterally. There was also no bilateral differences of gait parameters according to gender. But Doublesup. Avg and Propulsive Phase Avg. values had a significantly difference between men and women. The women had shorter time from men both doublesup. avg. and Propulsive Phase avg. values.

Measurement of gait is essential for identifying underlying deficits contributing to gait dysfunction, guiding clinical decisions and measuring rehabilitation outcomes (Patterson et al., 2012). The mean values in the results of the study conducted on healthy Korean individuals by Kim and Yoon (2009) with the mean values of the current study were similar. In another study, it was determined that the length of the step and the stride length of middle-aged individuals were higher than the results of our study (Lencioni et al., 2020). In a study comparing two different analysis systems, walking parameters of middle-aged individuals were compared. Our study showed similarity with the mean values of walking parameters obtained in this study (Healy et al., 2019). In a study by Jayakaran et al. (2014) in which different walking aid interventions were compared, it was stated that the dual support phase showed significant differences bilaterally. Rowe et al. (2021) compared gait patterns in different age groups and reported that when evaluated in terms of gender, women's stance times were shorter than men, and stride length was longer in men than in women. The main reason for this may be that women use their lower extremity joints at more limited angles than men. In the same study, the walking speed results were similar to the results of our study and did not show any difference in terms of gender (Rowe et al., 2021). In another study, researcher found that the men's stride length, vertical displacement, stride duration and length, and walking speed were higher than women, but lower in cadence. In the same study, it was stated that gait imbalances have similar characteristics in men and women (Senden et al., 2009). Similar results have been proven many times in different previous studies. The observation that men walk faster and take bigger steps, while having a lower cadence than women, is commonly reported in many studies using laboratory-based gait analysis systems (Cho et al., 2004; Öberg et al., 1993). Auvinet et al. (2002) reported that there was also a high level of correspondence in gait with the normative data for healthy subjects. Only a slightly higher speed, cadence and a slightly shorter step length for young and older subjects was observed. In addiction, comparing the men gait and the women gait, there were small differences. In a study investigating the gait analysis and asymmetries of individuals with neck pain by Kirmizi et al. (2019), the walking speed, stride length and frequency of the control group were similar to our study.

Andrews et al. (2022) reported that there was no significant difference between the gait speeds of men and women in the 30-39 age range in their systematic view studies on the effect of gender and age on walking speed. Similarly, Hollman et al. (2011) also stated that there was no significant difference in mean walking speed during normal walking in terms of gender. In a study in which walking parameters at different speeds were evaluated in terms of gender and age, it was reported that the men took longer strides, less cadence, and faster strides than women (Yoneyama et al., 2016). Conducted on 25 healthy individuals with volunteers by Jacobs et al., (2021), another study showed the gait stance time and stride length were not similar with results of present study. The main reason for this may be attracted to the lower average age of the sample group of this study. In a the study by Cho et al. (2004), similar results were obtained in our study. It has been reported that men have higher stride lengths and speeds than women. The main reason for this may be that the leg lengths of men are longer and their pelvises are more forward inclined in women. Contrary to this result, Chung and Wang (2010) reported that many of the walking parameters gave similar results in terms of gender and age variables.

When the gait parameters evaluated bilaterally, there was no significantly difference between overweight and normal body weight in all gait parameters except for contact phase. In overweight individuals, the contact phase time of the left side was longer than that of the right side. However, in individuals with normal weight, the contact phase time was in favor of the dominant side at a rate of 2%. Also, DoubleSup. Avg value had differences according to BMI. The doublesup avg. value of overweight was longer than normal weight. Senden et al., (2009) stated that gait imbalances have similar characteristics in men and women. In a study comparing walking parameters on different surfaces, it was stated that the knee and hip joint coordination of individuals walking on different surfaces changed, and this might have an effect on the double support phase, especially on flat surfaces. The reason for the difference in

BMI in current study may be due to the fact that overweight people put more strain on the knee and hip joints on hard floors (Ippersiel et al., 2022). It may also be that they spend more time in the double support phase because they have more fat and they spend more effort. In the study conducted by Lencioni et al., (2020), gait parameters were compared bilaterally and it was determined that the dominant limbs had higher values than the other in the stride length. Fukuchi et al. (2019) stated that walking at low speeds decreases the gait parameters. Gait speed is particularly affected by body composition. This may explain the difference in walking parameters of overweight individuals compared to normal individuals. In another study, Koo and Lee (2016) evaluated the gait parameters in different arm swinging styles and it was stated that there were significant differences in many walking phases according to the arm swinging styles. The absence of a limitation on arm swinging in the current study could be shown as the reason for the differences gender, BMI, bilateral.

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Conflict of Interest

No potential conflict of interest was reported by the authors.

Ethics Committee

(Date: 24.06.2023; Decision number: 2023/06-130). The study was approved by the sub-ethics committee of Atatürk University, Faculty of Sports Sciences. Participants were informed with a written informed consent form.

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Author Contributions

Study Design, HHY, MK; Data Collection, HHY; Statistical Analysis, HHY, MK; Data Interpretation, HHY; Manuscript Preparation, HHY, MK; Literature Search, HHY. Authors have read and agreed to the published version of the manuscript

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