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Gender Differences in Spatio-temporal Parameters of Gait Initiation

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Abstract

Introduction: The aim of the present study was to examine gender differences in spatio-temporal parameters of gait initiation.

Materials and Methods: In this semi-experimental study 26 randomly selected, young participants (13 men and 13 women) took part. To measure the spatio-temporal parameters, motion analysis system (Vicon 460) with five cameras was used in 100 HZ. The subjects were asked to stand comfortably in quiet standing position and, start to walk whenever they wanted. Then, with the use of Excel software, the speed, time, distance, swing time, stance time, double support time, hip, knee and ankle range of motion and finally the COM (center of mass) displacement parameters during gait initiation were calculated. Finally to describe the data, mean and standard deviations were calculated and the independent T-test was used to compare the parameters ($P<0.05$).

Results: Data analysis showed a significant difference between the speed of gait initiation ($p=0.00$) and hip ($p=0.03$) and knee ($p=0.00$) flexion range of motion among men and women.

Discussion and Conclusion: It seems that gender differences can affect the spatio-temporal parameters of gait initiation. However comparing to the similar studies done on the steady state gait (not gait initiation), it can be concluded that gender differences are less obvious in gait initiation compared to steady state gait.

Keywords: Gait Initiation, Gender Difference, Biomechanics

Introduction

Several studies have been reported differences between men and women in anthropometric and biomechanical aspects [1]. Thus, it is likely that gender differences contribute to the differences in the motion patterns of men and women. The gait can be considered as one of the most common transitional movements in humans. It takes about 7-8 years for a child to be able to perform the adults' gait pattern [2]. However different factors can affect this time. These factors are classified as individual, task and environment related factors [3]. Differences in age, physical, sexual and pathological disorders, are among the major individual factors affecting adult gait pattern development. however the effects of these factors depend on the type of motion. For example, studies have reported that women, compared to men, are better in activities requiring coordination [4]. Perhaps it is because women tend to move more slowly than men and they also tend to walk with shorter and slower steps [5].

The first studies on gender differences in spatio-temporal parameters of gait were done in 1964 where Marry et al reported that women, compared to men, have slower speed, shorter step and less movement in the joints of the lower extremities, particularly the knee joint during walking [6, 7]. However, they noted that cadence is greater in women. Moreover Kerrigan and et al (2000) studied the joint torque in men and women during walking and reported that women generate less torque in the knee joint [8]. Limited research on the effects of gender differences on gait initiation pattern was the most important reason of

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performing the present study.

Gait initiation is known as the transition from quiet standing situation to steady state gait [9]. This period involves all the activities that occur between swing limb heel-off and stance limb toe-off [9]. The complete collaboration of both the anterior-posterior and media-lateral muscle groups are never more evident in the initiation of gait. Going from a very stable balance condition during quiet standing to a steady state gait in about two steps requires coordination of the A/P muscles(plantar flexors/dorsiflexors) and M/L control(hip abductors/ adductors). The goal of these motor patterns during gait initiation is to change the quiet standing pattern to the steady state COP(center of pressure) and COM (center of mass) pattern [10]. On the other hand, in the gait initiation, these muscles make the COP move posteriorly and laterally toward the swing limb and move the COM in the invert direction, forward and towards the stance limb [11]. This kinematic pattern of COM and COP create a dorsiflexor torque in ankle joint that finally pull the leg toward the dorsal surface of the foot [11]. This action helps the swing limb heel off that is the starting point of gait initiation [10].

The first study on the effect of gender differences on gait initiation pattern was carried out by Nissan et al (1966), [12]. In this study, they reported that gender differences can affect the production of ground reaction force in medio-lateral and vertical direction and the leg (right and left) that leaves the ground in gait initiation. In addition, women tend to be slower in the weight shifting from the swing leg at the start of gait initiation. Due to the lack of similar studies in this regards, the purpose of this study was to investigate the role of gender differences in spatio-temporal parameters during gait initiation.

Material and Methods

This is a semi-experimental study in which 26 participants (13 men 13 women) volunteered to take part (table1). All the participants filled out a consent form, regularly exercised at least twice a week and had no history of injury especially in the lower extremity.

Table 1: Characteristics of participants

Gender	**Age**(year)	**Weight**(k.gr)	**Height**(c.m)	**Body mass index**(kgr.m2)
men	23.3±3.1	68.9±7	175±13	22.4±1.8
women	21.8±1	61.5±9	164±9	22.6±2.8

At first all the participants were led to a laboratory and the test was explained to them in details. Then after settling comfortably in the quiet standing position (in this position body weight is divided equally on both limbs) they were asked to perform gait initiation three times.

In this study, gender was considered as the independent variable and the dependent factors included gait initiation time(the time between the swing limb heel-off and stance limb toe-off), distance (the length of the first step taken at the gait initiation), speed, swing time(the time between swing leg toe-off and heel-contact in same foot), stance time(the time between the swing leg heel contact and toe-off in the same foot), double support time(the time that both limb are placed on land), hip, knee and ankle range of motion and finally the COM displacement in frontal and vertical plane. In order to measure the spatio-temporal parameters, motion analysis system (Vicon 460) with five cameras was used in 100 HZ. In addition, the modified Helen Hayes marker placement model was used to track the movement of the whole body during four steps (13).

After completion of the test performance, the best and the most complete trial of each participant was selected and processed. Following the completion of the data processing, the data were analyses using SPSS (version16.0). "kolmogrov-smirnov test was applied to check the normality of the distribution of the measured variables. To describe the data, mean and standard deviations were calculated and to compare the parameters, the independent T-test was used (P<0.05).

Results

The results of the Independent t-test presented in Table 2, show that gender does not have a significant effect on the measured variables, except for the gait initiation speed (p = 0.005)., In other words, gait initiation speed was 16.9% higher in women compared to men where men and women initiated the gait with an average speed of 0.73 and 0.87 Meters per second respectively. In addition, women have recorded higher values in the distance variable (6.4%) and also in the stance time (9.3%) but these differences were not significant.

Table2: Independent t-test results for some spatio-temporal parameters of gait initiation.

Variable	**Gender**	**Mean**(S.D)	**T**	**Df**	**Sig**
Distance (millimeter)	men	520.5(75)	1.5	24	0.14
	women	556.2(39)			
Time (second)	men	.70(.06)	1.8	24	0.8
	women	.64(.09)			
Speed (meters per second)	men	.73(.1)	3.6	24	0.005
	women	.87(.13)			
Swing time (second)	men	.45(.04)	1.06	24	0.29
	women	.43(.04)			
Stance time (second)	men	.76(.04)	.55	24	0.58
	women	.77(.05)			
Double support time (second)	men	.12(.03)	.75	24	0.45
	women	.11(.03)			

The results of the hip (flexion), knee (flexion) and ankle (plantar flexion and dorsiflexion) joints range of motion in both men and women are presented in Table 3. According to these results, hip (p = 0.02) and knee flexion (p = 0.00) have been significantly affected by the gender difference.

Table3: Independent t-test results for hip, knee and ankle range of motion (degree).

Variable	Gender	Mean(S.D)	T	Df	Sig
Hip (flexion)	men	25.5(2.3)	2.3	24	0.02
	women	28.9(4.3)			
Knee (flexion)	men	29(5)	6.3	24	0.00
	women	42.3(5.6)			
Ankle (plantarflexion)	men	4.3(3.6)	.290	24	0.77
	women	4.7(1.9)			
Ankle (dorsiflexion)	men	13.7(3.5)	.86	24	0.89
	women	12.6(3.1)			

Finally independent t-test results, presented in Table 4, show that gender does not have a significant impact on the COM displacement in the frontal and vertical plane. The displacement of the body's center of mass in the frontal plane had an equal value in both men and women (6.2 cm) but in the vertical plane these values were 2.7 and 3.5 centimeter in men and women respectively.

Table4: Independent t-test results for medio-lateral and vertical COM displacement (centimeter).

Variable	Gender	Mean(S.D)	T	Df	Sig
Medio-lateral	men	6.2(1.8)	-.01	24	0.98
	women	6.2(1.9)			
Vertical	men	2.7(.6)	-1.9	24	0.06
	women	3.5(1.3)			

Discussion and Conclusion

The aim of the present study was to investigate of gender differences in the biomechanical functions of the spatial-temporal parameters in gait initiation. According to the literature, anthropometric and biomechanical differences exist between men and women [1]. As gender affects the Kinematic [14] and kinetic parameters in steady state gait [8], it was also expected to affect the spatio-temporal parameters of gait initiation.

Among the variables examined in Table 2 (distance, time, speed, swing time, stance time and double support time), just the speed of gait initiation was statistically different between the two groups. In other words women walked more quickly during the gait initiation phase. According to the results of similar studies in steady state gait (not gait initiation) women tend to have shorter steps, slower speed and less movement in the joints of the lower limb, especially knee joint [5, 6, 7, 8, and 14]. However, in addition to gait initiation speed, women were also better in the distance and time of gait initiation. That is to say, they covered greater distances (6.4%) in less time (9.3%), which ultimately could lead to a significant difference in speed of gait initiation between the two groups. Nissan and et al (1966) is another related study [12]. In this study Parameters of gait initiation were studied regardless of the gender factor but the results showed that women not only tend to exert less force towards the ground in push off, but also remove the swing leg from the surface in more time. This is inconsistent with our results. Although factors such as anthropometric differences are used in several studies, one of the reasons causing these inconsistencies could be the participants' stress during the research process and the errors related to the researcher.

Another finding of the present study was a significant difference in the hip and knee joint flexion range of motion during gait initiation. where women performed greater flexion (11.7% in hip and 45.8% in knee) compared to men. This finding has also been reported in similar studies on gait initiation [12]. However, the point of maximum hip flexion in both groups was similar (Slightly after the toe- off). It seems that one of the reasons that women cover greater distances compared to men could be the use of greater hip and knee flexion in their movement. This makes the limb cover longer distances during the swing phase. However similar studies on steady state gait have reported that range of motion in lower extremity joints are more limited in women compared to men [14].

Plantar flexion and dorsiflexion were two other motions that were compared in the two groups. The results showed that gender did not have a significant impact on these movements. however Nissan et al (1966) reported that gender differences may affect plantar flexion [12]. Maximum plantar flexion and dorsiflexion showed at the moment of the toe-off and heel contact was similar in both groups.

Finally, the results of the COM displacement showed that the COM displacement in medio-lateral direction was greater than vertical direction. Furthermore according to the results of independent T-test, there was no significant difference in the amount of COM movement between women and men (6.2 cm). However, compared to men, women performed greater joint flexion in the hip (11.7%) and knee (45.8%). As the COM kinematic character is affected by the position of other organs in the body, the researchers expected a greater displacement of center of mass in women compared to men. Different studies have reported an equal center of mass displacement (about 2 inches or 5 cm) in men and women, in both the M/L and vertical direction [15]. In the present study also, no significant difference was observed in the amount of vertical displacement of COM in the two groups. However regarding the mean values, COM displacement was about 0.8 cm greater in women which might be the result of the greater hip and knee flexions in them. Raising the limb is accompanied with the increase of the COM displacement in vertical direction and it could happen when other organs do not cause height reduction.

With regards to these factors we may conclude that gender differences do not significantly affect the displacement of COM in M/L and vertical directions.

Based on the results the present study it can be said that gender differences affect the spatio-temporal parameters in gait initiation. However, according to the results of similar studies on the steady state gait, that examined same variables to the present study, it can be concluded that gender differences are less obvious in gait initiation compared to steady state gait.

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