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# COMPARISION OF KINEMATIC GAIT PARAMETERS IN THE 16-18 YEARS OLD MALE STUDENTS WITH THE FLAT AND NORMAL FOOT

Movahhed Molaei Karandagh<sup>1</sup>, \*Ramin Balochi<sup>2</sup> and Shahram Soheily<sup>3</sup>

<sup>1</sup>Department of Physical Education, Karaj Branch, Islamic Azad University, Karaj, Iran <sup>2</sup>Department of Physical Education and Sport Sciences, University of Allameh Tabataba'i, Tehran, Iran <sup>3</sup>Department of Physical Education and Sport Science, Shahr-e-Qods Branch, Islamic Azad University, Tehran, Iran

\*Author for Correspondence

#### ABSTRACT

Abnormal position of the lower leg effect on motor function, especially among children and adolescents has received less attention. The purpose of this study was to compare the kinematic gait parameters in the 16-18 year-old male students with a flat and normal foot. In doing so, 15 adolescents with the flat foot and 15 with the structure of the normal foot with a mean age of  $16.39 \pm 0.4$  years, mean height of  $172.4 \pm 0.8$ , mean weight of  $70.81 \pm 7.43$  participated in the study using the longitudinal arch middle toe method. To evaluate the kinematic gait parameters, treadmill testing was carried out using the camera and cinematography side view. Kolmogorov-Smirnov test was used to assess the normality assumptions of the statistical data and the Independent t-test was used for data analysis (P $\leq 0/05$ ). The results showed that there was no difference between the stance and swing of a gait cycle between the flat and normal footed-participants and there was no significant difference between gait numbers in both groups. Finally, there was no difference between gait length and walking speed. Based on the results it can be stated that foot deformities may not affect the gait kinematics parameters.

Keywords: Flat Foot, Gait Kinematic Parameters

## **INTRODUCTION**

Walking can be one of the basic activities of life (Winter, 1991). Some structural distortions in the lower extremities cause abnormal movements of the foot in walking, which can negatively affect people's ability to exercise. The foot posture is determined through foot bones alignment and is variable between individuals. The foot abnormality resulting from normal posture may influence lower extremity gait and may lead to injuries to the lower extremity (McPoil and Cornwall, 2005).

Lower limb deformities are contributing factors in the biomechanical properties of motor function in children and adolescents, especially when walking (Twomey *et al.*, 2010). The structure of the foot adjust itself through the Subtalar joint with surface roughness and therefore helps the body to maintain balance (Haris and Smith, 2010).

In addition to the weight-bearing and absorbing the forces acting on the ground, the foot acts as a transmission lever role, as well (Hallemans *et al.*, 2006).

Medial longitudinal arch is defined as flat foot and is regarded as one of the most common deformity of the lower limb amongst children in different countries and is typically slightly higher in the boys (Hallemans *et al.*, 2006).

Some children are born with flat foot (Scott *et al.*, 2007). Medial longitudinal arch of the foot is formed from 2 to 6 years (Chen *et al.*, 2009) and evolves in the years 12 to 13 (El *et al.*, 2006).

Generally, flat foot is characterized with additional subtalar joint eversion, internal tibial bone rotation and abduction of the forefoot which result in changes in the foot.

For example, heel over-eversion causes subtalar Joint pronation time to increase in the initial stance stage and decreased absorption of the forces acting on the foot results, accordingly (Volpon, 1994), thereby increases the stress applied to the leg (Garcia-Rodriguez *et al.*, 1999).

The increasing pressure and stress may distort the joints and upper joint as well as thigh and ultimately the walking process.

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Theoretically, foot posture setting is associated with abnormal movements of the foot in gait. Flat foot are represented with different performances like longer heels eversion, more tibial internal rotation, more abduction of the forefoot, reducing the efficiency of walking and shock absorption problems (Benedetti *et al.*, 2011).

That is why, the effect of the lower limb and foot deformities and flat feet has been a focal point particularly in the study of biomechanical gait analysis among the researchers.

It should be noted that flat foot effect-related studies on the children and adolescents on the structure and function of the musculoskeletal has been rare (Williams *et al.*, 2001); few studies, however, have been conducted to analyze the gait kinematics of children (Shih *et al.*, 2012).

For example Twmey and Mcintosh examined lower extremity kinematics differences among children of 11-12 years with flat and normal foot (Ledoux *et al.*, 2001). In this study, they examined the data on gait kinematics and the spatial and temporal parameters of gait during different stages of walking and noticed negligible thigh inversion and concluded that the flexible flat foot might be the result of inherent risk in the children walking, however, a more comprehensive and more detailed investigation is necessary in this respect.

Studying the essential parameters of gait is main component of clinical studies of walking that provide useful information to treatment and rehabilitation specialists (Hunt *et al.*, 2004).

Studies have shown that as far as flat foot is considered, subtalar joint at the terminal stance is placed in a state of pronation and thus bone stability needed to an effective advance decreases at the time of the toe lifting.

These changes could increase the activity of inverter including anterior tibialis and reduce evertors like the fibula (Lee *et al.*, 2009). Hunt and Smith's study in 2004 showed that people with flat foot exhibited more plantar flexion on their back foot in the 21% stance phase.

Also they showed that in the transverse plane, the people` forefoot with flat foot throughout the whole stance phase tended to be abducted. People with flat foot exhibit more anterior tibialis muscle activity in the time of heel contact phase. They assert that at the 80 percent state of stance phase, external and soleus biceps shows more activity .Also, in the early phase of Stance phase, the fibular muscle shows less muscle activity (Hunt *et al.*, 2004).

Kinematics parameters of gait study are not only a good way to analyze and identify walking defects, especially in adolescents with foot deformities, but also provide useful information on the different clinical research purposes. However, very few reports of changes in the parameters of the kinematics of a flat foot exist (especially in Iran). The present study compared the gait kinematic parameters of male students with flat and normal foot.

## MATERIAS AND METHODS

#### Methodology

The purpose of this study was to compare the kinematic gait parameters in the 16-18 year-old male students with a flat and normal foot and. In doing so, 15 adolescents with the flat foot and 15 with the structure of the normal foot with a mean age of  $16.39 \pm 0.4$  years, mean height of  $172.4 \pm 0.8$ , mean weight of  $70.81 \pm 7.43$  participated in the study using the method of longitudinal arch middle toe.

Then, in coordination with the school management and parents, all subjects were assessed by a physiotherapist before participation in the study at the Institute of Physical Education research. Admission requirements in research were lack of any traumatic injury, surgery of the lower limb and lower limb length discrepancy or acute orthopedic deformity (Murley *et al.*, 2009).

None of the participants had a history of medical insoles or shoes for walking and did not use any assistive device. The foot structure was measured using the navicolar bone prominence height in the standing position and static and arch index was used for dynamic walking measurements (Mickle *et al.*, 2008).

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Figure 1: The measurement of the foot (scaphoid bone breakdown)

The camera intended for testing was installed at 90 cm from the floor and at a distance of 35/2 cm lateral to the participants. To evaluate and test the walking, a Casio Ex- zr1000 video camera was used to test the model. The shutter speed was used to shoot 120 fps. Then to make the students familiar with the test implementation, the Landmarks were specified (iliac crest, large bumps hip and ankle) on the spots and the test was performed on one of the students.



Figure 2: View of test evaluation of gait

## **RESULTS AND DISCUSSION**

#### Findings

As can be seen in Table 1, the mean stance time for subjects with normal foot and for subjects with flat foot was  $60.33 \pm 1.54$  and  $61.13 \pm 1.55$ , respectively, and the obtained t -value is (1.41) and the

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significance level (P=0.17). Also according to Table 1, the mean swing time to subjects with normal foot and for subjects with flat foot was $39.66 \pm 1.54$  and  $38.86 \pm 1.55$ , respectively, and the obtained t -value is equal to (1.41) and the significance level (P=0.17). As a result, the results revealed that there was no difference between swing and stance time in normal and flat footed-participants.

Table 1: Comparison of mean Swing and stance time of walking in people with flat and normal foot									
Variable	Sig.	df	Т	Levene Test		SD	Mean	Groups	
				Sig.	F				
Stance	0.17	28	1.41	0.88	0.02	1.54	60.33	Normal foot	
						1.55	61.13	Flat foot	
Swing	0.17	28	1.41	0.88	0.03	1.54	39.66	Normal foot	
						1.55	38.86	Flat foot	

According to Table 2, mean walking Cadence for normal foot subjects and for subjects with flat foot was  $104.33 \pm 7.40$  and  $104.40 \pm 5.57$ , respectively, and the obtained t- value is equal to (-0.28) and the significance level (P=0.98). So between cadence walk healthy people with flat foot and there was no difference.

Table 2: Comparison of mean walking	g cadence of	people with normal and flat foot
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Sig.	df	Т	Levene Test	-	SD	Mean	Groups
			Sig.	f			
0.98	28	0.28-	0.33	1.06	7.40	104.33	Normal foot
					5.57	104.33	Flat foot

According to Table 3, the mean right foot step length is  $71.30 \pm 3.57$  and  $10\ 70.83 \pm 2.24$  for people with normal foot and flat foot, respectively, and the t-value obtained is equal to (0.43) and a significance level (P=0.67). Also, mean left foot step length for people with normal foot and flat foot  $71.76 \pm 3.34$  and  $70.76 \pm 2.17$ , respectively, and the obtained t-value is (0.97) and the significance level (P=0.34). So no significant difference was observed between left foot step length and right foot length of both groups.

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Variable	Sig.	df	Т	Levene Test		SD	Mean	Groups		
				Sig.	F					
Right	0.67	28	0.43	0.15	2.18	3.57	71.30	Normal foot		
foot						2.24	70.83	Flat foot		
Left Foot	0.34	28	0.97	0.08	3.28	3.34	71.76	Normal foot		
						2.17	70.76	Flat foot		

#### Table 3: Comparison of the mean right and left foot step length of both groups

According to Table 4, the mean stride length was  $144.4 \pm 6.29$  and  $143.13 \pm 4.45$  for normal foot and flat-footed subjects, respectively, and the t-value obtained is equal to (0.64) and significance level (P=0.53).As a result, there is no significant difference between subjects with normal and flat feet as for the stride length.

Table 4: Com	parison of mea	n stride length	and walking g	ait velocity o	f both groups
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Variable	Sig.	df	Т	Levene Test		SD	Mean	Groups
				sig.	F			
Stride	0.53	28	0.64	0.37	0.81	6.29	144.4	Normal foot
						4.45	143.13	Flat foot
Gait	0.74	28	-0.33	0.28	1.81	6.48	138.8	Normal foot
velocity						8.64	139.8	Flat foot

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Finally, the mean walking speed of normal foot and flat foot subjects is  $138.8 \pm 6.48$  and  $139.8 \pm 8.64$ , respectively, and the obtained t -value is equal to (-0.33) and significance level (P=0.74). So, there was no significant difference between walking speed of both groups.

#### Discussion and Conclusion

the findings showed that there is no significant difference in the stance time of both groups. The finding is consistent with that of Twomey *et al.*, (2010). This could be due to increased gastrocnemius activity during walking as a compensatory mechanism associated with the mechanical disorders of the foot joints, especially flat foot have (Ringleb *et al.*, 2007). Perhaps, this increase is due to muscular activity of flexors plantar (Murley *et al.*, 2009).

In such a situation, due to the alignment direction of the muscle fibers relative to medial longitudinal arch, it made be associated with the heel lifting from the ground in the people with flat feet.

Reduction of Peroneus Longus muscle activity in people with flat foot which is the subtalar overture acts a compensatory role for reducing the pressure inside the arch of the foot. This argument seems logical because it is likely that biomechanically, peroneus brevis muscle along with Peroneus Longus control the inverting (invertor) role of tibialis posterior muscle in creating plantar flexion with no metatarsus (sole) internal rotation.

The resulting changes in the joints of the lower extremities may, of course, involve in the movement disorders. For example, Twomey *et al.*, reported a slight difference in gait kinematics study of flat-footed children between 11-12 years compared with the control group with flat feet. It was stated that the only significant difference was the more external rotation of the hip in children with flat feet (Twomey *et al.*, 2009).

The findings showed that people with a healthy foot with a flat foot, there is no significant difference in the duration of swing. The results (Shariati, 1393) are consistent. Biomechanical factors in this context should not be ignored. Another reason for the lack of difference observed in this study may be the result of biomechanical interactions between different segments. Increasing the number of steps and walking speed necessitates more leverage for the balance and consequently, ankle and foot are everted relatively and, accordingly, influences thigh and shin rotation as well as swing phase.

There are variations and differences in lower extremity joint kinematics in people with flat feet which influence the muscle functions;

Since plantar flexors during walking are highly involved in the stability of the knee and ankle and tibia rotation which change following the joints of the lower limb mechanical changes associated with flat foot. Inward movement of the center of foot pressure in the weight transfer and the mid-stance in the flat-footed individuals can affect the swing phase thanks to eversion.

The structural shape of the foot, the height of the medial longitudinal arch and ankle support muscles can be helpful in walking. Factors such as lower extremity muscle strength, range of motion and muscle control were not evaluated in the present study can affect the results of the present investigation. The flat foot, the more serratus tibialis activity is reduced in proportion to the likely this is related to the characteristics of flat foot (Frigo *et al.*, 2009).

The results revealed no difference between normal and flat-footed participants in terms of gait numbers. This finding is consistent with that of Twomey *et al.*,. According to system function theory, the musculoskeletal factors include joint range of motion and muscle properties as well as the biomechanical associations amongst the various parts.

Strength and definite range of movement and neuromuscular control of the lower limb during the implementation of specific sports performance are factors that may affect the performance through the stability limit change.

This could indicate that individuals with structural abnormalities of the foot in unstable and dynamic situation highly engage sensory-motor systems.

Since everybody has a unique walking style and the participants would experience walking test for the first time, it might affect their mental profile .that is why, there was no difference between both group in this regard.

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Also, there was no significant difference between both groups regarding gait length. This finding is consistent with that of Shariati (1393). The quadriceps muscles and Ilion (Suez Khasrhay) increase stride length in which the knee extensor and hip flexors should be inactive.

The stride length depends on individuals` height, age, sex and the stride length increases as the walking speed increases. The more femoral head lowers down and the more angular position of lower extremities would be and consequently, the stride length increases.

Slower walking brings about slower swing time and more muscular effort and as result the hip joints lower down. Then, the step length is reduced. The movements of flexion, extension for taking a step depends on the muscle strength. Muscular strength causes the step size to be proportional to the size of the body.

Several factors such as the size of the muscle, the muscle fibers, and upper extremity musculoskeletal structure and lines of force are also effective in walking.

According to the Gonda rule, the far parts of injured muscle engage in dealing with the disorder and thus, the upper extremity role in controlling the posture is considerable (Page *et al.*, 1967).

The findings showed no difference between both groups concerning walking stride length. Of course, due to limited literature in this regard especially kinematic parameters studies on flat-footed children makes it difficult to compare it with the previous literature. Seemingly, there would be no difference between both groups regarding walking stride length as there was no difference concerning other parameters.

The findings showed that people with normal and flat foot did not exhibit any significant differences in the walking speed. The finding is consistent with that of Shariati (2014). Increase in speed is a result of an increase in the frequency and stride length. Of course, the lower extremities form a motor unit with a combination of joints that provide stability and absorption against any force and pressure.

These parts performance and their rehabilitation are highly related. Another reason for the lack of impact of fatigue on gait indicates that motor learning may cause permanent changes in the levels of the central nervous system. It is believed that the changes – regardless of being voluntary or reactive - may happen in any routine or applied activity.

Any individual's walking may be influenced by factors such as age, sex, height, size and shape of the components of bone, joint mobility, muscle strength, habits, psychological state that can vary depending on the length and speed of the gait and may have positive or negative effects on the walking distance (Sokhanguie *et al.*, 2013). Kinematics parameters of gait in people with flat foot compared with their normal counterparts are amongst the first studies that provide useful information for the health researchers and practitioners alike. However, it should also be considered with caution when generalizing findings to those with pathological flat foot. In contrast, in the present study had limitations. For example, the kinetic data were not examined. We found no differences in the kinematics parameters of gait in young boys with flat foot structure compared with the normal foot group. However, because there are very few studies in this area, there is a need for further investigation for conclusive clinical inference.

Due to importance of kinematic studies of walking parameters and the lack of information in this regard, it is suggested that more comprehensive studies to be undertaken in this regard, especially among normal and pes cavus - footed individuals.

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