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The Effect of Hallux Valgus on Foot Angle during Gait

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ABSTRACT

The Hallux Valgus and the first Metatarsalo Phalangeal joint have a major role during walking. So any condition that would impair the performance of the hallux, can influence the pattern of walking and consequently cause in reduction of efficiency in gait. One of the prevalent phenomenon of foot deformity, especially in females is Hallux valgus (HV) which is usually happened by various reasons such as improper wearing high heel shoes. The aim of this study was to investigate foot angle in one cycle from heel contact of left foot to another heel contact of same foot during gait by comparing people with HV (n=7) and a control group (n=3). Result shows that the greater foot angle in HV group comparing with control group at mid-stance and terminal stance may be related to avoiding HV group from decreasing in foot angle to diminish both the hallux contact duration time and force magnitude which is acted on hallux in order to relieve pain. There is no significant difference between groups at early stance and terminal swing. Knowing the foot angle in people with HV during walking can have a wide range of applications including shoe designs and orthotic device research and help surgeons to do the best in surgical decision-making.

KEYWORDS: Hallux Valgus, Foot angle, Stance, Swing

1. INTRODUCTION

Hallux valgus is a common foot problem which in its early stages will effect just the first Metatarsalo Phalangeas. It involves a valgus deviation of the big toe, increased varus of the first Metatarsal bone and a medial prominence of its head. The etiology of HV is multifactorial. Although inappropriate footwear may be the principal extrinsic cause, intrinsic factors play a role as well. Hallux valgus can lead to painful motion of the joint or difficulty with footwear (Hart ES, deAsla RJ, & Grottkau BE, 2008). Patients generally complain of pressure symptoms over the prominent pseudoexostosis, which together with the thickened bursa constitutes the bunion. The structure and function of the foot play the major role in gait. HV deformity usually occurs together with a reduction of the transverse arch, an circumstance of hammer toes, a widening of the fore-foot and pressure distribution alters under metatarsal heads, causing a metatarsalgia (Halebian & Gaines, 1983; Torkki, 2004). Surgical correction is the more invasive treatment option, with more than 100 different techniques having been defined (Hamilton RJ, Gray A, & Kumar S, 2005; Monga P, Kumar A, & Simons A, 2006). A significant step in the management of foot deformities is the objective analysis of foot and knee mechanics in dynamic conditions. Several authors have demonstrated that patients with HV have an altered plantar pressure pattern in the forefoot compared to normal people (Hutton WC & Dhanendran M, 1981; Waldecker U, 2004). These studies have shown that the most prevalently observed patho-mechanical manifestation is the first ray insufficiency during mid-stance, which causes an increased load over the central metatarsal heads. Postoperative outcome has also been estimated by means of pedobarography (Saro C et al., 2007). There are many studies analyzing the dynamic parameters of gait in people having HV (Bryant, Tinley, & Singer, 1999, 2000; Martinez-Nova et al., 2010), but only in a few studies were the kinematics of gait considered. HV was considered to be a static forefoot deformity. A multisegmental foot model for the purpose of 3D gait analysis is reported to indicate both decreased plantar and dorsal flexion in people with HV (Hwang et al., 2006). The impact of hallux valgus on foot kinematics has been reported Using the Oxford Foot Model (Deschamps et al., 2010). The influence of hallux valgus on kinematics of pelvis and lower extremities movement such as hip flexion, knee flexion during gait has been investigated (Kozakova et al., 2011). Much less is known about the effects of HV on foot angle during walking. The aim of this study was to investigate foot angle during gait by comparing people with HV and a control group in order to obtain the critical regions in HV people during gait.

METHOD

To consider kinematics of foot in HV people, foot angles of 10 people (n(HV)=7, n(CG)=3) in one cycle from heel contact of left foot to another heel contact of same foot during gait, were measured. Fig. 1

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indicates the hallux deformity which is called Hallux Valgus or bunion. Fiiling out of consent form to do the test was performed by subjects.

Figure 1. *Hallux Valgus*

Anthropometry data of HV subjects that have been tested can be seen in Table 1.

Table 1. *Anthropometry data of HV people*

HV subjects	gender	Height (cm)	Weight (kg)	Age (year)	HV Angle (deg)	Other problems in
1	female	165	68	36	14	-
2	male	178	83	42	17	-
3	male	172	77	44	15	-
4	male	176	80	39	12	-
5	male	182	79	47	16	-
6	male	175	85	49	15	disc
7	male	177	74	50	18	pelvis

To obtain desired data from foot angle, subjects were asked to walk across laboratory (Biomechanics laboratory at Mechanics Faculty at IUST, Fig. 2) on a force plate mounted in the middle of walkway. The walkway domain was calibrated using laser calibration in order to construct proper local and global coordinate systems.

Figure 2. *Biomechanics laboratory at IUST*

In order to track foot pathway and its angle during walking, 7 reflective markers were set on the left foot and leg of subjects as illustrated in Fig. 3.

Figure 3. *Reflective markers on the left foot of subject*

At least 2 cameras are needed to analyze in 3-D space. So to reach 3-D analysis and obtain more accurate data, 6 video cameras (Manfrotto,190XPROB.I Biomechanics laboratory at IUST shown in Fig. 4) were calibrated and used to take a film during walking. Data were filtered using 4th order low-pass Butterworth in Simi Motion analysis software. Then Filtered data were collected and imported into the Sigma Plot Software (version 11.) to perform statistical analysis on such data.

Figure 4. *High speed video camera*

RESULT

Foot angle in people with HV and control group in a cycle from heel contact of left foot to another heel contact of same foot during gait were measured and plotted (Fig. 5). Needs to say that foot angle data from control group were plotted in the form of one curve by averaging principle.

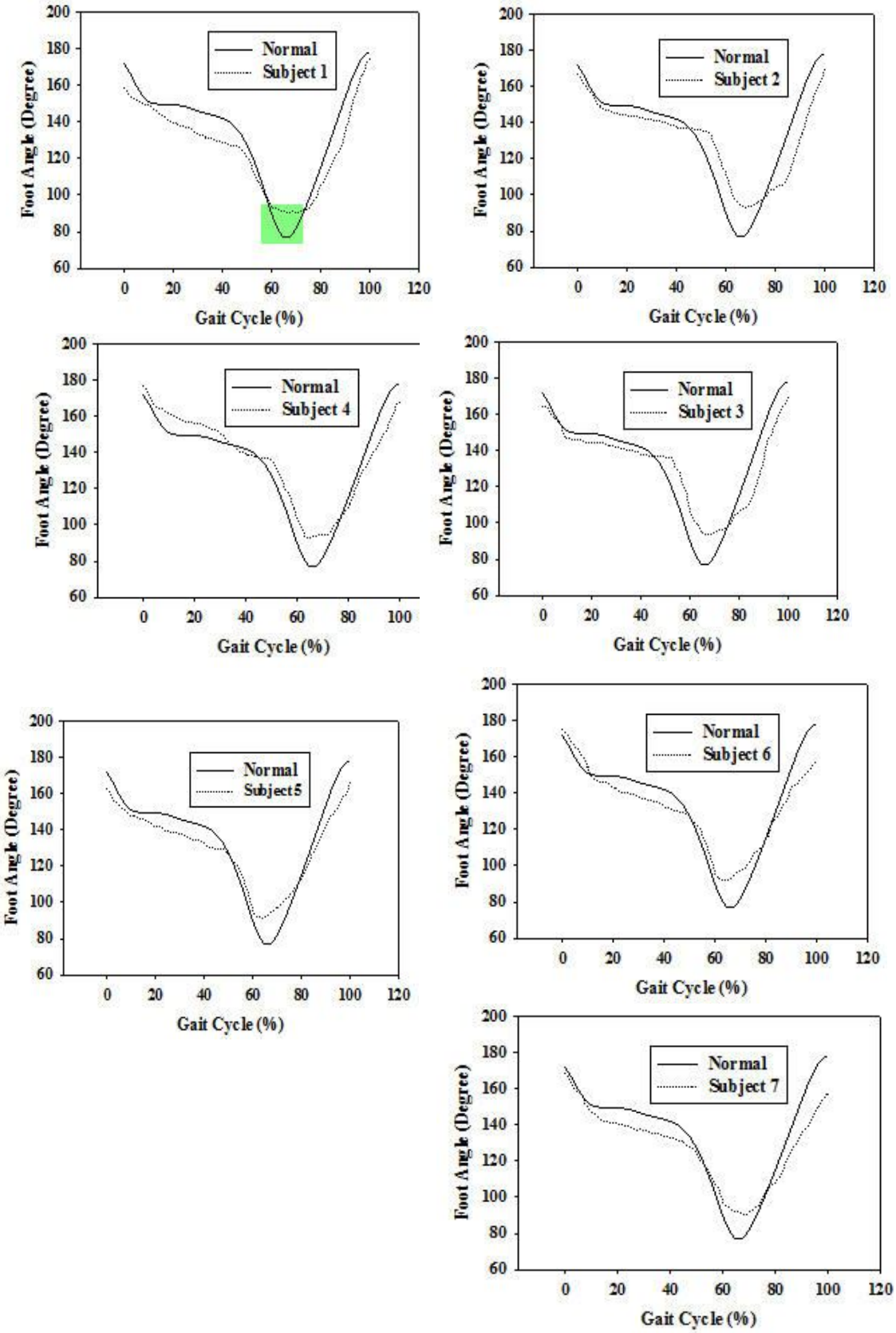

Figure 5. *Foot angle in people with HV and control group versus percent of gait cycle from heel contact of left foot to another heel contact of same foot*

Statistical analysis was performed using T-test and significant level was set at P<0.05. As shown in Fig. 5 there is no significant difference between HV and CG at the beginning of walking when the subjects' heels contact the ground (P>0.05). Maybe it is justifiable, because at the heel contact, there is not any contact between hallux and ground and consequently does not influence the pattern of gait. So the HV foot angle is close to that of CG at the beginning of walking. The considerable difference (P<0.05) in foot angle between HV and CG at the mid-stance and especially at the end of stance phase (the region which is shown with green color in fig. 4 and includes region between 55-65 percent of gait cycle) may be related to the avoiding HV group from decreasing in foot angle to diminish both the hallux contact duration time and force magnitude which is acted on hallux to relieve pain. Therefore it makes the minimum of foot angle curve in HV to perch above that of in CG. Significant level at the end of swing phase is greater than 0.05 (P>0.05). Despite of considerable deviation in foot angle at the end of swing phase in subjects 6 and 7 from CG foot angle, they can not be related to the specific reason because of totally great significant level and may be related to their anthropometry properties.

Conclusion

The purpose of this study was to investigate foot angle in one cycle from heel contact of left foot to another heel contact of same foot during gait by comparing people with HV and control group. To reach this purpose, two groups include 7 people (HV group) and 3 control people (CG) were asked to walk across the labratory on a force plate. Results indicated that there is not any difference in foot angle between HV people and CG at the early stance and the end of swing phase. Furthermore the considerable difference in foot angle between HV people and CG at the mid-stance and especially at the end of stance phase may be related to the avoiding HV group from decreasing in foot angle to diminish both the hallux contact duration time and force magnitude acted on hallux. However using more subjects in the test and kinetically analyzing foot and lower extremity can derive more accurate and reliable results.

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