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A Comparison Between Length of the Thumb and First Metatarsal in People Exposed with Hallux Valgus and Healthy People

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ABSTRACT

The purpose of this study was comparison between length of the thumb and the first metatarsal in people exposed with hallux valgus (HV) and healthy people. One hundred fourteen middle age (20-30 years-old) person (228 feet) based on hallux valgus angle (HVA) divided into; control group (74 feet), mild HVA (88 feet) and moderate HVA (66 feet). Radiography picture was used for analysis HVA. Then picture was taken by scanner and research variables measured by using AutoCad software. The results of this study did not show significant differences between groups in length of the first of metatarsal and distal phalanx of the hallux ($p>0.05$). The length of the Proximal phalanx of the hallux in mild and moderate HV groups was significantly shorter than control group ($p=0.001$). Also the length of the thumb in mild and moderate HV groups was shorter then control group ($p<0.05$). The maximal amount of hallux deviation was in mild, moderate HV an control group respectively ($p=0.000$). There wasn't significant different between 1 and 2 intermetatarsal angle (IMA) between control and mild group ($p=0.732$). The angle between 1 and 2 intermetatarsal in moderate HV was significantly higher then control and mild HV groups ($p<0.05$). Also dislocation of sesamoied bones there was not significant different between groups ($p=0.001$). It is concluded, that length of the first metatarsal and phalanxes the hallux cannot considered as an endogenous risk factor in mild to moderate HV.

Keywords: Hallux valgus, First metatarsophalangeal joint, Hallux valgus angle, Intermetatarsal angle, First metatarsal

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INTRODUCTION

Structure of human foot is very sensitive and complex yet it has full capabilities in weight-bearing and shock absorbed. Foot problems and suffers in modern society are common pains and deformities. These deformities are marked by biomechanics factors infection, and systemic disease (1). Hallux valgus is commonest deformity that in middle-age female is more than others. Hallux valgus is a progressive foot deformity that is characterized by a lateral deviation of thumb with corresponding medial deviation of the first metatarsal [2]. Hallux valgus is a common condition in which the first metatarsophalangeal (MTP] joint becomes progressively subdued, leading to lateral deviation of the hallux, and bony enlargement of the first metatarsal head and thumb adducts to second finger and compresses this finger and is located under or on it [2,3]. Late-stage changes may render the hallux painful and without functional utility, leading to impaired gait [2, 3]. Also if do not treatment as soon as possible, it effects on other areas of foot and create other abnormality in foot [2, 4].

Literature review showed various environmental, genetic, and anatomical predispositions as causes of this problem, but the exact cause of hallux valgus is unknown [3]. Therefore etiology of hallux valgus deformities is complex. Besides intrinsic factors like heredity [5, 6], flat foot [5, 7], contracture of the Achilles tendon [4], hypermobility of the first metatarsocuneiform joint [7, 8], neuromuscular disorders, including cerebral palsy and stroke [4]. Finally, extrinsic factors are also involved; fashion footwear can play an important role as a major extrinsic factor [4].

Length first metatarsal and length of the proximal phalanx of the hallux, length of the distal phalanx of the hallux were reported major intrinsic factors related with the of hallux valgus deformities [7, 9]. Medical literature showed excessively long or excessively short first metatarsal as an etiology of hallux valgus [9]. The increased protrusion of the first metatarsal was reported a cause of the hallux valgus deformity [9-12]. Paradoxically, an excessively short first metatarsal has also been attributed to the etiology of hallux valgus [13]. Also, the alteration in the length of the hallux, length of the proximal phalanx of the hallux and length of the distal phalanx of the hallux has been related with the etiology of hallux valgus, specifically an excessive length [10, 14, 15]. Therefore, based on contralateral reported results in the previous resarches investigations this issue is critical and important. This study was designed to compare length of hallux and the first metatarsal in people exposed with hallux valgus and healthy people to identify the role of first metatarsal and length of hallux in hallux valgus deformity.

MATERIALS AND METHODS

Participants

The subjects of this study were patients that recourses to the Clinical Radiography Service at the Ilam city, and students of the Payame Noor University of Ilam who volunteered to participate in this research during the same period. The present study was performed since January, 2009 until June, 2011. The subjects that participated in present study had to fulfill the following inclusion criteria: to be in the 3rd decade of life (20–29 years), the growth epiphysis had closed, never to have undergone osteoarticular surgery of the foot, never to have suffered serious injury to the foot that might have altered its bone morphology, HVA of 5°-35°, do not have degenerative osteoarticular diseases or neuromuscular imbalance, do not have deformities of the forefoot that could affect the results of the study. A total of 137 subjects (274 feet) were initially included. Finally 114 subjects (228 feet) in base of HVA divided to one of the three study groups: a control group of feet normal, a group of feet with mild and moderate HV. The subjects comprising the control group had to have HVA_less than 15°, The subjects of the mild HV group had to have HVA greater than 15° and less than 25° and the subjects of the moderate HV group had to have HVA greater than 25° and less than 35° [4,9,16]. Therefore control group was included 37 people (with 74 foot), mild HV group 44 subjects (with 88 foot) and moderate HV group was included 33 people (with 66 foot).

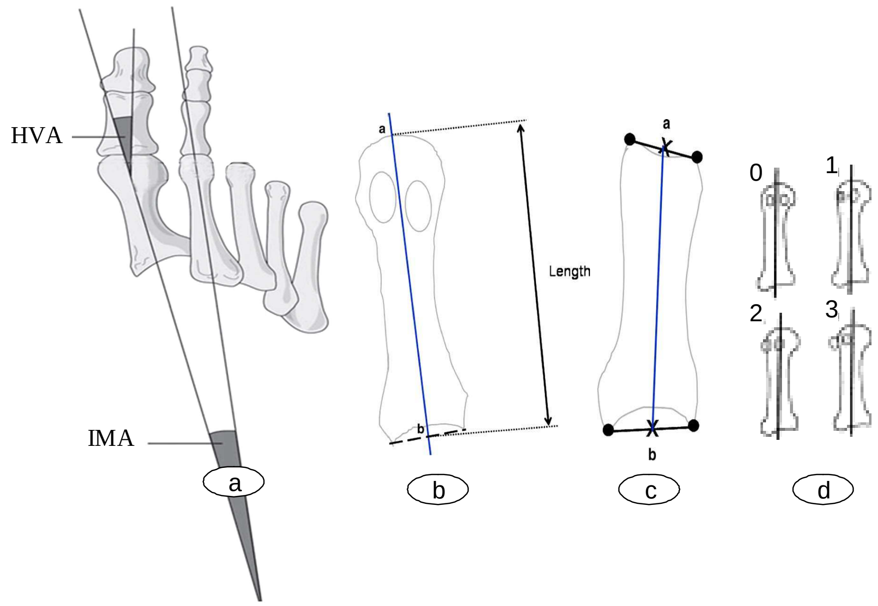

Figure 1. Radiographic parameters were measured: *a* HVA, hallux valgus angle; IMA, intermetatarsal angle; *b* the lengths of the first metatarsals; *c* the length of the proximal phalanx of the hallux; *d* deviation bony lateral sesamoid

Procedure

The following variables were studied; length of the first metatarsal, length of the proximal phalanx of the hallux, length of the distal phalanx of the hallux, and length of the thumb (obtained from the sum of the lengths of the proximal and distal phalanges of the hallux). Other measurements were made the HVA, an IMA and amount of dislocation bony lateral sesamoid.

All measurements were performed by the same researcher. A dorsoplantar weight-bearing radiograph was taken for each individual, with both feet together, with the tube inclined 15° to the vertical and at a tube-to-object distance of 1 meter [9, 17]. A digital image of each radiograph was made using a scanner, allowing the exploration of images on positive film. The radiographic measurements were made using AutoCAD software (version 2007), of proven efficacy for this task [9, 18]. All the radiographic parameters were measured in accordance with previously described procedures; HVA and IMA angle [16], the lengths of the first metatarsals [10], the length of the proximal phalanx of the hallux as well as the length of the distal phalanx [19] and amount of dislocation bony lateral sesamoid [20, 21]. Also, dislocation of internal sesamoid bone with Head of first metatarsal was graded by American Orthopaedic Foot and Ankle Society's (AOFASs) method. This means that 0 degree or natural position, 1 degree or mild position (passing sesamoid of lever first metatarsal bone lesser than 50%), 2 degree or moderate position (passing sesamoid of lever first metatarsal bone more than 50%) and 3 degree or sever position (passing sesamoid of lever first metatarsal bone completely) [20,21] (Figure 1).

A one way analysis of variance (ANOVA) design was applied to examine the possible differences. In case of statistical significance, the post-hoc LSD test was conducted to determine pairwise differences. The data met all the assumptions for linear statistics and the Levene's test was used to assess homogeneity of variance between groups ($p>0.05$). Moreover the Kolmogorov-Smirnov test was performed as a check of normality ($p>0.05$). A significant level was accepted at the 95% confidence (CI) level for all statistical parameters. P-values below 0.05 were considered statistically significant.

RESULTS

Table 1 shows descriptive information of subjects for example age, height and weight. The results showed that there is no significant difference between study groups in terms of age and weight ($p>0.05$). But there is significant difference in terms of height ($p= 0.001$) (Table 1).

Table 1 Descriptive information of subjects (Mean ± standard deviation)

Groups	Age (y)	Height (cm)	Weight (kg)
Control	23.7±2.1	175.1±7.3	71.4±11.1
Mild HV	24.3±2.4	171.7±9.8	70.9±12.1
Moderate HV	23.1±1.9	170.3±10.7	69.4±10.6

In table 2 shows average and standard deviation of length of first metatarsal, length of phalange of thumb length of the proximal and distal phalanx of the hallux. HVA and also IMA. The results showed that there is no significant difference between study groups in terms of length of first metatarsal and distal phalanx of the hallux ($p>0.05$). Observed difference in other variables were significant ($p<0.05$). Results of LSD test showed that length of the proximal phalanx of the hallux in mild and moderate HV groups was significantly shorter than in control group ($p=0.001$). But observed difference between mild and moderate HV groups wasn't significant ($p=0.529$). Also in relation with length of thumb, the results showed that the length of this finger in mild ($p=0.003$) and moderate ($p=0.006$) HV groups was shorter than control group, but there wasn't significant difference between mild and moderate HV groups ($p=0.995$). In relation with HVA the results showed that there was the most deviation in mild, moderate and control HV groups respectively. This difference was 6.77° between control and mild HV groups, 15.64° between moderate HV and control groups and 8.65° between mild and moderate groups that these differences was significant ($p=0.000$). In amount of IMA angle there is no significant difference between control and mild HV group ($p=0.732$). This angle in moderate HV group was significantly more than control ($p=0.025$) and mild HV groups ($p=0.044$) (Table 2).

Table 2. Comparison of Radiographic parameters between groups

Parameters	Control	Mild HV	Moderate HV	F	P-value
1MMT length	61.4±5.8*	59.6±6.1	59.8±6.6	1.94	.146
PFH length	33.2±3.3	30.6±3.5	30.9±3.3	13.66	.001
DFH length	25.8±2.9	25.7±3.6	25.4±2.3	.331	.719
Hallux length	58.9±5.7	56.3±5.9	56.6±5.2	5.60	.004
HVA	13.1±1.5	19.8±2.7	28.4±2.1	830.7	.0001
IMA	10.1±2.4	10.3±1.5	10.9±1.4	2.98	.043

** Radiographic parameters were measured is expressed in millimeters.*

Also in terms of amount of dislocation sesamoid bones there was significant difference between studied groups ($p=0.001$). The result of statistic analysis showed that only 6.8% of subject of control group exposer with moderate dislocation and none of them doesn't exposer with sever dislocation. Around 32% in mild HV group exposer with moderate and sever dislocation and around 36% have normal position but none of subjects in moderate HV group don't have normal position and 53% of them exposer with moderate to sever dislocation of sesamoid bones (Figure 2).

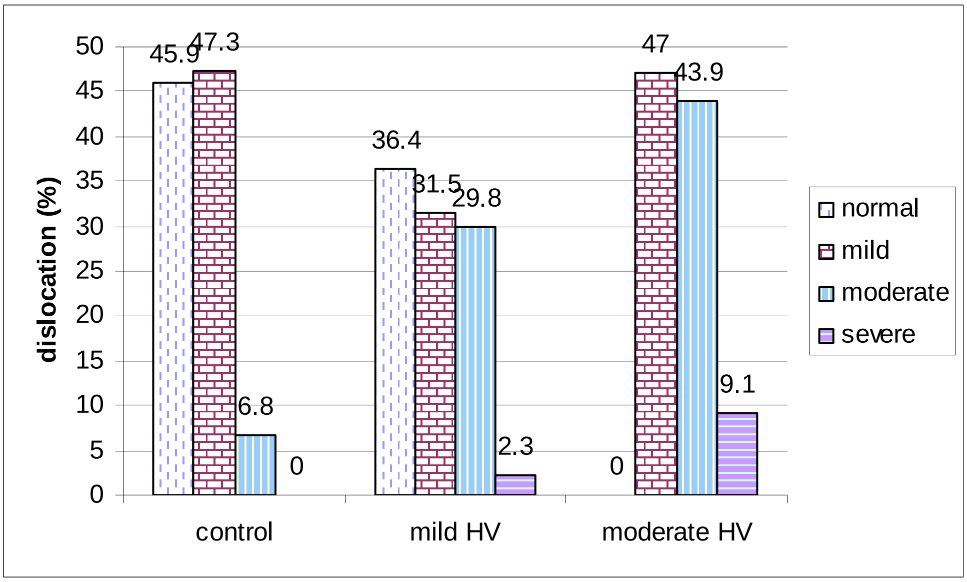

Figure 2. Dislocation of sesamoid bones

DISCUSSION

The result of this study showed that there is no significant difference in terms of length of first metatarsal between study groups. Munuera et al. (2008), investigated the effect of length of first metatarsal in HV disease in 2 group with safe thumb (HVA angle lesser than 15°) and mild HV group (HVA angle 15°-30°) and showed that length of first metatarsal in HV group (67.91±4.41) was greater than control group (65.48±4.67) [9]. The result of this study was similar with Coughlin and Shurnas (2003). They determined that length of first metatarsal in HV patients was in normal range and it was not more than persons with safe thumb [19]. However, Munuera et al. (2008) reported that differences in terms of first metatarsal between control and HV group were not significant clinically, because these differences are relatively small. However, this difference is important in HV dieses with attended to increase the length of first metatarsal between groups [9]. The genetic factor may be were cause of contradictory result in our results with other articles. Some study indicated that genetic context is the most important factors in HV disease. They reported that genetic was cause of 68% of HV disease [17]. Other study indicated that wearing uncomfortable shoes is also one of the important factors in HV [5]. So with attended to this results, further research is needed.

The result of this study showed that the length of proximal phalanx of the thumb as well as length of thumb in mild HV group is significantly shorter than control group, but there were no significant differences between mild and moderate HV groups. Also in terms of length of distal phalanx of thumb there was no significant difference between three groups. Some authors reported that the length of proximal phalanx of the thumb in persons with HV is greater than healthy people. In contrast these studies, other study reported significant difference between the lengths of first phalanx of thumb with HVA [23]. However, some studies indicated that the length of thumb is effective factor in HV disease. Munuera et al. (2008), showed that the length of thumb and proximal phalanx of the thumb in person with HV is greater than healthy person; but no significant differences between the length of distal phalanx of thumb in two groups was reported [9]. The studies showed that if the lever of first metatarsal and the hallux was more than enough long, the pressure received by the hallux in the push-off phase of gait, and the pressure of footwear generated, is required to shorten that lever. Producing segmentary deviations of metatarsal in the oblique plane is one of the ways to access this aim. The deviations that must be produced in the first metatarsal and the hallux to compensate this excessive length require a joint that allows movement in the oblique plane, so that it acts as a hinge. When excessive length is combined with a rounded shape of the head of the first metatarsal (as is very frequent in the hallux valgus deformity) the deviation takes place at the level of the metatarsophalangeal joint. The hallux moves in abduction under normal conditions because it is already located a little in this position [9, 24]. It seems that shorter length of hallux than normal status may cause of this problem. The deviation in oblique plan of metatarsophalangeal joint may be created because of short length of lever in the push-off phase of gait and also pressure of ground in walking on top of hallux. These results confirm that more and less than enough of length of proximal phalanx could be cause of HV.

The maximum thumb deviation was respectively in mild HV, moderate HV and control groups in related to HVA angle. Moreover, there is no significant difference between control and mild HV groups in amount of IMA. But this angle in moderate group was significantly more than control and mild HV. Studies determined severity of HV using of radiography evaluation and HVA and IMA evaluation [16]. The HVA is the intersection of the longitudinal axes of the proximal phalanx and the first MT. The IMA is the intersection of the longitudinal axes of the first and second metatarsals. A normal HVA and IMT were considered to be less than 15°, and 9°, respectively. The IMA is considered to be less than is considered normal. Mild HV is defined as an HVA and IMT less than 20°, and 11°, respectively. Moderate HV is introduced as a HVA and IMT less than 20°-40°, and 16°, respectively. Severe HV is defined as a HVA and IMT more than 40° and 16°, respectively [4, 16]. This definition is a little bit different in researches.

The results showed that there was significant difference between dislocations of sesamoids bone of groups. Our results indicated that sesamoid bones in control group was normal but mild and moderate HV groups exposer with moderate to severe dislocation of sesamoid, respectively. The big sesamoid and fibular sesamoid bones are under first MTP joint between tendons of interensic muscles of foot. These bones move on anterior and posterior while HV created and improved. Moreover, fibular sesamoid rotated in to posterior and caused degenerative variation in MTP joint [3]. Scranton and Rutkowski (1980) qualitatively evaluated the extent of cartilage and subchondral bone damage in 35 cadavers having hallux valgus. Erosion of the plantar surface of the metatarsal head was present in every specimen having completely dislocated sesamoids [25]. Therefore, with attended to gained result of this study and moderate to severe dislocation of sesamoid bones in mild and moderate HV groups we must attended to dislocations of these bones and to sever of HVA and IMA in HV disease and radiography evaluation.

CONCLUTION

With attended to gained result of this study we can say that persons with mild and moderate HV groups have shorter thumb than people with normal thumb. Also HVA, IMT and sesamoid bones dislocation IN HV people are more than healthy people. But there was no significant difference in length of first metatarsal between groups. Therefore, it seems that the length of first metatarsal dose not effect on HV disease. But the length of thumb was effect on HV disease. The length of first metatarsal and phalanx of thumb aren't intrinsic risk factor in created mild to moderate HV diseases. The contradictory results between result of present studies with other investigations may be because that the severity of HV diseases related to life style, activity types, age and genetic of subjects. Differences in measurements' instruments and procedures may be other explanation for conflicting results. Therefore, it would be recommended that HV factors of each investigation discussed individually. The authors considered that a limitation of this study was using of two-dimensional images to evaluate tridimensional elements.

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