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Original Research

Comparison of Q Angle in Hallux Valgus and Healthy Individuals

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Abstract

Objectives: To compare the Q angle in individuals with hallux valgus (HV) and healthy individuals and to explore the correlation between HV and Q angle.
Materials and Methods: In this cross-sectional study, 15 individuals with HV (HV group-mean age: 41.60 ± 18.66 years) and 15 healthy individuals without HV with similar characteristics (Control group-mean age: 39.80 ± 8.59 years) participated. Hallux valgus angle (HVA) and Q angle were measured with a universal goniometer while demographic information was recorded.
Results: No significant difference was found between the Q angle values on both the right and left sides in the HV group and the control group (p=0.056, Effect Size (ES)=0.730; p=0.376, ES=0.331, respectively). A weak positive correlation was found between the right-sided HV and right-sided Q angles of the study participants (r=0.446, p=0.013). When the relationship was analyzed according to the groups, a moderate positive correlation was found between right-sided HV and right-sided Q angles in the control group (r=0.533, p=0.041).
Conclusion: There is a relationship, albeit weak, between HVA and Q angle in individuals with HV and healthy individuals. HVA should be taken into consideration when evaluating lower extremity alignment.

Keywords: *Hallux valgus, hallux valgus angle, q angle, cross-sectional studies*

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Introduction

Hallux valgus (HV), a very common foot deformity, is estimated to affect 35.7% of the elderly and 23% of adults (Nix et al., 2010). Hallux valgus is associated with pronation and hypermobility of the first metatarsal head and causes pain and subluxation in the first metatarsophalangeal joint (Fournier et al., 2019). The occurrence rate is more pronounced in females than in males (Nix et al., 2010). Age, female gender, genetics, and narrow shoes are among the factors predisposing to the development of HV (Coughlin, 1995; Coughlin & Jones, 2007). Hammer toe deformity, tense or short Achilles tendon, pes planus, and metatarsus adductus are associated with HV due to various mechanical causes (Ray et al., 2019).

Individuals with HV typically present to the clinic with complaints of pain, a prominent swelling, or protrusion in the medial forefoot. In addition, some types of shoes may cause discomfort in individuals with HV due to the medial protrusion at the first metatarsophalangeal joint (Ray et al., 2019). Hallux valgus angle (HVA) and intermetatarsal angle (IMA) measurements are widely used for objective evaluation of HV deformity (Hardy & Clapham, 1951; Pique-Vidal & Vila, 2009). In radiologic evaluation, HVA, IMA between the 1st and 2nd metatarsals, and an anteroposterior view of the distal metatarsal joint angle (DMJA) are examined (Condon et al., 2002). While HVA and IMA have been proven to give reliable results, DMJA has been found to be less reliable (Coughlin & Freund, 2001; Coughlin & Jones, 2007). HVA < 15° and IMA < 9° are considered normal. If HVA < 20°, IMA < 9°-11°, it is considered mild HV. If HVA is between 20°-40° and IMA between 11°-16°, it is considered moderate HV. If HVA>40°, IMA>16°, it is considered severe HV (Coughlin & Jones, 2007; Smith & Bluman, 2014). Methods such as clinical goniometer and computerized plantar pressure measurement are used when radiographic measurement is not possible (Janssen et al., 2014).

Hallux valgus may exert an impact not solely on the foot but also on the mechanics of the lower extremity (Steinberg et al., 2013). Various studies have demonstrated that HV deformity has the potential to exert an influence on the movement patterns of the entire lower extremity and pelvis (Gaston et al., 2011; Kothari et al., 2016; Svoboda et al., 2014). In a 2013 study conducted by Steinberg et al. involving female participants, the investigation revealed a correlation between HV and lower extremity alignment as well as range of motion (Steinberg et al., 2013). A case study associated HV with knee osteoarthritis (Ozguclu et al., 2008), and another study by Shih et al. revealed that HV increased internal rotation at the hip and knee abductor moment (Shih et al., 2014). These findings imply that HV may exert an impact not solely on the foot but also on additional lower extremity joints, including the knee and hip.

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The knee joint plays a crucial role in lower extremity mechanics and alignment (Sato et al., 2020). Alterations in the angular alignment of the lower extremity are regarded as significant risk factors for lower extremity injuries, with a particular emphasis on knee injuries (Nguyen et al., 2009). One reason for this is the Q angle (Livingston & Mandigo, 1997), which represents the direction of the force vector of the quadriceps muscle in the frontal plane (Schulthies et al., 1995). Increases in the Q angle are theorized to heighten the risk of injury through the induction of abnormal quadriceps force within the patellofemoral joint (Nguyen et al., 2009). Studies have also confirmed that the Q angle is associated with lower extremity problems, such as anterior cruciate ligament injury and patellofemoral pain syndrome (Griffin et al., 2000; Haim et al., 2006; Messier et al., 1991).

Within the literature, there exist studies illustrating the association between HV and, in particular, knee osteoarthritis (Ozguclu et al., 2008). However, there is a gap in the research concerning the relationship between HV and the Q angle. The aim of this study was to compare the Q angle in individuals with HV and healthy individuals and to investigate the potential relationship between HV and Q angle. It was hypothesized that Q angles would differ between individuals with HV and healthy individuals.

Material And Method

Study Design and Participants

This cross-sectional study involved 15 individuals with HV (HV group) and 15 healthy individuals without HV, matched for similar characteristics (control group). Approval for the study was secured from the Ethics Committee of the Faculty of Medicine at KTO Karatay University. This approval was granted on September 21, 2023, and designated as decision number 2023/008. All participants provided written informed consent, and the study adhered rigorously to the principles outlined in the Declaration of Helsinki. The study included voluntary individuals over the age of 18, and an HVA of 15° and above in both feet was a requirement for participation in the HV group. Those who had undergone knee surgery had a known joint disease like rheumatoid arthritis or osteoarthritis and individuals with HV were excluded from the control group.

Study Plan

Data collection for this study occurred between September 2023 and December 2023. Demographic information for each participant was recorded, and the evaluation commenced.

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The demographic details encompassed age, gender, weight, height, body mass index (BMI), and dominant side. The HV and Q angles of the individuals were evaluated within the study.

Evaluation Methods

Measurement of Hallux Valgus Angle

The evaluation of the HVA was conducted using a universal goniometer. The goniometric evaluation was performed barefoot in a standing position. The pivot point of the goniometer was placed medially or anteriorly on the 1st metatarsophalangeal joint. One of the arms of the goniometer was placed on the long axis of the 1st metatarsal bone, and the other arm was placed on the long axis of the proximal phalanx of the thumb, and the angle value between the arms was recorded (Janssen et al., 2014).

Measurement of the Q angle

The Q angle represents the angle between the line drawn from the anterior superior iliac spine (ASIS) in the coxa bone to the middle of the patella and the line drawn from the midpoint of the patella to the tuberosity tibia in the tibia bone (Skouras et al., 2022). The measurement of this angle was conducted using a universal goniometer. The goniometer's pivot point was situated at the midpoint of the patella. One arm of the goniometer was placed pointing to the tuberosity tibia and the other arm to the ASIS. The recorded angle represented the inclination between the line extending from the ASIS to the midpoint of the patella and the line drawn from the midpoint of the patella to the tuberosity tibia (Merchant et al., 2020). This assessment was conducted while the individual was in a standing position.

Statistical Analysis

Data analysis was performed using the statistical software package SPSS 25 (IBM Inc., Armonk, NY, USA). The sample size of the study was determined by G* Power (version 3.0.10; Franz Foul, Universität Kiel, Germany). A pilot test with ten volunteers (5 in each group) determined the necessary sample size. Based on the results of the pilot study, a power analysis was conducted to attain a significant α level of 0.05, a power of 0.95, and an effect size of 1.54. The findings suggested that the current study would necessitate a minimum of 13 participants in each group. To increase the power of the study and compensate for possible data loss, 15 participants were recruited in each group. Mean and standard deviation values were reported for continuous variables. The "Levene" test was employed to assess the homogeneity of variances, a prerequisite for parametric tests. The normality assumption was evaluated using the "Shapiro-Wilk" test. In cases where parametric test prerequisites were satisfied, differences between two independent groups were assessed using the "Independent Sample Test." The

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relationship between two continuous variables was evaluated using the Pearson correlation coefficient for parametric data and the Spearman correlation coefficient for nonparametric data. Statistical significance was established at a p-value of < 0.05. The correlation coefficient (r) was interpreted as follows: 0.00 - 0.25 as very weak; 0.26 - 0.49 as weak; 0.50 - 0.69 as moderate; 0.70 - 0.89 as high; 0.90 - 1.0 as a very high relationship (Plichta & Kelvin, 2013).

Results

A total of 30 participants, 23 females (76.7%) and seven males (23.3%), aged between 19 and 65 years (mean age: 40.70 ± 14.30 years) participated in the study. The mean right HVA was 15.07 ± 8.87, the mean left HVA was 15.77 ± 8.66, the mean right Q angle was 14.65 ± 4.95, and the mean left Q angle was 14.90 ± 4.63. Out of all participants, 96.7% (29 out of 30 individuals) were right-sided dominant. In the HV group, 93.3% (14 out of 15 individuals) exhibited right-sided dominance, while all participants in the control group (15 out of 15 individuals) were also right-sided dominant. The mean age, BMI, and HVA of the participants in both the HV group and the control group, along with the comparison results, are presented in Table 1.

Table 1. Demographic Data of Participants

		HV Group (n=15) Mean ± SD	Control Group (n=15) Mean ± SD	p
Age (y)		41.60 ± 18.66	39.80 ± 8.59	0.738[a]
BMI (kg/m2)		26.57 ± 5.11	26.24 ± 3.71	0.840[a]
HVA (°)	Right	21.80 ± 6.43	8.33 ± 4.97	<0.001[a,]*
	Left	22.20 ± 6.65	9.33 ± 4.73	<0.001[a,]*

*p<0.05: Statistically significant; SD: Standard Deviation; HV: Hallux Valgus; n: number; y: years; kg: kilogram; m: meter; HVA: Hallux Valgus Angle; BMI: Body Mass Index; [a] : Independent Sample Test.

No significant difference was found between both right and left side Q angle values in the HV group and the control group (p=0.056, Effect Size (ES)=0.730; p=0.376, ES=0.331, respectively) (Table 2).

Table 2. Comparison of Q Angle Values Between Groups

		HV Group (n=15) Mean ± SD	Control Group (n=15) Mean ± SD	t	p	Effect Size
Q Angle (°)	Right	16.37 ± 3.91	12.93 ± 5.40	- 1.993	0.056[a]	0.730
	Left	15.67 ± 3.27	14.13 ± 5.71	- 0.903	0.376[a]	0.331

*p<0.05: Statistically significant; SD: Standard Deviation; HV: Hallux Valgus; n: number; Effect size was calculated using Cohen's d formula; [a] : Independent Sample Test.

A weak positive correlation was found between right-sided HV angles and right-sided Q angles (r=0.446, p=0.013) (Table 3).

Table 3. *The Relationship Between Hallux Valgus Angle and Q Angle in All Participants*

		Q Angle Right		Q Angle Left	
		r	p	r	p
HVA (°)	Right	0.446[a]	0.013*	0.269	0.151
	Left	0.322	0.083	0.070	0.714

*Pearson correlation coefficient; r: correlation coefficient; [a] : Weak correlation (.26–.49); *p<0.05: Statistically significant; HVA: Hallux Valgus Angle.

When the relationship was analyzed according to the groups, a moderate positive correlation was found between right-sided HV angles and right-sided Q angles in the control group (r=0.533, p=0.041) (Table 4).

Table 4. The Relationship Between Hallux Valgus Angle and Q Angle According to Groups

		HV Group				Control Group			
		Q Angle Right		Q Angle Left		Q Angle Right		Q Angle Left	
		r	p	r	p	r	p	r	p
HVA (°)	Right	-0.065	0.817	-0.028	0.922	0.533[a]	0.041*	0.363	0.183
	Left	-0.090	0.750	-0.189	0.501	0.277	0.318	-0.055	0.845

*Spearman correlation coefficient; r: correlation coefficient; [a] : Moderate correlation (.50 - .69); *p<0.05: Statistically significant; HVA: Hallux Valgus Angle.

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Discussion

In our study comparing Q angle in individuals with HV and healthy individuals, we found that there was no significant difference between both right and left side Q angle values in the HV and control group. Considering all participants, we found a weak positive correlation between right-sided HVA and right-sided Q angle. When we looked at the groups, we found a moderate positive correlation between right-sided HVA and right-sided Q angle in the control group.

Although not statistically significant, we reached a result close to significance in the difference between the right-side Q angles between the groups. Based on these findings, it was observed that the right Q angle exhibited a greater magnitude in the HV group compared to the control group. A problem occurring in more distal structures, such as the ankle and metatarsophalangeal joints, may cause disruption in a more proximal joint, such as the knee joint alignment (Powers, 2003; Rao et al., 2011; Robinson et al., 2006). Powers et al. (2003) reported that the Q angle is associated with several factors, including the position of the pelvis, rotation of the hip joint, rotation of the tibia, position of the patella, and alignment of the foot. Taking all these factors into account, the higher right-sided HVA in the HV group compared to the control group may contribute to the observed difference, which is close to significance, in the right-sided Q angles. Both female (n=23) and male (n=7) subjects were included in our study. Q angles and pelvic structures of women and men are different from each other (Aglietti et al., 1983; Caylor et al., 1993). It has been proven in the literature that the Q angle of women is larger than the Q angle of men (Nguyen & Shultz, 2007). If we had conducted our study only in women or men, the Q angle values between the HV and control groups might have been different, which might have affected the results.

In a study, Q angle was found to be related to knee and hip joint alignment (Nguyen et al., 2009). As the human body is a closed kinetic chain, an issue arising in one joint can kinesiologically and biomechanically impact the joints both above and below it (Shih et al., 2012). Disruption of the normal alignment and biomechanical structure of the foot due to a pathology such as HV may cause various changes in body structures, especially the knee and hip joints (Gerlach & Lierse, 1990; Menz et al., 2013). In the course of our investigation, we discerned a significant albeit weak correlation between HV and the Q angle. It is possible that HV has an effect on the Q angle, which affects the mechanics of the knee and hip joints. However, we found a weak correlation between HVAs and Q angles only on the right side in all individuals who participated in our study. In a previous study involving 25 women with HV

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and 24 healthy women, hip internal rotation, Q angle, and tibiofemoral angle were found to be highly correlated with HV (Steinberg et al., 2013). In congruence with existing literature, our study identified an association between HV and the Q angle, albeit manifesting at a modest level of significance. The reason for the lower level of the relationship we found may be attributed to the relatively smaller sample size and the inclusion of both male and female individuals in our study. The observed occurrence of the relationship exclusively on the right side may be attributed to the predominant right-sided extremities among the majority of individuals in our study. Greater load transfer to the dominant side may potentially result in mechanical problems. We think further investigations are deemed necessary to comprehensively explore the intricate relationship between the dominant limb, load transfer, and HV. It is understood that the reason for the relationship between HVA and the Q angle we found in our study is due to the control group. While lower HVA was associated with a lower Q angle, higher HVA was not associated with a Q angle as in the HV group. Even though the Q angle was higher on the right side in the HV group, these higher values did not cause a relationship with the Q angle. The relationship between HVA and Q angle in a normal foot seems to disappear when a pathology such as HV occurs in the foot.

Our study has some limitations. While we determined the sample size using power analysis, the outcomes of an investigation conducted with a larger sample size could potentially have exhibited variations. The unequal distribution of males and females prevented a gender comparison. It would have been better to make comparisons with different genders. Similar to our study, the universal goniometer is a widely used method for the evaluation of joint space and alignment in other studies. However, radiographic evaluations may give more precise measurement results in such studies. Finally, in our study, HVA and Q angle were measured while standing with equal load on both sides, that is, with the quadriceps muscle active. We think that performing the same measurements in the supine position, i.e., with the quadriceps muscle in a passive position, may be more appropriate for the clarity of the study.

Conclusion

The Q angles of individuals with HV and healthy individuals were similar. On the other hand, there was a weak correlation between HVA and Q angle. It is useful to consider HVA when evaluating the Q angle, which plays an essential role in lower extremity alignment. Furthermore, the proximity of the data obtained from our study to the statistical significance level suggests the need for studies involving a larger sample size.

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Declaration of Conflicting Interests

There is no conflict of interest between the authors.

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