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RESEARCH

Investigation of the relationship between hallux valgus, quadriceps angle, and body image perception in young adults

Genç yetişkinlerde hallux valgus, quadriseps açısı ve beden imge algısı arasındaki ilişkinin incelenmesi

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Abstract

Purpose: Our study aimed to identify the presence and severity of hallux valgus deformity in young adults, using both by the Manchester classification and goniometry, to evaluate the Quadriceps angle (Q angle), and to examine the relationship between some anatomical parameters and body image perception.
Materials and Methods: A total of 158 individuals aged 18-30 (111 females, 47 males) who voluntarily agreed to participate in the study were included. Demographic characteristics, Quadriceps angle, and hallux valgus angle were measured. Hallux valgus and Quadriceps angles were determined using a goniometer, while the Manchester scale was employed to evaluate the level of Hallux valgus deformity. The Golden Ratio for the lower extremity was calculated by taking the ratio of lower extremity length to leg length, and the body image perception score was determined.
Results: Body weight, height and body mass index showed statistically significant differences in terms of gender, while age parameter did not show statistically significant difference between genders. Also, no significant difference in Quadriceps angle was observed between genders for both right and left sides, while a significant difference in Hallux valgus angle was noted. A high, positive, and significant relationship was found between Manchester classification and hallux valgus, while Golden ratio values did not significantly differ by gender. Additionally, body image perception scores were higher in males (162.60±25.45 points) than in females (153.51±25.89 points).
Conclusion: Deviations from their normal values of the hallux valgus and quadriceps angle which affect the musculoskeletal system, may lead to some health problems, as well as difficulties in performing daily life

Öz

Amaç: Çalışmamızda genç yetişkinlerde hallux valgus deformitesinin varlığını ve şiddetini hem Manchester sınıflaması hem de gonyometre kullanılarak belirlemek, Quadriceps açısını (Q açısı) değerlendirmek ve bazı anatomik parametreler ile beden imge algısı arasındaki ilişkiyi incelemek amaçlanmıştır.
Gereç ve Yöntem: Çalışmaya gönüllü olarak katılmayı kabul eden 18-30 yaş arası 158 kişi (111 kadın, 47 erkek) dahil edildi. Demografik özellikler, quadriceps ve halluks valgus açıları ölçüldü. Ayrıca, hallux valgus ve quadriceps açısı gonyometre kullanılarak belirlenirken, hallux valgus deformite seviyesini değerlendirmek amacıyla aynı zamanda Manchester skalası kullanıldı. Alt ekstremite uzunluğunun bacak uzunluğuna oranı alınarak alt ekstremite için Altın Oran hesaplandı ve beden imge algısı skoru belirlendi.
Bulgular: Vücut ağırlığı, boy uzunluğu ve beden kitle indeksi cinsiyet açısından istatistiksel olarak anlamlı farklılık gösterirken, yaş parametresi cinsiyetler arasında istatistiksel olarak anlamlı farklılık göstermemiştir. Ayrıca, sağ ve sol tarafta quadriceps açısında cinsiyetler arasında anlamlı farklılık bulunmazken, hallux valgus açısı cinsiyetler arasında anlamlı farklılık göstermiştir. Manchester sınıflandırması ile hallux valgus arasında yüksek, pozitif ve anlamlı bir ilişki olduğu bulunurken, Altın oran değerleri cinsiyet açısından anlamlı farklılık göstermemiştir. Ayrıca, beden imge algısı skorunun erkeklerde (162,60±25,45 puan) kadınlardan (153,51±25,89 puan) daha yüksek olduğu bulunmuştur.
Sonuç: Kas iskelet sistemini etkileyen halluks valgus ve quadriceps açısının normal kabul edilen değerinden sapma göstermesi bazı sağlık problemini beraberinde getirmesinin yanısıra kişinin günlük yaşam aktivitelerini gerçekleştirmede zorluk ve bazı estetik kaygıların

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activities, and concerns about aesthetics. Failure to fulfil one's normal functions or not to find oneself aesthetically insufficient will also make it likely that the body image perception will deteriorate.
Keywords: Hallux valgus, quadriceps angle, manchester scale, body image perception, golden ratio,

yaşanmasına neden olacaktır. Kişinin normal fonksiyonlarını yerine getirememesi veya estetik açıdan kendini yeterli bulmaması da beden imge algısının bozulmasını muhtemel hale getirecektir.
Anahtar kelimeler: Halluks valgus, quadriceps açısı, manchester skalası, beden imge algısı, altın oran

INTRODUCTION

The foot, with its lever function, enables the body to move forward, thus fulfilling two crucial functions: walking and running. Composed of numerous small bones and divided into multiple joints within the region of the foot which can more easily adapt to uneven terrain. This adaptation prevents reliance solely on the activity of the gastrocnemius muscle and soleus muscle during forward movement. Capable of providing both stability and mobility depending on the activity, the foot is among the structures in the body that bear the most load. It also facilitates the transmission of proprioceptive sensory information essential for walking by ensuring the body's contact with the ground[1,2]. The direct impact of external and internal forces, their magnitude, and their variation on the foot stems from it being the region where the body weight and the reactive forces of the ground counterbalance each other. Sometimes, forces exceeding normal limits can cause mechanical disorders in the foot. If untreated, these can impose stress on higher-level structures, setting the stage for undesirable pathologies[1,3].

The complex anatomy of the foot allows it to adapt to rugged surfaces during heel strike and to become a rigid lever for better propulsion during take-off. Given the significance of these structures for daily life activities, the prevalence of foot-related injuries and pain is inevitable[4,5]. Factors such as gender (female), increased age and body mass index (BMI), prolonged standing, and the use of inappropriate footwear have been reported as significant underlying causes of foot deformities. Workplace safety encompasses both foot health and the wearing of appropriate footwear[6-8]. Common foot problems are reported to include calluses, deformities in the toes, pain, edema, pes planus, pes cavus, and varices[6,7]. Another study reported that the most common foot problem is the plantar fasciitis (7.8%), followed by hallux valgus (HV) (7.0%) and metatarsalgia (4.9%), and that healthcare workers are more prone to foot problems compared to other individuals[8,9].

The term hallux valgus (HV) was introduced by German surgeon Carl Heuter in 1871, describing the deformity as the lateral deviation of the hallux at the level of the metatarsophalangeal joint, causing a prominent medial metatarsal head with subluxation of the joint and its divergence from the median axis. The term "hallux" is Latin, referring to the big toe[10-12]. The deformity is accompanied by degenerative changes and various pathological conditions. Also, it is one of the most common deformities of the foot[11,12]. This condition often includes a bony protrusion on the medial side of the head of the first metatarsal bone, known as a bunion[12]. The literature frequently reports that with the increase in the degree of HV deformity, there arise aesthetic concerns such as dissatisfaction with the appearance of the foot, alongside difficulties in walking, balance, daily life activities, functional insufficiency, reduced quality of life, arch problems, foot pain, and the formation of bunions and calluses as secondary issues[13-15].

Body image encompasses perceptions, attitudes, and behaviors, with these factors playing an active role in the development of an individual's body image. Gender, age, body structure, the significance attributed to the body, and societal beauty ideals are among other factors affecting body image[16]. Body perception is an important concept that has evolved through accepted standards and preferences over time. The meaning and value each person attributes to their own body and its functions vary[17]. The Golden Ratio, represented by the Greek letter phi (ϕ) and discovered by the Italian mathematician Fibonacci, corresponds to the mathematical ratio of 1.618 obtained through the division of numbers. Additionally, the Golden Ratio can be encountered in morphometric measurements performed anatomically, from the proportions of the lower and upper extremities to the ratios between sections of these extremities. In the field of Plastic, Reconstructive, and Aesthetic Surgery, as well as in the planning of aesthetic operations, the presence and application of these proportions are considered and utilized[18-21].

The Manchester Scale was developed by Garrow to determine the degree and severity of hallux valgus deformity. It is a practical and clinical method that categorizes foot deformity severity (none, mild, moderate, severe) through a series of photographs, step by step, and then matches it with the patient's foot. The scale's validity and reliability have been established by various researchers[11,22,23]. The technique's standardization, which necessitates the ability to record the progression of the deformity prospectively and offers a non-invasive method, is said to have numerous advantages for identifying the deformity. Furthermore, in clinical settings, such a grading scale can reliably be used to record the degree of hallux valgus during initial assessments of patients, even before the onset of symptoms[22].

The Quadriceps angle (Q angle) is a parameter related to the bone structure and soft tissue condition of the lower extremity, developed for assessing the biomechanical status of the patellofemoral joint and is regularly used in clinics[24, 25]. This angle is formed between an imaginary line extending from the anterior superior iliac spine (ASIS) to the midpoint of the patella and a line from the tibial tuberosity to the center of the patella[25,26]. It is also the angle formed between the force vectors created by the combined pulling force of the quadriceps femoris muscle and the patellar tendon[24,27,28]. While the average Q angle is expected to be between 12°-20°, with 14° in males and 17° in females considered normal, an increase of 15° to 20° in the Q angle may lead to dysfunction in the knee extensor mechanism and patellofemoral pain[24,25,27,28].

Deviations from the normal values of hallux valgus and the Q angle, affecting the musculoskeletal system, will bring about health problems. Such conditions can negatively affect an individual's daily life activities and normal functionality, as well as cause aesthetic concerns. The inability to perform normal functions or feeling aesthetically insufficient may likely lead to body image disorders. Being aware of the presence of a deformity that may develop in the early period will not only reduce health costs, but will also pave the way for the person to take precautions to prevent the deformity from progressing. For this reason, the hypothesis of this study was to investigate the presence of HV deformity in young adults, does body mass index have an effect on quadriceps and hallux valgus angles or degree of HV and Body image scale?. Our study aims to identify the presence and severity of hallux valgus deformity in young adults, measured both by the Manchester classification and goniometry, to evaluate the Quadriceps angle (Q angle), and to examine the relationship between these anatomical parameters and body image perception.

MATERIALS AND METHODS

This study included 158 volunteers aged between 18 and 30 years (111 females, 47 males) who consented to participate. This study has been approved by the Cukurova University, Clinical Researches Ethics Committee, with Decision No:2021/117-75. Informed consent forms were signed by the individuals before any measurements were taken. Each measurement was repeated three times, and the averages were calculated. The measurements of the volunteers were taken while the person was in an anatomical position, distributing their body weight equally to both lower extremities. Additionally, sample photographs were taken with a digital camera to demonstrate the measurement points.

Data collection

Students agreeing to participate in the study were informed about the study's aim both written and verbal, and the consent was obtained. The questionnaire and other participation forms were completed in the classroom and after the questionnaire forms were filled out, the students were taken to the laboratory of Abdi Sütcü Vocational School of Health Services. Also, each participant was taken individually to the laboratory where the measurement was performed, and the measurements lasted approximately 60 min. by the researcher, one by one, to be measured. Measurements were carried out by the same researcher (E.T.). In order to increase the accuracy and reliability of the measurements, trial measurements were made and controlled by experts in this field (E.İ.I, and SP). Additionally, anthropometric dimensions were measured and recorded.

Sample

In the measurement and evaluation phase of this cross-sectional study, approximately 201 (two hundred and one) students were initially identified to participate. Seventeen (17) of these students chose to withdraw from the study during the measurement phase of their own volition. It was reported that three individuals had a history of trauma to the toe and foot area. Twelve (12) individuals were identified to have conditions related to the medial longitudinal arch (pes planus (flatfoot) in ten (10) individuals, and pes cavus (high arch) in two (2) individuals). Additionally, nine (9) females and two (2) males were excluded from the study because their dominant side was not the right side. In briefly, our sample group consists of healthy young individuals who agreed to participate in the study, met the inclusion criteria we determined for the study, and studied at Abdi Sütcü during the 2021-2022 academic year and 2022-2023 autumn semester.

Inclusion criteria for the study participants were not having undergone any surgery related to the lower extremities having no history of fractures related to the lower extremities and the vertebral column, not suffering from neurological, orthopaedic, and/or rheumatic diseases having no real leg length discrepancy and absence of congenital hip dislocation, pes planus (flat feet), and pes cavus (high arch).

Demographic data (age, body weight, height) of the participants were collected, and the Body Mass Index (BMI) was calculated. Body weight was measured using a digital scale, while height was measured using a stadiometer. BMI was calculated by dividing the body weight (kg) by the square of the height in meters (kg/m^2).

Measurements

Goniometric measurements

A universal goniometer is used in clinics to objectively measure and evaluate the normal range of motion of joints. In addition to assessing joint motion range, it is preferred for determining functional capacity, deciding on a treatment program, and assessing the effectiveness of treatment. The movement should be performed smoothly within a defined plane without any compensation. The fixed arm of the goniometer is placed on the non-moving part of the extremity, while the moving arm is aligned parallel to the region of the extremity that is planned to move. The pivot point should be placed in alignment with the axis of the actual joint [29]. The goniometer was used for two measurements including the quadriceps angle and hallux valgus angles.

Quadriceps angle (Q angle)

The Q angle is formed by the Q line of pull, extending from the center of the patella to the anterior superior iliac spine (ASIS) (Figure 1). The Q angle of both knees of the participants was measured while lying supine. One arm of the goniometer was positioned parallel to the ASIS, the other arm was placed on the tibial tuberosity, and the fixed arm was placed on the midpoint of the patella. The angle between the arms indicates the Q angle [27].

Hallux Valgus angle (HVA)

Measured while the person stands upright. The pivot point of the goniometer was placed on the first metatarsophalangeal joint, the fixed arm on the first metatarsal bone, and the moving arm parallel to the proximal phalanx[11,12,22,29].

Manchester scale

Developed to determine the level of HV deformity, this scale uses clinical tools including photographs of the foot to determine the level of Hallux valgus deformity. According to this scale, a score of 1 is considered in the absence of deformity. If the deformity is mild, the score is 2; if moderate, the score is 3; and if severe, the score is 4. At score 1, the first phalanx has a normal appearance. At score 2, the metatarsal bone has a minimum level of medial deviation, and the first phalanx has lateral deviation. At score 3, the medial deviation of the first metatarsal bone is increased, and the distal end bone protrusion becomes pronounced. Moreover, the first phalanx begins to orient beneath the second phalanx. Score 4 represents the most severe form of Hallux valgus, where ossification at the distal end of the first metatarsal bone is completely pronounced, and the deviation of the first phalanx beneath the second phalanx is complete[22] (Figure 2).

Body Image Perception Scale

Developed by Secord and Jourard in 1953, this scale was validated and adapted to the Turkish population by Hovardaoğlu in 1989, resulting in a 40-item scale. The scale is rated as "I do not like it at all" for 1 point, "I do not like it" for 2 points, "I am undecided" for 3 points, "I like it" for 4 points, and "I like it very much" for 5 points. In our study, the Cronbach's alpha value of the Body Image Perception scale was found to be 0.792. Hovardaoğlu, in his validity/reliability studies of the scale, calculated the Cronbach Alpha Internal Consistency Coefficient as 0.91 ($p<0.01$). Each item on the scale is related to an organ or part of the body (such as eyes, nose, arms, or face) or a function (such as the level of digestive activity) and scores range from 1 to 5. The scale allows for a minimum score of 40 and a maximum score of 200. The higher the score, the higher the level of satisfaction, indicating a positive body image perception[30].

Golden ratio

The ratio of body lengths to each other was examined. The lower extremity length and thigh length of the volunteers were measured with a tape measure. After obtaining the values, the lower extremity length was divided by the thigh length to calculate the lower extremity golden ratio[30-33].

Lower extremity length

While the weight was distributed equally to both extremities, the distance between the ASIS and the medial malleolus was taken as the reference. Any issues with the pelvis could affect this measurement, hence the measurement was conducted while standing. Additionally, during the measurement, the distance between the umbilicus and the ASIS was checked[29].

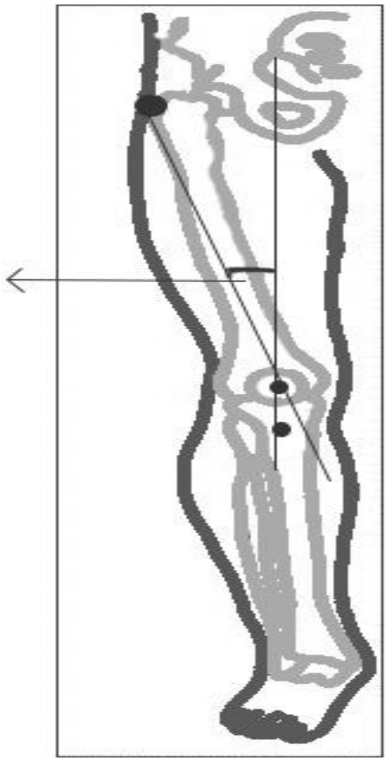

Figure 1. Schematic representation of the quadriceps angle

Leg length

In an anatomical position, the distance between the tibial tuberosity and the medial malleolus was taken as the reference. The measurement was made while the person was sitting with one leg crossed over the other[29].

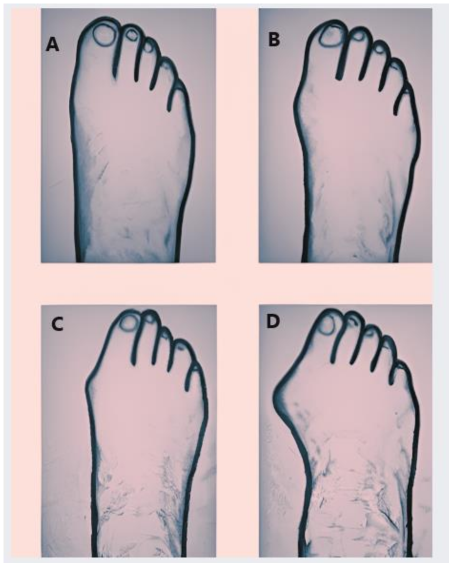

Figure 2. Manchester Scale: A: Normal; B: Mild; C: Moderate; D: Severe

Statistical analysis

For the statistical analysis of the data obtained in the study, the "Statistical Package for Social Sciences for Windows 21.0 (SPSS 21.0)" software was utilized. In evaluating the study data, descriptive statistical methods including mean, standard deviation (SD), minimum (min.), maximum (max.) values, and percentages were employed. The Kolmogorov-Smirnov normality test was used to decide which test method should be selected based on whether the data followed a normal distribution. The Mann-Whitney U Test was chosen for comparing non-normally distributed quantitative data (Quadriceps angle; demographic data, etc), while the ANOVA test was selected for normally distributed data (Hallux valgus, Body image scale, etc.). The Chi-Square test was used for the analysis of qualitative data. The Pearson correlation test was utilized to investigate the magnitude, direction, and significance of the relationship between two variables. Results were considered significant at $p<0.05$, within a 95%

confidence interval. For determining the correlation coefficient, the following scale was accepted: $0<r\leq0.19$ = Very weak; $0.2\leq r\leq0.39$ = Weak; $0.40\leq r\leq-0.59$ = Moderate; $0.6\leq r\leq0.79$ = Strong or High; and $0.8\leq r\leq1$ = Very strong or very high relationship[31].

RESULTS

The demographic data (age, height, body weight, and BMI) of the 111 females and 47 males participating in the study, along with mean and standard deviation values, are shown in Table 1. The study found the average age of females to be 20.49 ± 2.44, body weight 56.88 ± 9.21 kg, height 164.28 ± 6.23 cm, and BMI 21.06 ± 3.11 kg/m², while for males, these parameters were respectively 20.89 ± 2.41 years, 72.30 ± 11.03 kg, 176.02 ± 5.94 cm, and 23.32 ± 3.29 kg/m². As shown in Table 1, there was no statistically significant difference in the age parameter between females and males ($p>0.05$). However, significant differences were observed between females and males regarding body weight ($p<0.001$), height ($p < 0.001$), and BMI ($p<0.001$).

Table 1. Comparison of demographic data between genders

Demographic data	Females (n=111)	Males (n=47)	P value
	Mean±Standart Deviation (SD)	Mean±Standart Deviation (SD)	
Age (Year)	20.49±2.44	20.89±2.41	0.337
Body weight (kg)	56.88±9.21	72.30±11.03	<0.001
Height (cm)	164.28±6.23	176.02±5.94	<0.001
Body mass index (BMI;kg/m²)	21.06±3.11	23.32±3.29	<0.001

N: number; kg: kilogram; cm: centimeter; BMI: Body mass index; m²: square meter

Table 2. Comparison of quadriceps and hallux valgus angles in genders on the right and left side

Measurements	Females (n=111)	Males (n=47)	P value
	Mean±Standart Deviation (SD)	Mean±Standart Deviation (SD)	
Quadriceps Angle (Right)	12.20±2.14	11.83±2.26	0.332
Quadriceps Angle (Left)	12.04±2.13	11.81±2.34	0.552
Hallux Valgus Angle (Right)	8.78±4.56°	6.43±3.15	0.002
Hallux Valgus Angle (Left)	9.25±5.15	6.94±2.78	0.004

The comparison of Quadriceps (Q angle) and Hallux Valgus (HV) angles on the right and left sides for both genders is presented in Table 2. The Q angle for females on the right and left sides was 12.20° ± 2.14° and 12.04° ± 2.13°, respectively, while for males, it was 11.83° ± 2.26° and 11.81° ± 2.34°. Although there was no statistically significant difference in the Q angle between males and females ($p > 0.05$), the Q angle values for males were found to be lower on both sides compared to females. The HV angle for females was measured to be 8.78° ± 4.56° on the right side and 9.25° ± 5.15° on the left side, while for males, it was 6.43° ± 3.15° on the right side and 6.94° ± 2.78° on the left side. The HV angle showed a statistically significant difference between females and males on both sides ($p < 0.05$), with higher HV angles found in females ($p = 0.002$ and $p = 0.004$ respectively).

The comparison of the relationship between BMI with Q angle and HV angle is shown in Table 3. For females, the HV angle did not show a significant difference on the right and left sides according to BMI values ($p = 0.227$; $p = 0.314$). For males, the HV angle showed a statistically significant difference on the right side according to BMI ($p = 0.044$) but not on the left side ($p > 0.05$). However, it was found that HV values decreased on both sides as BMI increased. Additionally, although no statistically significant difference was found between Q angle and BMI for both females and males, a decrease in Q angle as BMI increased was observed. When evaluating the relationship between HV and Q angles with BMI for all participants, both angles were found to decrease inversely as BMI increased (Table 3).

The comparison of the Body Image Scale and Golden Ratio by gender is presented in Table 5. According to this table, statistically significant differences were found in lower extremity lengths and leg lengths between genders ($p < 0.05$). In contrast, no significant difference was found in Golden Ratio values derived from the ratio of lower extremity length to leg length by gender ($p > 0.01$). However, a statistically significant difference was found between genders in the Body Image Scale (p = 0.044) (Table 4). Severe HV deformity according to the Manchester classification was found only in females, with rates of mild and moderate HV deformity also higher in females compared to males. A statistically significant difference was observed between genders for the right foot according to the Manchester classification (p = 0.023), while no significant difference was found for the left foot (p = 0.120) (Table 5).

Table 3. Comparison of the relationship between body mass index and quadriceps and hallux valgus angle

Measurements		18.5< (underweight;n=25)	18.5-24.99 (normal; n=73)	25.00-29.99 (overweight; n=13)	P value
BMI of females (n=111)	Quadriceps angle (right)	12.72±2.19	12.16± 2.04	11.39±2.47	0.185
	Quadriceps angle (left)	12.44±1.83	11.99± 2.10	11.54±2.76	0.442
	Hallux valgus angle (right)	10.16±6.21	8.34± 3.90	8.61±4.13	0.227
	Hallux valgus angle (left)	10.52±6.61	8.74± 4.35	9.69± 6.07	0.314
BMI of males (n=47)	Quadriceps angle (right)	13.50±0.71	12.06± 2.23	11.00±2.31	0.206
	Quadriceps angle (left)	13.00±1.41	11.97± 2.43	11.23± 2.20	0.491
	Hallux valgus angle (right)	8.00±5.66	7.06± 3.24	4.62±1.81	0.044
	Hallux valgus angle (left)	8.00±5.66	7.47± 2.66	5.46±2.33	0.075
BMI Total (n=158)	Quadriceps angle (right)	10.00±6.09	7.95± 3.74	6.61±3.73	0.014
	Quadriceps angle (left)	10.33±6.49	8.35± 3.95	7.58±4.99	0.073
	Hallux valgus angle (right)	12.78±2.12	12.13± 2.09	11.19±2.35	0.027
	Hallux valgus angle (left)	12.48±1.78	11.98± 2.20	11.38±2.45	0.189

Table 4. Comparison of Body Perception Scale and Golden Ratio in terms of genders

Measurements	Females (n=111)		Males (n=44)		P value
	Mean	Standart Deviation (SD)	Mean	Standart Deviation (SD)	
Lower extremity length right (cm)	83.72	5.84	89.47	5.45	<0.001
Lower extremity length left (cm)	83.62	5.87	89.38	5.39	<0.001
Leg extremity length right (cm)	44.31	5.04	47.64	4.44	<0.001
Leg length left (cm)	43.92	5.13	47.60	4.51	<0.001
Golden Ratio (GR; LEL/LL) (right)	1.90	0.16	1.89	0.14	0.556
Golden Ratio (GR; LEL/LL) (right)	1.92	0.17	1.89	0.14	0.269
Body Image Scale	153.51	25.89	162.60	25.45	0.044

The comparison of the relationship between Manchester classification and BMI by gender is provided. It was observed that the parameter of no HV deformity was highest in individuals with normal weight for both genders. Additionally, 1 individual with severe HV deformity on the right side was categorized as underweight, and 2 as normal weight among females. On the left side, 1 individual with severe HV deformity was underweight, 2 were normal weight, and 1 was overweight. No severe form of HV was observed in males on either side. While a statistically significant difference was found for the right side according to BMI classification (p=0.023), no significant difference was observed for the left side (Table 6) (p=0.120). When evaluating the relationship between Body Mass Index, Gender, Hallux Valgus, Quadriceps angles, Manchester classification, and Body Image Score, especially Hallux Valgus, Q angle, and Manchester classification were found to have a statistically significant relationship with each other (Table 7).

Table 5. Comparison of Manchester categorisation in terms of genders by Chi-square method

Measurements	Females (N=111)		Males (N=47)	
Manchester Scale	Right	Left	Right	Left
A (Normal)	67 (60.36%)	67 (60.36%)	40 (85.11%)	36 (76.60%)
B (Mild)	28 (25.22%)	25 (22.52%)	5 (10.64%)	9 (19.15%)
C (Moderate)	13 (11.71%)	15 (13.51%)	2 (4.26%)	2 (4.26%)
D (Severe)	3 (2.70%)	4 (3.60%)	-	-
P value for gender (Right side)	0.023			
P value for gender (Left side)	0.120			

Table 6. Comparison of the relationship between Manchester classification and BMI in terms of gender

			BMI Values		
Gender	**Manchester Classification**		**18.5< (underweight)**	**18.5-24.99 (normal)**	**25.00-29.99 (overweight)**
Female (n=111)	**Right**	A	16 (%14.41)	45 (%40.54)	6 (%5.41)
		B	4 (%3.60)	20 (%18.02)	4 (%3.60)
		C	4 (%3.60)	6 (%5.41)	3 (%2.70)
		D	1 (%0.90)	2 (%1.80)	0 (%0.00)
	Left	A	14 (%12.61)	45 (%40.54)	8 (%72.07)
		B	6 (%5.41)	17 (%15.32)	2 (%1.80)
		C	4 (%3.60)	9 (%8.11)	2 (%1.80)
		D	1 (%0.90)	2 (%1.80)	1 (%0.90)
Male (n=47)	**Right**	A	1 (%2.13)	26 (%55.32)	13 (%27.66)
		B	1 (%2.13)	4 (%8.51)	0 (%0.00)
		C	0 (%0.00)	2 (%4.26)	0 (%0.00)
		D	0 (%0.00)	0 (%0.00)	0 (%0.00)
	Left	A	1 (%2.13)	24 (%51.06)	11 (%23.40)
		B	0 (%0.00)	7 (%6.31)	2 (%4.26)
		C	1 (%2.13)	1 (%2.13)	0 (%0.00)
		D	0 (%0.00)	0 (%0.00)	0 (%0.00)

A: No hallux valgus deformity; B: Mild Hallux valgus deformity; C: Moderate Hallux valgus deformity; D: Severe Hallux valgus deformity

Table 7. Relationship between body mass index, gender, hallux valgus, quadriceps angles, manchester classification and body image scale

Measurements	BMI	Q angle (Right)	Q angle (Left)	HV Right	HV Left	Manchester classification Right	Manchester classification Left	Body image scale	Gender
Body Mass Index	-	-0.211 0.008	-0.146 0.068	-0.228 0.004	-0.172 0.031	-0.082 0.308	-0.104 0.192	0.259 0.001	0.270 0.001
Quadriceps angle (Right)	-0.211 0.008	-	0.776 <0.001	0.246 0.002	0.187 0.019	0.207 0.009	0.122 0.126	-0.004 0.881	-0.078 0.332
Quadriceps angle (Left)	-0.146 0.068	0.776 <0.001	-	0.121 0.130	0.202 0.011	0.087 0.277	0.157 0.049	-0.023 0.776	-0.048 0.552
Hallux valgus angle (Right)	-0.228 0.004	0.246 0.002	0.121 0.130	-	0.792 <0.001	0.822 <0.001	0.660 <0.001	-0.139 0.081	-0.250 0.002
Hallux valgus angle (Left)	-0.172 0.031	0.187 0.019	0.202 0.011	0.792 <0.001	-	0.659 <0.001	0.810 <0.001	-0.191 0.016	-0.227 0.004
Manchester classification Right	-0.082 0.308	0.207 0.009	0.087 0.277	0.822 <0.001	0.659 <0.001	-	0.733 <0.001	-0.083 0.300	-0.231 0.003
Manchester classification Left	-0.104 0.192	0.122 0.126	0.157 0.049	0.660 <0.001	0.810 <0.001	0.733 <0.001	-	-0.157 0.048	-0.190 0.017
Body image scale	0.259 <0.001	-0.078 0.332	-0.048 0.552	-0.139 0.081	-0.191 0.016	-0.083 0.300	-0.157 0.048	-	0.160 0.044

DISCUSSION

Our study was conducted with the aim of identifying the presence and severity of Hallux Valgus deformity in young adults, measured both by the Manchester classification and goniometry, evaluating the Quadriceps angle, and determining the relationship between these anatomical parameters and body image perception. The Q angle is a regularly used measurement in clinics to assess the mechanics of the patellofemoral joint[24]. It is measured to evaluate the biomechanical status of the patellofemoral joint. Initially, Brattstrom (1964) defined it as the angle formed between the line of force produced by the patellar ligament and the quadriceps femoris muscle, extending to the patella [34]. The line on which the quadriceps femoris muscle exerts force is the direction in which the quadriceps femoris muscle-tendon applies its pulling force. Later, Insall (1976) described the technique for measuring the Q angle using the ASIS as the proximal reference point[35]. Additionally, the Q angle is considered an important factor in evaluating knee joint function and determining the health of the knee in individuals suffering from anterior knee pain [32, 33]. This angle assists in determining the force vector on the patella and the degree of lateral displacement in the patellofemoral joint[35]. It also aids in deciding whether surgical intervention is needed and in assessing the risk of disability arising from the condition[32,33]. The most commonly applied measurement method is the one used while lying down or standing, in the extension position of the knee joint, and during the contraction of the quadriceps femoris muscle. In the literature, other studies comparing Q angle measurements between genders in similar age groups have also found no statistically significant difference between male and female participants[36,37]. In our study, Q angle measurements were performed in a standing position. The clarity of the results on the difference between Q angle measurements in standing and supine positions has not been fully established. Some studies have indicated that the measurement position of the Q angle could affect the outcomes[38]. Shultz et al. (2006) and Guerra et al., (1994) in their studies measuring the Q angle in both supine and standing positions, have stated that the Q angle is independent of the measurement method and does not affect the measurement outcome, noting no statistically significant difference between the two measurement procedures[39,40]. Although there was no statistically significant difference in our study, the average Quadriceps angle on the right side was higher than on the left in both genders. Ebeye et al.' study similarly shows that the right Q angle is higher than the left for both genders[41]. While the larger measurement of the angle in females could be related to pelvic width, differences in the angle could also be associated with an individual's height or muscle strength[42]. Values of the Q angle above or below normal serve as a warning for potential knee joint pathologies. Studies involving athletes or non-athletes during adolescence have shown that athletes have better Q angle values, cartilage thickness, and volumes compared to non-athletes. According to the results of these studies, with increases in age, body weight, and height, Q angle values have been found to decrease at a statistically significant level[43,44]. When reviewing literature information according to gender differences, it has been confirmed by many studies that females' Q angles are larger than males' Q angles[32,42,43]. The difference in Q angles between females and males may be related to the difference in height between genders; that is, females have larger Q angles because their average height is shorter[36]. The Q angle can show age-related variations. It has been stated that the Q angle value is higher in individuals under 8 years of age and decreases gradually and significantly until the age of 17-21. It has been found that the right Q angle value is 5.73° ± 2.78° and the left Q angle value is 5.88° ± 2.55° in the age range of 17-21 years. In the literature, studies have shown that factors such as height, leg length, body weight, BMI, activity level, and the type of sport chosen can affect the Q angle, in addition to the age factor[45, 46]. Kumar and Arya (2023) reported a statistically significant relationship between the Q angle and BMI[47]. Although our study did not find a statistically significant difference between BMI and the Quadriceps angle, it was observed that the Q angle decreases as body weight increases. This suggests that body weight can influence the Q angle, and the lack of statistically significant difference might be due to the BMI values of the participants in our study not having a BMI of 30 and above. When comparing the average Body Mass Index and Q angle among all participants in our study, no statistically significant difference was found between BMI and the Q angle, both on the right and left sides. Olaniyan et al. (2012), in their study on healthy young adults, reported no statistically significant difference between BMI and the Q angle, which aligns with the findings of our study[48]. Contrary to this, a study conducted by Lan et al. in 2010 indicated that BMI significantly affects the Q angle[49]. The reason for obtaining a different result from ours in this study is thought to be due to the sample group consisting of patients experiencing knee pain, unlike our participants.

The term Hallux Valgus (HV) was introduced in 1871 by the German surgeon Carl Heuter, who defined the deformity as the lateral deviation of the hallux and its consequent distancing from the body's median axis. "Hallux" is a Latin term meaning "the biggest toe," and "valgus" refers to its position away from the body's longitudinal axis[10]. The normal value for the hallux valgus angle, which is the angle between the longitudinal axis of the proximal phalanx of the hallux and the longitudinal axis of the ossa metatarsi I, is between 5°-15°. Values below 0° are considered hallux varus or adductus. According to Mann Coughlin's classification, an HV angle less than 20° is termed as mild bunion deformity, between 21°- 40° with subluxation at the first metatarsal joint as moderate bunion deformity, and more than 40° as severe bunion deformity[12,50].

This condition often accompanies a bone formation known as a bunion on the medial side of the head of the first metatarsal bone. Furthermore, as the deformity progresses, the lateral displacement of the hallux sets the stage for the development of claw and hammer toe deformities in other digits of the foot. The hallux is in a pronation position, with relaxation in the abductor hallucis brevis muscle and contracture in the adductor halluces muscle. Additionally, the flexor tendons have shifted laterally. It is also a progressive deformity that alters the anatomy and biomechanical structure of the foot[10, 12]. Factors responsible for HV deformity include both intrinsic and extrinsic factors such as pronation position of the hindfoot, pes planus, contracture of the Achilles tendon, increased joint laxity, gender, genetic predisposition, neuromuscular disorders, the use of inappropriate footwear with high heels and a narrow toe box, a long big toe, and a rounded the head of the first metatarsal bone[10,11,51,52].

A meta-analysis on the prevalence of HV has reported an increasing trend with age: 7.8% in youths (16 studies, n = 73,030), 23% in adults aged 18-65 (15 studies, n = 23,790), and 35.7% in the elderly (37 studies, n = 16,001) [53]. In Turkey, the prevalence of HV is reported to be approximately 54.3 percent[54]. It was reported that the main reason for the prevalence of HV deformity in females or accelerating the deformity was the use of inappropriate footwear [10, 11]. HV angle showed a statistically significant difference in females compared to males for both right and left foot ($p<0.05$). At the same time, the mean HV angle measurements of females were found to be higher than males. According to the results of another meta-analysis including 76 studies with a total of 496,957 participants, the prevalence of HV in the general population was calculated as 13% in males and 30%

in females [53]. In another study investigating the prevalence of HV among university students, it was reported that HV was more common in female students (11%) than male students (5%) [55]. These results are similar to the results obtained in our study.

When comparing the relationship between BMI and Hallux Valgus (HV) measurements in males and females, no statistically significant difference was observed in BMI (except for the right HV angle in males). HV angles in females reached their highest values among participants in the underweight category, whereas the lowest values were recorded in those in the normal weight category. In males, an increase in BMI led to a decrease in HV angle, and a similar inverse relationship between HV and BMI was observed when examining the data from 111 females and 47 males, totaling 158 participants. Studies investigating the relationship between BMI and HV have reported conflicting results, with an increase in BMI associated with a decrease in HV angle. According to the study by Nguyen et al. (2010), the relationship between Hallux Valgus and BMI in males does not appear to be linear [56]. Males with overweight and obesity were found to have a higher likelihood of possessing hallux valgus compared to males with a normal BMI. In the same study, a significant reduction in the average measurement of hallux valgus was observed as BMI increased in females. The discrepancies between our findings and those of Nguyen et al. might be attributed to the older average age of participants in Nguyen et al.'s study. Additionally, the observed inverse correlation between BMI increase and the prevalence of hallux valgus in females might be due to the likelihood of females with a normal BMI wearing tighter or more narrowly toed shoes compared to their overweight and obese counterparts. Cho et al. (2009), in a study that explored the impact of BMI on individuals with HV, found that people with HV deformity exhibited higher BMIs [57]. Nguyen and colleagues (2010), in a population-based study of 600 individuals, identified a significant positive correlation between increasing BMI and HV in males, whereas obesity was suggested to act as a protective factor against HV in females[56]. Additionally, a study conducted by Frey and Zamora (2007) on 1,411 patients from orthopaedic practices in the United States reported that patients with a normal BMI were more likely to have HV compared to those who were overweight or obese[58].

The Manchester Scale, developed by Garrow, is used to determine the degree and severity of Hallux Valgus (HV) deformity. The scale evaluates the degree of HV deformity in four levels: none (1), mild (2), moderate (3), and severe (4). Additionally, it is used as a clinical observational tool that includes four different photographs of the foot. The Manchester Scale is a convenient and practical method that categorizes the severity of foot deformity (none, mild, moderate, and severe) through a series of photographs, matching them with the patient's foot. The validity and reliability of the scale have been established by numerous researchers[11,22,23]. The use of standardized photographic measurements in the Manchester scale means that learning and applying the Manchester scale technique requires minimal skill. The standardization of the technique offers numerous advantages for determining the progression of the deformity prospectively and provides a non-invasive method of measurement. In our study, the degree of HV was evaluated not only by angle measurement but also using the Manchester scale. The Manchester scale is simple to use and has excellent inter-observer repeatability, making it suitable for clinical and research purposes[22]. According to the Manchester scale, Hallux valgus deformity was not observed in 67 females and 40 males on the right side, while mild deformity was found in 28 females and 5 males. Additionally, moderate deformity was present in 13 females and 2 males, and severe HV deformity was observed in 3 females. On the left side, Hallux valgus deformity was not detected in 67 females and 36 males, mild deformity was observed in 25 females and 9 males, and moderate HV deformity was found in 15 females and 2 males. No severe Hallux valgus deformity was found in males on either the right or the left side. The most likely reason for this could be the significantly different shoe-wearing habits of males and females. Females' frequent choice of narrow-toed flats or high-heeled shoes predisposes them to HV.

In a study that included participants with mild and moderate deformities according to the Manchester scale, without distinguishing between males and females, the findings reported the presence of 30 participants with mild severity and 30 with moderate severity on the right side, and 28 with mild severity and 32 with moderate severity on the left side[59]. In another study aimed at the radiographic validation of the Manchester scale for classifying HV deformity, which included 31 male and 64 female participants, the distribution was as follows: for the right foot, 24 participants with mild severity, 17 with moderate severity, and 6 with severe deformity; for the left foot, 22 with mild severity, 19 with moderate severity, and 12 with severe deformity[59]. Similar to our study, this research also observed a decrease in numbers with increasing severity. HV is one of the most common musculoskeletal disorders in the foot and is associated with pain arising from various conditions such as osteoarthritis, patellofemoral knee pain, and rheumatoid arthritis[59].

The original name of the scale developed by Secord and Jourard in 1953 is the Body-Cathexis Scale (BCS)[17]. The level of satisfaction an individual has with their body parts or functions is indicated by the high scores obtained from the scale, while dissatisfaction is reflected in lower scores (17,30). In our study, the Cronbach's alpha value was found to be 0.792. Body image encompasses perceptions, attitudes, and behaviors. Perception involves how an individual visualizes their body size and shape, attitude pertains to what a person cognitively and emotionally thinks about their body and how closely it fits the ideal body image, and behavior is how an individual responds to these two components (such as eating habits or engaging in excessive exercise, dieting). These three factors play an active role in the development of an individual's body image. Gender, age, body structure, the significance attributed to the body, and societal beauty ideals are among the factors affecting body image [16]. Body perception is an important concept that has evolved through accepted standards and preferences over time. The importance placed on physical appearance or the concept of beauty is associated with an individual's weight and the conformity of their body to an ideally accepted shape, and since this is transmitted across all societies, people are tied to the necessity of a common appreciation. The meaning and value each person assigns to their body parts and their functions differ. Therefore, an individual's body image may not align with others' perceptions of their body[17]. In a study investigating the relationship between foot pathology and its impact on psychopathological variables, it was reported that patients with at least one-foot pathology had higher levels of stress and depression[60]. This situation is also related to how individuals monitor and perceive their own bodies. Therefore, in our study, the body image perception scores of participants were also examined. The average body image perception showed a statistically significant difference between male and female participants ($p<0.05$), with females scoring lower on body image perception compared to males. Body image affects females more than males in today's society [61]. In the study by Matsumoto et al., the HV angles of males and females with HV were measured, and participants were asked to estimate their degree of deformity. A negative deviation of 8.5 degrees in males and 13.1 degrees in females was determined. This study also reported that an angular deviation of 20 degrees from the normal limit marks the threshold where the effects on body image perception become significant [62]. While it is stated that aesthetic concerns are among the primary complaints of patients with HV and leg structure disorders, it is emphasized that, regardless of the patient's complaints, aesthetic concerns, especially in females, should never be overlooked[63].

The Golden Ratio is a geometric and numerical value considered to give the most ideal ratios in terms of harmony in mathematics and art. Although its first emergence is not clear, it is known that the Egyptians and Greeks conducted some studies on this subject[18]. Scientists and artists use the human body, determined according to the Golden Ratio, as a measure in their research and works[19]. In our study, the Golden Ratio of the lower extremities, one of the ratio-proportion systems in the human body, was examined. Statistically non-significant results were found for the Golden Ratio in both legs of males and females ($p>0.01$). For females, the result was 1.90 ± 0.16 for the right leg and 1.92 ± 0.17 for the left leg; for males, it was 1.89 ± 0.14 (1.8875 ± 0.1399) for the right leg and 1.89 ± 0.14 (1.8878 ± 0.1388) for the left leg. According to the results of a study examining the Golden Ratio calculations of the human body in adults, the average Golden Ratio of the lower extremities was calculated as 1.94[64].

The study has some limitations: Data were collected from a single center. The type of footwear used by the person could be questioned. Additional research utilizing a larger sample would significantly advance the overall research and provide more comprehensive reference data.

Considering the findings of the study, it can be said that BMI has an effect on HV and the Q angle. The fact that males have higher body image perception scores compared to females might indicate that males have a more positive body image, encompassing perceptions, attitudes, and behaviors, compared to females. Additionally, females's closer follow-up on fashion and prioritizing aesthetic values, along with their use of high heels, flats, and narrow-toed shoes, could be cited as reasons for their frequent exposure to foot deformities. Therefore, deviations from the normal values of HV and the Q angle, affecting the musculoskeletal system, may lead to health problems. Such conditions can negatively affect an individual's daily life activities and normal functionality, as well as cause aesthetic concerns. The inability to perform normal functions or feeling aesthetically insufficient may likely lead to body image disorders.

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