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Assessment of quadriceps angle in children aged between 2 and 8 years

2–8 yaş arası çocuklarda kuadriseps açısının değerlendirilmesi

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The known about this topic

Q angle is a measurement index used in the assessment of knee function and patellofemoral joint kinetics. If the literature is examined, it can be observed that Q angle is used to determine knee deformities such as genu varum-genu valgum and especially patellar femoral instability, or lower extremity alignment in conditions including cerebral palsy. A Q angle of 8-15° in heathy adult men and 12-19° in women is considered normal. Normal values may show variance by some factors including ethnicity, age, sex, and presence of pes planus.

Contribution of the study

Our study gives an idea about the normative values of Q angles in children. The study showed that the Q angle reduced with advanced age in healthy children aged between 2 and 8 years. It was found that the Q angle value in children was not dependent on factors such as sex, presence of pes planus, and measurement position. It was observed that there was a low-level association between body mass index and the Q angle.

Abstract

Aim: The quadriceps angle is the angle between the line drawn from the spina iliaca anterior superior to the midpoint of the patella, and the line drawn from the midpoint of the patella to the tuberositas tibiae. It is important for lower extremity posture. The aim of this study was to determine the normative quadriceps angle value by measurement, and to assess the probable effect of factors such as measurement position, age, sex, and presence of pes planus on these values.

Material and Methods: A total of 599 children consisting of 296 (49.4%) girls and 303 (50.6%) boys aged between 2 and 8 years, were included in the study. The children were divided into three groups by age as 2–4 years, 4–6 years, and 6–8-years. After the children's demographic data were collected, the quadriceps angle was measured using an electronic goniometer. Pes planus was assessed by drawing the Feiss line.

Results: In bilateral measurement, it was found that the quadriceps angle decreased with age both in the supine and standing positions ($p<0.05$). It was observed that sex and presence of pes planus had no effect on the quadriceps angle independent from measurement positions ($p>0.05$). A low negative correlation was found between body mass index and the quadriceps angle in both measurement positions ($p<0.05$).

Öz

Amaç: Kuadriseps açısı spina iliaka anteriordan patella orta noktasına çizilen hat ile patella orta noktasından tibial tüberküle çizilen hat arasındaki açıdır ve alt ekstremite postürünün belirlenmesinde önemlidir. Bu araştırmanın amacı 2–8 yaş arası çocuklarda kuadriseps açısını ölçerek normal değerini belirlemek; yaş, cinsiyet, ölçüm pozisyonu ve pes planus varlığı gibi etmenlerin ölçümlere olabilecek olası etkisini değerlendirmektir.

Gereç ve Yöntemler: Yaşları iki ile sekiz arasında değişen 296 (%49,4) kız, 303 (%50,6) erkek olmak üzere toplam 599 çocuk değerlendirmeye alındı. Çocuklar yaşlarına göre 2–4, 4–6 ve 6–8 yaş olmak üzere üç gruba ayrıldı. Çocukların demografik bilgileri alındıktan sonra sırtüstü ve ayakta iken kuadriseps açıları elektronik gonyometre yardımı ile ölçüldü. Feiss çizgisi çizilerek pes planus varlığı değerlendirildi.

Bulgular: Ayakta ve sırt üstü pozisyonda yapılan iki taraflı ölçümlerde çocukların kuadriseps açılarının yaşla birlikte azaldığı saptandı ($p<0,05$). Cinsiyetin ve pes planus değerlerinin pozisyondan bağımsız olarak kuadriseps açısı değerlerini etkilemediği bulundu ($p>0,05$). Her iki ölçüm pozisyonunda da vücut kütle indeksi ile kuadriseps açısı arasında düşük düzeyde negatif ilişki saptandı ($p<0,05$).

Cont. ➡

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Conclusion: It was found that positional changes and weight bearing on limbs did not cause any change in knee position in healthy children. We consider that the decrease in quadriceps angle in this age group is due to growth rate asymmetry between the femur shaft and pelvic diameter.

Keywords: Genu valgum, genu varum, knee, patella

Çıkarımlar: Sağlıklı çocuklarda pozisyon değişiklikleri ve ekstremite üzerine ağırlık vermenin diz pozisyonunda değişikliğe sebep olmadığı görüldü. Kuadriseps açısının 2–8 yaş arası çocuklarda giderek azalmasının femur boyunun pelvis çapına göre orantısal olarak daha fazla büyümesinden kaynaklandığı düşünülmektedir.

Anahtar sözcükler: Diz, genu valgum, genu varum, patella

Introduction

The quadriceps angle (Q angle) was first defined by Brattström (1), and has become a widely used assessment method by orthopedicians, physiotherapists, and other healthcare professionals in the evaluation of certain pathologies or tendencies to pathology that may be observed in the lower extremities.

The Q angle is a measurement used in the evaluation of the function of the knee and kinetics of the patellofemoral joint (2). In the literature, this measurement has recently been used with the objective of determining the alignment of the lower extremities in conditions including genu varum-valgum (especially patellofemoral instability) or cerebral palsy (3–5). In addition, studies have also examined the association of the Q angle with static and dynamic balance (6). The Q angle gives an idea about the direction of the net lateral force occurring in the patella as a result of contraction of the quadriceps muscle (7). A Q angle of 8–15° in men and a Q angle of 12–19° in women is considered normal (8–12). Normal values may show variance depending on some factors including ethnicity, age, sex, and presence of pes planus (8, 10, 11, 13–15).

A Q angle below or above the normal value increases the risk of exposure to some musculoskeletal problems in the lower extremities according to the degree of aberration (16, 17). An angle above the normal value causes some problems including anterior knee pain, joint instability, and patellofemoral pain syndrome by leading to an increase in the lateral patellofemoral comp active force (16, 18–22).

Although the normal values of the Q angle have been specified in studies in the literature, there are also studies reporting that variations may be observed in these angular values depending on some factors including sex, age, and measurement position (10, 13, 14, 23). In addition, as far as we know, no studies have evaluated individuals aged under 8 years among studies focusing on the effect of age on the Q angle (14, 19, 23–29). In this context, we aimed to determine normal Q angle values in children aged between 2 and 8 years by measuring the relevant angles and to evaluate the potential effect of factors such as age, sex, and presence of pes planus on measurements.

Material and Methods

A total of 599 healthy children aged between 2 and 8 years including 296 girls and 303 boys who studied in kindergartens and elementary schools in the province of Bolu, were included in the study.

The parents of the children were informed about the study and written informed consents were obtained. This study was conducted in accordance with the Declaration of Helsinki after obtaining the required approvals from Bolu Abant İzzet Baysal University Human Research in Social Sciences Ethics Committee (02.09.2015-2015/122) and the provincial directorate for national education.

The study exclusion criteria were specified as history of knee surgery; neurologic, orthopedic or metabolic diseases involving the lower extremities, and extremity shortness of more than 2 cm.

Following preliminary consideration, individuals aged between 2 and 8 years were selected using the layering technique. Layering was based on the individuals' ages, and three groups including those aged 2–4 years, 4–6 years, and 6–8 years, were established. The individuals' Q angles were measured and the presence of pes planus was evaluated.

In addition to measurements and assessments, the participants' demographic and physical characteristics including age, height and body weight were also recorded.

Q angles were measured bilaterally while the participants were standing and in the supine position by experienced physiotherapists. The measurement was primarily performed in the supine position. Before measurement of Q angles in the supine position, the reference points including the patellar center, spina iliaca anterior superior (SIAS), and tuberositas tibia were palpated and marked using an acetate pen. Before taking the measurement, the individuals were positioned such that the hips and knees were in extension, the quadriceps muscles were relaxed, and the legs and ankles were neutral. Following marking, one of the arms of the electronic goniometer was placed such that the SIAS and the patellar middle point were combined, and the other arm was placed so that the tuberositas tibia and the patellar center were combined (Fig. 1, 2). The measurement value was recorded after the electronic goniometer was placed (1, 30).

Figure 1. Measurement of Q angle in the supine position

Figure 2. Measurement of Q angle in the standing position

For measurement of the Q angle in the standing position, the same measurement procedure was performed besides positioning the subjects. Before measurement, the individuals were positioned such that the feet were shoulder width apart and directed right across (25).

Pes planus was evaluated using the Feiss line method. In the standing position, the participants' 1st metatarsophalangeal joints were marked using an acetate pen by palpating the tuberositas navicularis, medial malleolus, and scaphoid tubercle. Following marking, the line known as the Feiss line was drawn such that these points were combined. Following drawing, the position of the scaphoid tubercle with respect to the line was evaluated. First- degree pes planus is defined as lowering of the scaphoid tubercle about one-third of the distance between the Feiss line and the ground. Second-degree pes planus is defined as lowering of the scaphoid tubercle about two-thirds of the distance between the Feiss line and the ground. Third-degree pes planus is defined as placement of the scaphoid tubercle completely on the ground (31).

Table 1. The participants' demographic and physical data

	Min.	Max.	Mean	SD
Age (years)	2	8	4.76	1.60
Body weight (kg)	12.4	53	20.51	5.15
Height (m)	0.90	1.54	1.11	0.09
BMI (kg/m^2)	10.48	38.06	16.19	2.28

Min.: Minimum; Max.: Maximum; SD: Standard deviation; BMI: Body mass index

Table 2. Effect of sex on Q-angle

	Female	Male	p
Q-angle[a] (right)	13.32±1.17°	13.30±1.21°	0.637
Q angle[a] (left)	13.29±1.14°	13.25±1.22°	0.717
Q-angle[b] (right)	13.30±1.16°	13.27±1.22°	0.583
Q angle[b] (left)	13.29±1.18°	13.25±1.23°	0.617

a: Measurement data in the supine position; b: Measurement data in the standing position. Independent samples t-test

Statistical Analysis

The SPSS 20 program was used in analysis of the data and a p value of <0.05 was considered significant. The effect of sex on Q angles was examined using the t-test in independent groups. The effects of age groups and the degree of pes planus on Q angles were examined using one-way analysis of variance (ANOVA) and Bonferroni test. The relationship of body mass index (BMI) with the Q angle was examined using Pearson's correlation test.

The mean effect size was found as 0.17 in G*Power analysis performed using the results of the study conducted by Sendur et al. (32). With this effect size, an α value of <0.05 and a β value of 95%, the required sample size was calculated as 540 (33).

Results

The demographic data of the individuals included in the study are shown in Table 1.

In all age groups, it was observed that the girls' mean Q angle values and the boys' mean Q angle values were similar. No significant differences were found between the right and left Q angle values in all age groups in both sex groups (Table 2).

It was found that 455 (76%) of the children included in the study had different degree of pes planus according to

Table 3. Changes in Q-angle by age

	2–4 years (n=196)	4–6 years (n=203)	6–8 years (n=200)	p
Q-angle[a] (right)	14.16±0.67°	13.10±1.36°	12.69±0.91°	<0.001
Q-angle[a] (left)	14.11±0.67°	13.06±1.37°	12.67±0.87°	<0.001
Q-angle[b] (right)	14.10±0.67°	13.08±1.41°	12.71±0.87°	<0.001
Q-angle[b] (left)	14.07±0.69°	13.06±1.43°	12.69±0.90°	<0.001

a: Measurement data in the supine position; b: Measurement data in the standing position. One-way ANOVA p<0.05

Table 4. Q-angle variance between the groups

			Mean difference	p
Q-angle[a] (right)	2–4 years	4–6 years	1.05°	<0.001
	2–4 years	6–8 years	1.46°	<0.001
	4–6 years	6–8 years	0.40°	<0.001
Q-angle[a] (left)	2–4 years	4–6 years	1.04°	<0.001
	2–4 years	6–8 years	1.43°	<0.001
	4–6 years	6–8 years	0.38°	<0.001
Q-angle[b] (right)	2–4 years	4–6 years	1.02°	<0.001
	2–4 years	6–8 years	1.38°	<0.001
	4–6 years	6–8 years	0.36°	**0.001**
Q-angle[b] (left)	2–4 years	4–6 years	1.01°	<0.001
	2–4 years	6–8 years	1.38°	<0.001
	4–6 years	6–8 years	0.37°	**0.001**

a: Measurement data in the supine position; b: Measurement data in the standing position. One Way ANOVA and Bonferroni test

Table 5. Change in Q-angle by pes planus

	None (n=144)	1st degree (n=244)	2nd degree (n=192)	3rd degree (n=19)	p
Q-angle[a] (right)	13.33°±1.39°	13.35°±1.04°	13.31°±0.97°	12.65°±2.59°	0.108
Q-angle[a] (left)	13.29°±1.36°	13.32°±1.03°	13.28°±0.95°	12.57°±2.66°	0.070
Q-angle[b] (right)	13.26°±1.45°	13.32°±1.01°	13.33°±0.93°	12.65°±2.62°	0.113
Q-angle[b] (left)	13.25°±1.47°	13.30°±1.03°	13.32°±0.94°	12.64°±2.63°	0.131

a: Measurement data in the supine position; b: Measurement data in the standing position. One Way ANOVA

the Feiss line method. Two hundred twenty-four children (40.7%) had first-degree pes planus, 192 children (32.1%) had second-degree pes planus, and 19 children (3.2%) had third-degree pes planus; 144 children (24%) had no pes planus. In the distribution, first-degree pes planus was observed with the highest percentage, and third-degree pes planus had the lowest percentage.

A significant difference was found between the Q angle measurements performed in the standing and supine positions in all age groups, and it was observed that the Q angle value decreased with age (p<0.05) (Table 3). As a result of post hoc analysis performed to determine from which group this difference originated, it was found that there was difference between all age groups (p<0.05) (Table 4).

When the individuals were divided according to the degree of pes planus, it was found that the Q angle values both in the standing and supine positions were similar (p>0.05) (Table 5).

A negative low-level correlation was found between the Q angle values obtained in the standing and supine positions and BMI (Table 6).

Discussion

Our study showed that the Q angle decreased with age in healthy children aged between 2 and 8 years, and the value was not dependent on factors such as sex, presence of pes planus, and measurement position, and there was a low-level correlation between BMI and Q angle.

Table 6. Effect of BMI on Q-angle

	BMI	Q-angle[a] (right)	Q-angle[a] (left)	Q-angle[b] (right)	Q-angle[b] (left)
BMI	1	-280	-294	-297	-293
		p<0.05	p<0.05	p<0.05	p<0.05
	599	599	599	599	599
Q-angle[a] (right)		1	0.991	0.953	0.962
			p<0.05	p<0.05	p<0.05
		599	599	599	599
Q-angle[a] (left)			1	0.958	0.967
				p<0.05	p<0.05
			599	599	599
Q-angle[b] (right)				1	0.989
					p<0.05
				599	599
Q-angle[b] (left)					1
					599

BMI: Body mass index; a: Measurement data in the supine position; b: Measurement data in the standing position. Pearson Correlation Analysis

In all age groups, a significant reduction in the mean Q angle value was observed with age, similar to existing studies. We think that the change in muscle strength with age was effective in this reduction. The study conducted by Guerra et al. (8), which emphasized that the Q angle decreased depending on the increase in quadriceps muscle strength, supports our opinions. Another factor in the reduction in the Q angle might be the fact that femoral height increase was proportionally greater compared with pelvic enlargement among the age groups in our study.

When the girls and boys were compared in our study, it was found that the Q angle values were similar in all age groups. We think that the similar values found in both sexes was associated with the similar heights in the groups (p=0.793). The study conducted by Grelsamer et al. (34) related to Q angle, also supports this view. Another factor related to there being no significant difference between the mean Q angle values by sex, was inadequate completion of some age-dependent and sex-specific characteristic morphologic differentiations including pelvic width and femoral length. The fact that the age range in our study did not include the adolescence period, and the study conducted by Horton and Hall (13) related to this issue confirms our hypothesis.

Another factor influencing the Q angle is deformities observed in the ankle (15). Elvan et al. (35) reported that the foot tended to pronate and the amount of load carried in the medial side increased with an increase in the Q angle, whereas a decrease in the Q angle caused supination in the foot and greater load in the lateral side. In addition, they reported that the most important marker influencing the Q angle was navicular height. In the individuals included in our study, no significant difference was found between pes planus, which is a foot deformity, and the mean Q angle value. We think that this finding was associated with the fact that the distribution of pes planus between the groups was homogeneous, and there was a limited number of individuals with second- and third-degree pes planus. Finally, we believe that the high number of cases of first-degree pes planus might be a factor depending on our method of measurement.

In many studies, it has been emphasized that measurement position caused a change in Q angle (19, 36). When we compared the mean Q angle values measured in the supine and standing positions in our study in this context, no significant difference was found. We think that lack of a difference between measurement positions was associated with compensation of increased pelvic width by way of lateral movement of the patella, as stated by Guerra et al. (8). Another factor is the fact that standardization of the measurement position has not yet been provided (19, 25, 36). In the literature, the Q angle has been measured in the supine position with the knee in 20–25° flexion in some studies, and it has been measured with the knee in extension in some other studies, similar to our study (25, 27, 30).

In many studies, it has been reported that BMI had no statistically significant effect, though it does cause an increase in the Q angle (37, 38). Similar to other studies, a

low-level negative correlation was found between BMI and Q angle in both measurement positions in our study. We think that the low-level of correlation between Q angles and BMI is primarily associated with the fact that the BMI values of the individuals included in the study were in the normal range. In addition, this low-level correlation, which indicates that Q angles decrease as BMI increases, shows that a tendency to mild genu varum in the knee occurs with an increase in BMI in the age group that was included in our study.

Finally, when we compared the mean Q angle values found in existing studies and in our study, our values were similar to some studies (23, 24), but different from other studies (14, 25, 29), though our age range was different from the studies in the literature. At this point, we are faced with the fact that age and ethnicity lead to variance in measurement values, as emphasized in many studies (19, 28). In this context, normal mean Q angles for other age groups in our community should be prospectively specified and measurements including Q angles and pes planus should be assessed using more objective methods including photoshoot and radiologic imaging. In addition, we recommend that the statistically significant results found in our study should also be assessed by clinics of pediatrics in order to determine if they were clinically significant.

The lack of detailed and objective posture assessment and the fact that the potential effect of posture on Q angle was not specified are among the limitations of our study.

Ethics Committee Approval: The study was conducted in accordance with the principles of the Declaration of Helsinki. Approval was obtained from Bolu Abant İzzet Baysal University Human Research in Social Sciences Ethics Committee (02.09.2015/122).

Informed Consent: Written consent was obtained from the parents of all children.

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