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Age related changes in the Q angle of non-professional football players

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ABSTRACT

Background: Football practice involves a great muscular demand, leading to the development of the lower limbs that, on occasions, can cause deviations from the normal anthropometric values. The quadriceps angle (Q angle) is a value often taken as a reference for the alignment of the lower limbs.

Objective: To observe the changes of the Q angle in young football players, because of muscular effort, analyzing the differences between four groups of different ages and to determine whether the playing position might influence these variations.

Methods: A cross sectional study was carried out with 104 male subjects divided into four groups according to age: under 8 years-old, 8-17 years-old, 17-21 years-old and over 21 years-old. A photograph was taken in standing position and the Q angle was plotted with KINOVEA® software. As for the reliability of the measurements, intraclass intra and interobserver coefficient were 0.958 and 0.860 respectively. The study was conducted in mid-season.

Results: Q angle value is greater in those under 8 years of age and decreases gradually and significantly ($p < 0.005$) until 17–21 years of age, where it stabilizes at values of 5.73° ± 2.78 for right Q angle and 5.88° ± 2.55 for left Q angle. Two way ANOVA demonstrated a significant group*position interaction for goalkeepers with a medium effect size in both angles ($p < 0.001$) with a medium effect (η^2 Right Q angle = 0.31; η^2 Left Q angle = 0.37). The values remain unchanged in subjects over 21 years of age ($p > 0.005$), except for goalkeepers, who suffered a difference in the evolution of the angle within their age category ($p < 0.005$) and with a high effect size with the other positions (value > 0.8) except forward (value < 0.5).

Conclusion: This study determines that the Q angle in football players decreases with growth, reaching values below 15° at the end of development. Playing positions only influence players over the age of 21, and the Q-angle of goalkeepers is greater than that of other players.

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1. Introduction

Football is often practiced from early ages and implies the development of motor skills, as aiming and catching, in a greater way than other sports [1]. However, it is a high-contact sport extremely demanding, especially for the lower limbs, leading to higher rate of lower extremities injuries [2]. It has been shown that many of the injuries caused to the lower limbs in children who play football are due to overexertion [3]. Moreover, these overloads can result in apophysitis, such as those of the tibial tubercle [4] and the anterior inferior iliac spine (ASIS) [5].

The Q angle is the angle most commonly used to detect lower limbs malalignment [6]. This angle is conformed by the axis between the ASIS and the center of the patella and the axis of the patellar tendon and the tibial tuberosity [7]. Its measurement is non-invasive and very simple and can therefore be performed in a clinical setting without the need for expensive equipment. However, when measuring directly on the subject we can find biases in the measurement due to possible variations in the position of the joint and muscle contraction. The practice of football can influence the values of this angle in subjects in growth stages, with conflicting evidence regarding the differences of this angle between athletics and non-athletic young people [8]. In both cases, deviations from normal values might cause alterations in patellofemoral contact [9], triggering nonspecific anterior knee pain. If this abnormal patella alignment persists over time, patellofemoral pain syndrome appears, causing muscle imbalance, wear of the cartilage in the lower aspect of the patella (chondromalacia patellae) and degeneration of the joint surfaces of the knee (degenerative joint disease). Beyond this point, the damage is frequently permanent and fully recovery is usually not possible [10]. However, the results of investigations that relate the Q angle with knee disorders are equivocal given the disparity of methodological criteria and the lack of an established normal interval [11].

The muscular demand of soccer players is different depending on the position they occupy on the field of play therefore the training load and mechanical work required for each playing position may differ, which may result in different physiological adaptations and risk of injury. Although studies cannot conclude higher risk of injury according to playing position, they all agree on how these positions can shape the body due to its differences on physical demands [2,12].

Since there is no consensus on the normality ranges established for angle Q, the aim of this study is to observe the variation of this angle by comparing its values in different developing groups that practice soccer. In addition, we intend to determine if the playing position can interact in the variations.

2. Material and methods

2.1. Study design

A prevalence cross-sectional study was carried out following the ethical principles set out in the Declaration of Helsinki. The Research Ethics Committee from Universidad de Extremadura approved the research (25/2022). It was performed and reported according to the Strengthening the Reporting of Observational Studies in Epidemiology Criteria (STROBE) [13].

2.2. Participants

104 male subjects from two amateur football clubs in Cáceres (Spain) were recruited for the study. Aged between 5 and 28 years-old and according to the skeletal development of the knee, the participants were divided into 4 age categories: 1. under 8 years of age, in

Fig. 1. Placement of rubber stickers and Q angle measurement using KINOVEA® software.

the period when the physiological valgus of the knee stabilizes [14]; 2. subjects between 8 and 17 years of age, in a transition period before completion of the ossification processes of the tibia and femur; 3. subjects between 17 and 21 years of age, in the ossification period of the proximal tibial epiphysis [15]; 4. over 21 years of age, in the period of ossification of the distal femoral epiphysis [15].

As inclusion criteria, participants were required to train regularly for at least 2 h per week. Subjects with injuries at the time of the study or with surgery in the lower extremity were excluded.

All subjects and their legal representatives in case of under-aged were orally and in writing informed about the nature of the study. All football players and legal representatives who agreed to participate signed the informed consent form and their authorization was obtained for the use of data and images in the study.

2.3. Outcomes measurements protocol

All subjects filled in a form with their affiliation information and playing position on the field. Weight and height were measured before the photograph was taken for Q-angle measurement. A calibrated digital scale (SECA® 861, Vogel and Halke, Hamburg, Germany) was used to measure weight and wall stadiometer (SECA® 222, Vogel and Halke, Hamburg, Germany) was used to measure the height. For the photograph, three 8 mm diameter circular rubber stickers were previously placed on each lower extremity of the football player at the following sites: one on the ASIS, one on the center of the patella and one on the anterior tibial tuberosity (Fig. 1). Subjects were required to stand in front of a wall with arms extended alongside the body and relaxed lower limbs, with feet forward and shoulder-width apart. In this position and following protocols from other similar studies [16], with the intention of calculating intra-observer reliability, two photographs were taken with a NIKON D7100® digital camera, 30 min apart. The camera was set 3 m from the subject on a tripod at 80 cm height and calibrated by a bubble level. The vertical axis of the camera was aligned with the midpoint between the lower limbs of the participant. The image was zoomed to the closest capture, where the stickers could be clearly visible, and always set in the same position.

Subsequently, data was exported to a computer for digital measurement of the Q angle using KINOVEA® software. To determine interobserver reliability, two independent evaluators analyzed the same photograph of each participant. Intra-observer reliability was calculated by measuring the two photographs of each participant by a single evaluator. The study was conducted in mid-season and took 14 days to complete. All measurements were taken in the early afternoon and before training.

2.4. Statistical analysis

The simple size was calculated using software Gpower 3.1.0 (Franz Faul, Universität Kiel, Germany). F Test family, statistical test ANOVA fixed effects and Omnibus and one-way and type of power analysis was a priori used. The power was 0.80, with an alpha error of 0.05 and large size effect of 0.4. A total sample size of 76 subjects was necessary (finally 104 subjects participated).

Data was analyzed with SPSS software version 26.0 for Windows. Normality tests were performed using the Kolmogrov-Smirnov test. A two-way ANOVA was performed to determine the interaction of position and group with Q angle values. The ANOVA test was used to analyze angle differences within a group. Finally, effect size was calculated using Cohen’s D. Statistical significance was considered for $\alpha = 0.05$.

3. Results

Based on a nonprobabilistic convenience sampling, 104 footballers participated in the study, including 21 under 8 years of age (mean age 5.70 ± 0.80 years; BMI 15.50 ± 1.22), 39 in the age group of 8–17 years old (mean age 11.74 ± 2.14. BMI 18.58 ± 2.34; BMI 18.58 ± 2.34), 26 subjects were between 17 and 21 years old (mean age 18.56 ± 0.79 years; BMI 21.07 ± 2.57) and 18 were over 21 years of age (mean age 25.06 ± 2.04 years; BMI 24.01 ± 1.45).

In the descriptive analysis of the Q angle (Table 1), we observed in both knees a descending trend of the angle mean values up to the age of 17 years. At this age, Q angle values were similar to the normal and stablished value of 15° [17]. However, and contrary to the normal tendency, the angle continues to decrease after the age of 17 years in our sample.

In both right and left Q angles, two way ANOVA demonstrated a significant group*position interaction with a medium effect size.

Table 1
Descriptive analysis of the Q angle for the various age groups.

			Confidence Interval 95%	
	Age	Mean ± SD	Lower limit	Upper limit
RIGHT Q ANGLE	<8	24,19 ± 1,47	22,45	25,93
	8–17	13,54 ± 0,62	12,31	14,77
	17–21	5,73 ± 0,54	4,66	6,80
	>21	4,83 ± 0,69	3,57	6,10
LEFT Q ANGLE	<8	24,76 ± 1,53	22,73	26,79
	8–17	13,74 ± 0,62	12,57	14,92
	17–21	5,88 ± 0,51	4,91	6,86
	>21	5,44 ± 0,61	4,62	6,27

Table 2
Significant differences in Q-angles between groups, positions and group*position interaction.

		F	p	η^2
RIGHT Q ANGLE	group	3171.78	<0.01	0.99
	position	7.87	<0.01	0.21
	group*position	5.09	<0.01	0.31
LEFT Q ANGLE	group	3531.07	<0.01	0.99
	position	8.74	<0.01	0.23
	group*position	6.41	<0.01	0.37

Table 2 table shows the results of the ANOVA test for both angles.

After multiple comparisons of the right and left Q angle between the 4 age groups, significant changes were observed between all of them ($p < 0.001$), excluding between the groups of 17–21 and > 21 years old (p right Q-angle = 0.82; p left Q-angle = 0.58).

Regarding the playing positions, the Q angle only showed significant differences between goalkeepers and the rest of the categories in the group of subjects over 21 years of age (Fig. 2), finding higher values of the Q angle of both lower limbs in goalkeepers. Subsequently, the effect size was calculated, obtaining high values for both Q angles (effect size>0,8) in all positions except for the forward position in which the effect was small (effect size<0,5) (Table 3).

As for the reliability of the measurements, intraclass intra and interobserver coefficient were 0.958 and 0.860 respectively ($p < 0.001$).

4. Discussion

The purpose of this study was to determine whether the regular practice of football and the position of the player in the field influence the evolution of the Q angle during growth. The results show that, in football players, the angle decreases as age increases, reaching values well below the normal 15° once growth is complete. Between 5 and 8 years of age, the high value of the Q angle is due to the natural alignment of the limb in valgus [18]. From this age onwards, the knee valgus progressively changes towards genu varum [19] and adopts values of 15° as ossification maturity is completed [19–21]. This value is considered normal and stable throughout adulthood [17]. However, in the present study we observed that from the age of 17 years onwards the angle continues to decrease, stabilizing in those over 21 years of age. This may be due to the development of a non-physiological genu varum. Q angle shows a tendency to be reduced in football players when compared to other sport disciplines. Furthermore, there is a negative association between the angle value and the years of sporting practice [22]. The intercondylar distance in football players is greater than in non-sporting individuals during growth and from the age of 14 years [8]. In our study, we observed a steady decrease in the Q angle at all ages. This could be ascribed to alignment of the two lines of the Q angle during the player's growth. Additionally, the non-physiological genu varum favors this alignment. A similar tendency has been observed in athletic versus non-athletic subjects [8]. They hypothesized a possible tibial deformity induced by the significant development of the quadriceps, frequently observed in players of this sport, leading to a straightening the Q angle. In line with our results, Braz and Carvalho determined lower Q angle values in professional versus non-professional football players [23]. In this way, recent studies [24] show that subjects with greater hip mobility and spinal flexibility may develop a greater knee valgus and therefore a greater q-angle. These parameters are more preserved in younger subjects as there is a direct relationship between age and loss of flexibility [25] and decreased movement in sports kinetics [26].

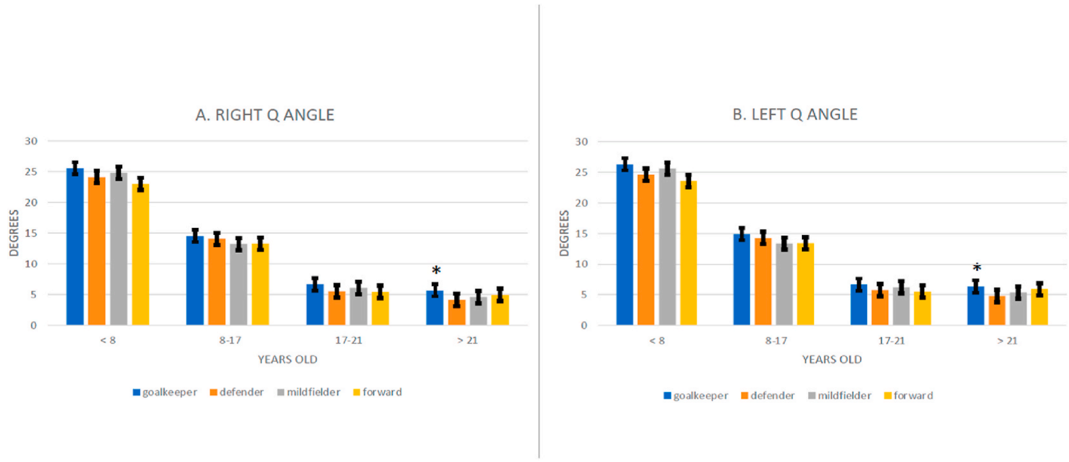

Fig. 2. Comparison of the Q angle value between the different playing positions grouped according to age. A-figure shows the right Q angle comparison and B-figure shows the left Q angle comparison. Values are means and standard deviation. *Significant differences within group.

Table 3
Q angle by playing position and differences between the goalkeeper and all other positions among >21 years old. Range effect size D-Cohen: 0.2: no effect; 0.2–0.5: small effect; 0.5–0.7: moderate effect; >0.8: large effect.

Playing position	Right Q angle	p	Effect size D-Cohen	Left Q angle	p	Effect size D-Cohen
Goalkeeper (n = 3)	5,7 ± 0,57	–	–	6,35 ± 0,10	–	–
Defender (n = 6)	4,16 ± 0,48	0,001	0,82	4,8 ± 0,19	0,001	0,98
Midfielder (n = 4)	4,59 ± 0,08	0,004	0,81	5,37 ± 0,37	0,004	0,96
Forward (n = 5)	4,97 ± 0,89	0,008	0,43	5,89 ± 0,36	0,04	0,35

The prevalence of factors involved in the reduction of the Q angle during growth, such as genu varum, continues in subjects aged 18 years [8]. From this age onwards, the ossification process of the tibia and femur can be considered completed [15]. Accordingly, our results point out to a stabilization of the Q angle from the age of 17.

Considering the playing position, we observed goalkeepers' Q angle to be significantly higher compared to the rest of the players' angle at the age of 21 years and over. In younger age groups, we found no significance in the variation of the angle, regardless of their playing position. This fact can be ascribed to the movement patterns performed on the field and the greater muscle power that adult players have, compared to younger players [27]. In the case of goalkeepers, the muscular demands of the lower limbs are not comparable to the demands of players in other positions, e.g., they usually run for shorter times and distances. Consequently, the biomechanical load on the knee would not be as demanding as for other players and the reduction of the Q angle would not be as pronounced. Likewise, this could lead to lower incidence of injuries of goalkeepers over other position's player at all age categories [2,28,29].

4.1. Limitations

Our study has some limitations. The main limitation of this study lies in its temporal cross-sectional nature. Although the sample covers a wide age range, the results would have been more accurate if the observation of the evolution of the Q angle had been possible following up the same subjects as they grow. Secondly, the sample included only male subjects. Further research is necessary including also female football players.

4.2. Clinical implications

In this study we have tried to provide useful information on the evolution of the anthropometric parameters of the Q angle. This may allow us to anticipate possible treatments in case anomalies are observed.

5. Conclusions

The Q-angle of soccer players decreases significantly with increasing age groups. After the age of 17, the changes are not significant. Goalkeepers over 21 years of age have higher Q angle than defenders, midfielders and forwards.

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Author contribution statement

Elena Escamilla: Conceived and designed the experiments.
Fátima Sánchez: Conceived and designed the experiments; Performed the experiments.
Javier Ramos: Analyzed and interpreted the data.
Paula González: Contributed reagents, materials, analysis tools or data; Wrote the paper.
María-Dolores Cortés: Contributed reagents, materials, analysis tools or data.
Lourdes Mª Fernández: Analyzed and interpreted the data; Wrote the paper.

Data availability statement

Data will be made available on request.

Additional information

No additional information is available for this paper.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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