ÇOMÜ SPOR BİLİMLERİ DERGİSİ
http://dergipark.gov.tr/comusbd Cilt:4 Sayı:3 Yıl: 2021

Relationship Between Q Angle, Dynamic Balance and Vertical Jump Height in Gymnasts

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ABSTRACT

Purpose: The aim of this study was to investigate the relationship between dynamic balance, vertical jump height and Q angle.

Method: A total of 24 gymnasts aged 8 to 14 years (mean age, 11.38 ± 1.83 years) participated to study. The Q angle of the participants was measured by a universal goniometer. The dynamic balance was evaluated by the modified version of the Star Excursion Balance Test (SEBT) including anterior (A), posteromedial (PM) and posterolateral (PL) reach directions. The vertical jump height was measured by squat jump.

Results: There was no significant difference between genders in the Q angle values of both right (p=0.528) and left side (p=0.320). No significant correlation was found between squat jump height and Q angle values of both right (p=0.300) and left side (p=0.258). There was no significant correlation between right side Q angle values and both right side A (p=0.825), PM (p=0.939), PL (p=0.950) and left side A (p=0.826), PM (p=0.919), PL (p=0.981) reach directions of SEBT. There was no significant correlation between left side Q angle values and both right side A (p=0.426), PM (p=0.372), PL (p=0.120) and left side A (p=0.909), PM (p=0.337), PL (p=0.216) reach directions of SEBT.

Conclusion: No significant relationship was found between the Q angle and the vertical jump height in gymnasts. Also, the Q angle was not associated with dynamic balance performance.

Keywords: Balance, gymnastics, Q angle, vertical jump.

ÖZET

Cimnastikçilerde Q Açısı, Dinamik Denge ve Dikey Sıçrama Yüksekliği Arasındaki İlişki

Amaç: Bu çalışmanın amacı cimnastikçilerde dinamik denge, dikey sıçrama yüksekliği ve Q açısı arasındaki ilişkiyi incelemektir.

Yöntem: Çalışmaya, 8-14 yaşları arasında 24 cimnastikçi (ortalama yaş, 11.38 ± 1.83 yıl) katıldı. Katılımcıların Q açısı universal gonyometre ile ölçüldü. Dinamik denge, anterior (A), posteromedial (PM) ve posterolateral (PL) uzanma yönlerini içeren Yıldız Denge Testi'nin (YDT) modifiye versiyonu ile değerlendirildi. Dikey sıçrama yüksekliği squat sıçrama ile ölçüldü.

Bulgular: Hem sağ (p=0.528) hem de sol taraf (p=0.320) Q açısı değerlerinde cinsiyetler arasında anlamlı fark yoktu. Squat sıçrama yüksekliği ile hem sağ (p=0.300) hem de sol taraf (p=0.258) Q açısı arasında anlamlı bir korelasyon bulunmadı. Sağ taraf Q açısı değerleri ile YDT'nin hem sağ taraf A (p=0.825), PM (p=0.939) ve PL (p=0.950) hem de sol taraf A (p=0.826), PM (p=0.919), ve PL (p=0.981) uzanma yönleri arasında anlamlı bir korelasyon yoktu. Sol taraf Q açısı değerleri ile YDT'nin hem sağ taraf A (p=0.426), PM (p=0.372) ve PL (p=0.120) hem de sol taraf A (p=0.909), PM (p=0.337) ve PL (p=0.216) uzanma yönleri arasında anlamlı bir korelasyon yoktu.

Sonuç: Cimnastikçilerde Q açısı ile dikey sıçrama yüksekliği arasında anlamlı bir ilişki bulunamadı. Ayrıca, Q açısının dinamik denge performansıyla da ilişkisi yoktu.

Anahtar Kelimeler: Denge, cimnastik, Q açısı, dikey sıçrama.

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INTRODUCTION

Gymnastics is a popular sport all over the world dating back to very old times. Gymnastics requires a combination of many physical fitness parameters such as speed, agility, strength, balance and flexibility (Daly, Bass & Finch, 2001).

Balance is the ability to maintain the body's center of gravity on the support surface, based on continuous sensory inputs from visual, vestibular and somatosensory systems. Balance, which is one of the basic motor abilities in most sports, is an important physical parameter, in which a minimum loss in gymnastics can affect the competition result. Dynamic balance is the ability of an individual to perform a movement while maintaining a fixed position during movement (Heller, Taylor, Perka & Duda, 2003; Wilson and Kitsell, 2002). Inadequate balance may affect the competition performance of the athletes negatively and increase the risk of injury (Hrysomallis, 2007).

Jumping is the movement body weight of an individual to rise from the ground against gravity. Jumping performance depends on features such as muscle strength, explosive speed, flexibility, body anthropometry, and motor coordination (Di Cagno, Baldari, Battaglia, Monteiro, Pappalardo, Piazza & Guidetti, 2009; Markovic, Dizdar, Jukic & Cardinale, 2004; Sharma, Gandhi, Meitei, Dvivedi & Dvivedi, 2017). In all gymnastics disciplines, vertical jump is a basic skill and jumping height has an important role affecting the athlete's success (Di Cagno et. al., 2009).

Deviations from the normal alignment create an increase in load distribution in knee joint (Heller et. al., 2003). Q angle is one of the widely investigated alignment variables in knee joint. Q angle is defined as the angle between a line connecting the anterior superior iliac spine (ASIS) to the center of the patella, and a line between the center of the patella and the tibia1tubercle. The normal Q angle values were reported as 14.5°-17° in women and 10°-14° in men (France and Nester, 2001). Q angle can be used to reveal the relationship between sports injuries and structural factors and to determine the risk of injury (Nguyen, Boling, Levine & Shultz, 2009; Rauh, Koepsell, Rivara, Rice & Margherita, 2007; Shambaugh, Klein & Herbert, 1991). Abalo-Nunez, Gutierrez-Sanchez, Perez, & Vernetta-Santana (2018) suggested that as a result of the study involving 22 gymnasts, an increased Q angle could be a factor that predisposes athletes to injury. Denızoglu Kulli, Yeldan & Yildirim (2019) concluded that dynamic balance performance was lower in healthy young individuals with less Q angle. Hahn and Foldspang (1997) reported that Q angle values between 11°-19° positively affected the jump performance in young individuals. Powers (2003) reported that

larger Q angle values than normal caused a reduction in hip abduction and ground reaction force. Also, increased Q angle has been reported to be associated with a decrease in vertical jump performance and the isokinetic quadriceps muscle strength (Sac and Tasmektepligil, 2018; Witvrouw, Lysens, Bellemans, Cambier & Vanderstraeten, 2000).

To our knowledge, the higher Q angle may affect both dynamic balance and decrease quadriceps femoris muscle strength. Therefore, the aim of our study was to investigate the relationship between the dynamic balance, vertical jump and Q angle in gymnasts.

METHODS

Participants

A total of 24 gymnasts (16 females and 8 males) (15 artistic and 9 trampoline) in age from 8 to 14 years who participated in gymnastics training for at least 2 years at Murat Canbaş Gymnastics Hall, affiliated to Bolu Provincial Directorate of Youth and Sports were included in this study. The participants who had lower extremity injury, or related surgery within the past year that might have affected the tests were excluded from the study. Data were collected by the sport physiotherapist at Murat Canbaş Gymnastics Hall in September 2020. This study was approved by the Karabuk University Ethical Committee. Descriptive characteristics of the participants are presented in Table 1.

Table 1. Descriptive characteristics of the subjects (n=24)

Variables	$\bar{X} \pm Sd$
Age (years)	11.38 ± 1.83
Height (cm)	140,37 ± 10.02
Weight (kg)	33.20 ± 8.33
Training experience (years)	5.13 ± 2.47

Data Collection

The height of the participants were measured with stadiometer (SECA, Germany) which has 0.01 m. degree of accuracy and the weight of the participants with electronic scales which has 0.1 kg (Tanita, Japan) degree of accuracy.

The Q angle values of the participants were measured using a 360° Baseline universal goniometer. The subjects were asked to stand on the gym floor with their feet bare and parallel to each other. The center of the patella, tibial tubercle and SIAS were marked by physiotherapist. The pivot point of the goniometer was placed in the center of the patella. Then, the one arm of the goniometer towards the tibial tubercle and the other arm towards the

SIAS were aligned. The angle at which these two lines intersect was measured as the Q angle (Greene, Edwards, Wade & Carson, 2001).

Dynamic balance was evaluated by the modified version of the Star Excursion Balance Test (SEBT) including anterior (A), posteromedial (PM) and posterolateral (PL) directions. Three tape were fixed in A, PM and PL directions on the floor of the gymnasium. The subjects were asked to reach as far as possible with the non-dominant leg in A, PM and PL directions while maintaining dominant-leg stance. The dominant leg was determined by as the leg used to kick a ball. Leg length was measured from the anterior superior iliac spine to the most prominent bony point of the ipsilateral medial malleolus with a standard tape measure while subject lay supine. Leg length was used to normalize excursion distances by dividing the distance reached by leg length and then multiplying the result by 100 (Bulow, Anderson, Leiter, MacDonald & Peeler, 2019).

Vertical jump height was assessed by the squat jump test using a contact mat (Swift Performance Equipment, Lismore, NSW, Australia). The subjects were asked to stand barefoot on the contact mat their hands on their hips. Each subject jumped from a semisquatting position for maximum height with two feet. The best score of two jumping effort with a 30 sec interval was recorded (Markovic, Dizdar, Jukic & Cardinale, 2004).

Statistical Analysis

Data was analyzed using SPSS (Version 16.0, SPSS Inc, Chicago, IL). Descriptive statistics ($\bar{X} \pm Sd$) were calculated for all variables. Data were analysed for the normality of sample distribution with Shapiro-Wilk test. Spearman's rho correlation analysis was used to evaluate the relationship between the dynamic balance, vertical jump and Q angle test scores. The correlation coefficient values were categorized as follows: very strong correlation ($\geq$0.8); moderately strong correlation (0.6-0.8); fair correlation (0.3-0.5), and poor correlation ($\leq$0.3). Independent t-test was used for comparisons between both genders. According to previous study data, a sample size of 24 was required to detect a correlation coefficient of at least 0.269 with a statistical power (1-beta) of 80% and an alpha of 0.05. A p value of <0.05 was considered statistically significant.

RESULTS

The values of the Q angle, modified SEBT and squat jump height of the participants are shown in Table 2. There was no significant difference between genders in the Q angle values of both right (p=0.528) and left side (p=0.320) (Table 3). No significant correlation was found

between squat jump height and Q angle values of both right (p=0.300) and left side (p=0.258). There was no significant correlation between right side Q angle values and both right side A (p=0.825), PM (p=0.939), PL (p=0.950) and left side A (p=0.826), PM (p=0.919), PL (p=0.981) reach directions of SEBT. There was no significant correlation between left side Q angle values and both right side A (p=0.426), PM (p=0.372), PL (p=0.120) and left side A (p=0.909), PM (p=0.337), PL (p=0.216) reach directions of SEBT (Table 4).

Table 2. The values of the Q angle, modified SEBT and squat jump height of the participants

Variables	$\bar{X} \pm Sd$
Q angle right (°)	7.21 ± 3.52
Q angle left (°)	5.58 ± 2.51
A right (cm)	80.60 ± 11.51
PM right (cm)	87.44 ± 16.45
PL right (cm)	85.56 ± 16.02
A left (cm)	77.17 ± 9.92
PM left (cm)	86.95 ± 14.55
PL left (cm)	87.64 ± 16.57
Squat jump height (cm)	24.74 ± 4.08

A, Anterior; PM, Posteromedial; PL, Posterolateral.

Table 3. The difference between genders in the Q angle values (n=24)

Variables	Males (n=8) $\bar{X} \pm Sd$	Females (n=16) $\bar{X} \pm Sd$	p
Q angle right (°)	8 ± 3.66	6.81 ± 3.50	0.528
Q angle left (°)	6.38 ± 2.06	5.19 ± 2.68	0.320

Table 4. The relationship between the values of the Q angle, modified SEBT and squat jump height of the participants (n=24)

Variables	Squat jump height	A right	PM right	PL right	A left	PM left	PL left
Q angle right	0.300	0.825	0.939	0.950	0.826	0.919	0.981
Q angle left	0.258	0.426	0.372	0.120	0.909	0.337	0.216

A, Anterior; PM, Posteromedial; PL, Posterolateral.

DISCUSSION

The results of the present study indicated that there was no significant relationship between the Q angle and vertical jump height in gymnasts. Also, no significant relationship was found between the right and left Q angle values and the right and left side dynamic balance performance.

Q angle, which has an important role in lower extremity biomechanics, is a widely researched in both athletes and individuals with patellofemoral dysfunction. It has been reported that the increase in Q angle is a result of the displacement of the patella to the lateral, which causes a mechanical disadvantage and reduces the force production of the quadriceps femoris muscle (Byl, Cole & Livingston, 2000). In contrast, the Q angle values less than 10 ° have been reported to increase the traction of the quadriceps femoris muscle (Brezzo, Fort & Hall, 1996). In our study, the Q angle values of the athletes were found to be close to the values obtained in the study by Wilson and Kitsell (2002), an average of 7° on the right leg and 5° on the left leg. In another study that supports low Q angle values of our athletes, Q angle values were reported to be lower in physically active individuals compared to sedentary ones in children and adolescents (Bayraktar, Yucesir, Ozturk, Cakmak, Taskara, Kale, & Camlica, 2004). The authors suggested that this result was associated with the developmental process considering the anthropometric factors such as pelvis width and femur length, and decreased Q angle due to increased quadriceps femoris muscle strength. In our study, the Q angle values of the participants were lower than those of other studies involving children (Bayraktar et al., 2004; Bhalara, Talsaniya & Nikita, 2013). To our knowledge, gymnastics training from an early age may lead the displacement of the patella due to the increase in quadriceps femoris muscle strength and may cause a decrease in the Q angle (Byl, Cole, & Livingston, 2000). Furthermore, the Q angle may not be compared between different age groups in children and adolescents because of developmental differences. When the Q angle values were compared between both genders in our study, it was observed that there was no significant difference in accordance with the other studies (Bhalara et. al., 2013; Cankaya, Dursun, Davazlı, Toprak, Cankaya & Alkan, 2020). Cankaya et al., (2020), suggested that the lack of a significant gender-related difference in Q angle among children aged 2-8 years because both sexes had to the similar skeletal development levels in the pre-pubertal period (Cankaya et al., 2020). Sac and Tasmektepligil (2018) measured as an average of 13° the Q angle values in physically active young individuals, and found that the higher Q angle value was associated with weaker isokinetic knee extension muscle strength (Sac and Tasmektepligil, 2018). Hahn and Foldspang (1997), observed the higher Q angle values in the right leg than the left in a study with a large sample of 396 athletes from various sports. The authors suggested that the increase in the strength of the quadriceps femoris muscle would change the position of the patella and decrease the Q angle, especially as a result of soccer training. Yilmaz, Kabadayı, Mayda, Cavusoglu & Tasmektepligil (2017) showed that Q angle

values could be related to parameters such as sports branch, sports experience and quadriceps femoris muscle strength.

Gymnastics is a sport that participates at an earlier age compared to other sports. The exposure to intense training from an early age shapes the musculoskeletal system (Caine, Bass & Daly, 2003). To our knowledge, it is possible that gymnastic training involving high speed and explosive movements of the lower extremities may lead to an increase in the strength of the quadriceps femoris muscle, which is the primary determinant in the Q angle (Sands, Friemel, Stone & Cooke, 2006). On the other hand, it may be considered that the reason for the lack of a significant relationship between the Q angle and the vertical jump height in our study, many factors such as anthropometric, physiological and biomechanical characteristics play a role in the jumping action (Aouadi et al., 2012; Sharma, Gandhi, Meitei, Dvivedi, & Dvivedi, 2017). The vertical jump is an action that requires neuromuscular coordination involving muscles of the ankle, knee, hip joints and trunk (Blache and Monteil, 2014; Lees, Vanrenterghem & De Clercq, 2004). In consistent with our results, Jones (2013), did not found significant relationship between anterior or posterior pelvic tilt and Q-Angle and performance tests such as the 40-yard dash, vertical jump and broad jump. The author attributed this result to the small number of subjects. Similarly, Jeffries (2011) showed that there was no significant association between the Q angle and the vertical jump height.

In the present study, no significant relationship was found between the Q angle and the dynamic balance performance. This result can be explained by a more intense training program on balance skills in gymnastics at an early age compared to other sports. The sport of gymnastics requires a quick and aesthetic movement change to different positions. Gymnastic training promotes improvements in the both static and dynamic balance performance and allows almost perfect stability, even under extremely demanding conditions (Atilgan, Akin, Alpkaya & Pinar, 2012; Garcia, Barela, Viana & Barela, 2011). The relationship between balance and Q angle in other populations have investigated while there are limited studies on the Q angle in gymnasts. Hazar, Gürsoy & Günay (2016) observed the static balance performance of both male and female athletes with high Q angles was poor. Senol, Altınoglu, Toy, Kısaoglu & Özbag (2019), examined the relationship between the Q angle, somatotype and balance in healthy young individuals. No statistically significant difference was found the relationship between the Q angle and balance scores for 7 different somatotypes. On the other hand, Denizoglu Kulli et. al. (2019), investigated the relationship between Q angle and static and dynamic balance ability in sedentary young individuals. The authors measured much

higher Q angle values (about 12°) than our study, and did not find a significant relationship between Q angle and static balance. However, the authors found a weak positive relationship between Q angle and dynamic balance. It was observed in the lateral and PL directions of SEBT. Also, balance performance in L direction was lower in subjects with small Q angle. The authors suggested that a small Q angle may increase postural sway in the medial-lateral direction. It has been suggested that the high Q angle is associated with increased knee valgus and excessive tibial rotation (Powers, 2003). Samaei, Bakhtiary, Elham & Rezasoltani (2012), reported that the postural sway in the mediolateral direction was high in both static and dynamic balance analysis in sedentary young individuals with genu varum deformity. In contrary, a study evaluated dynamic balance with SEBT in the healthy controls and subjects with patellofemoral pain syndrome and reported that the Q angle was lower and the dynamic balance scores was higher in the healthy controls (Arun, Vakkachan & Abraham, 2013).

One of the limitations of this study is that the Q angle was not evaluated by more objective measurement methods such as X-Ray or electronic goniometer. However, many researchers measured the Q angle with a universal goniometer. Another limitation in this study is that the quadriceps femoris muscle strength were not measured. But in our study, squat jump height which is the main functional indicator of the explosive power of the quadriceps femoris muscle was measured.

CONCLUSION

The results of this study showed that there was no significant relationship between the Q angle and vertical jump height in gymnasts. Also, the Q angle was not associated with dynamic balance performance. The change in Q angle may cause abnormal load transfer in the knee joint and predispose the athlete to future injury. Therefore, lower extremity alignment variables such as Q angle should be evaluated in athletes. Further studies are needed to investigate the relationship between Q angle and balance performance with larger sample size in different age groups and sports.

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