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Correlation of Quadriceps Angular Biomechanics to Anxiety in Amateur Women Football Athletes : Injury Risk Analysis

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Abstract

Injury prevention in female football athletes requires a multidimensional approach that integrates both biomechanical and psychological assessments. This research aims to examine the relationship between the quadriceps angle (Q-angle) and competitive anxiety in amateur female football players, with a focus on understanding the impact of Q-angle as an injury risk factor on anxiety levels. The importance of this study stems from the global rise of female participation in football, which is accompanied by a high incidence of lower extremity injuries, particularly among adolescents—a group that is physically and emotionally vulnerable. A total of eleven female athletes aged 14–21 years participated in the study. Q-angle measurements were conducted using image-based digital goniometry (KINOVEA®), whereas the Sport Anxiety Scale-2 (SAS-2) was utilized to assess levels of anxiety both before and after match participation. The findings revealed a non-significant decrease in anxiety scores following match play (from 35.23 ± 7.21 to 32.28 ± 8.49; $p = 0.076$), which may suggest a reduction in anticipatory stress after real-game involvement. Q-angle values varied widely from 9.5° to 29°, with several athletes exhibiting angles outside the normative female range of 15°–20°, indicating a possible increased risk for lower-extremity injuries. Even though a meaningful association was not established between the Q-angle measurements and anxiety levels, the occurrence of extreme readings in both areas among specific individuals suggests a potentially compounded injury risk that should be further investigatedIn spite of constraints such as a limited number of participants and the use of a cross-sectional study design, this research underscores the practical utility of low-cost, field-friendly tools for early detection of biomechanical and psychological injury risk factors. The results support the integration of dual-domain screening into injury prevention programs for adolescent female football players.

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INTRODUCTION

Football (soccer) ranks as the most widely played and viewed sport globally, as evidenced by its massive television audience and the participation of over 260 million individuals actively engaged in the game (Mandorino et al., 2023). FIFA has established a goal aiming to grow the global participation of women in football to 60 million by 2026. In Spain, women's football is presently one of the most rapidly growing and widely embraced sports. (Molina-López et al., 2024). As a sport, football is categorized as an acyclic endurance activity (Jagim et al., 2020), consisting of short bursts of both anaerobic and aerobic efforts at high intensity. Essential physical qualities required in the game include speed, strength, and endurance (Randell et al., 2021). However, as a sport involving frequent physical contact, it imposes substantial physical pressure on the players, especially on the lower extremities, leading to a greater occurrence of injuries in that region (Torrontegui-Duarte et al., 2020). Several studies have established that a considerable number of football-related lower limb injuries are attributed to physical overexertion. Such overuse may result in apophyseal injuries, including those found in the tibial tuberosity (Faude et al., 2013) and the lower front region of the iliac bone known as the anterior inferior iliac spine (ASIS) (Gudelis et al., 2022)

A specific biomechanical factor relevant to lower limb function and susceptibility to injury is the Q-angle. This Q-angle, Brattstrom was the first to define it, functions as a critical marker for evaluating steadiness of the patellofemoral joint, where an optimal Q-angle helps prevent misalignment of the knee (Brattström et al., 2001; Skouras et al., 2022) It assesses the sideways force generated through the pressure exerted by the quadriceps femoris muscle on the. (Shetty et al., 2024) When measured precisely, the Q-angle provides important information about the alignment of the lower extremities, demonstrating the angular interaction between the femur and tibia, along with the path of quadriceps traction relative to the patella and tibial axis (Livingston, 1998; Nguyen et al., 2009). A survey of existing studies reveals that the typical, standardized range of static Q-angle varies by gender for males, it generally falls between 10° and 15°, whereas for females, it typically spans from 15° to 20° (Skouras et al., 2022). Playing football may influence Q-angle measurements in individuals who a still in their growth phase, though research offers inconsistent findings regarding the variation in this angle (Shetty et al., 2024) The objective of the present analysis is to examine the critical function of the Q-angle within the context of knee joint biomechanical dynamics and its impact on injury susceptibility, particularly among female athletes (Gant et al., 2024).

A sports competition serves as the natural culmination of the training process and imposes a certain level of pressure on athletes (Kaplánová, 2020). Young and talented athletes are particularly vulnerable to these pressures (Nylandsted et al., 2018; Swann et al., 2018) The prevalence of typical psychological conditions, such as depression and anxiety, among elite youth athletes is estimated to fall within the range of 15% to 40%. (Tachom & Hauw, 2024) Given that physical abilities among athletes are often comparable, psychological preparedness becomes a key differentiator for success. Researchers recommend evaluating all performance-related factors, particularly psychological ones, during competition (Etemadi & Ali, 2010; Kaplánová, 2019; Tachom & Hauw, 2024) These mental characteristics should be monitored with the same importance as physical performance and body composition. Furthermore, enhancing mental training is necessary to improve self-confidence and reduce anxiety among football players (Kapl, 2024; Kaplánová, 2020; Singh et al., 2023), Moreover, it remains uncertain to what degree the nature of the specific sport and the role of coaching have contributed to shaping athletes' personalities (Harvey et al., 2020; Kapl, 2024) This research investigation seeks to examine the interconnection between psychological readiness, confidence and performance-related anxiety in football athletes. Additionally, it investigates whether attributes such as resilience, coachability, achievement motivation, goal orientation, execution in high stress situations, and apprehension about underachievement can be strongly influenced by self-esteem or specific components of competitive anxiety (Kapl, 2024)

Anxiety is one of the psychological elements that critically impact athletic performance, particularly during high-stakes situations. It is defined as a feeling of threat or discomfort in which the source is not clearly understood (Jamshidi et al., 2011). A prominent subtype is competitive anxiety, which arises in sports settings perceived as threatening, often resulting in stress-related responses such as worry and physical tension (Jamshidi et al., 2011; Reteguiz, n.d.) Even elite athletes with high anxiety levels, compared to those with lower anxiety, show elevated physiological arousal under pressure, increasing the likelihood of performance setbacks such as mid-game

withdrawal (Jamshidi et al., 2011) Mental fatigue also impairs athletic performance due to its impact on decision-making and technical skills, both of which rely on cognitive capacit (Fitri et al., 2021) Mental fatigue has a negative impact on athletic performance because both decision making and execution of technical skills depend heavily on cognitive capacity (Fitri et al., 2021). Recent comprehensive reviews and aggregated analyses indicate that athletes disclose experiencing degrees of psychological strain, signs of depression and levels of anxiety which are comparable to those observed in individuals who are not athletes (Gorczynski et al., 2017; Rice et al., 2016) or even greater than (Knowles et al., 2021; Reardon, 2021) those of non-athletes. This might appear unexpected, as athletes are often viewed as a privileged group presumed to be less affected or even resistant to such issues (Rice et al., 2016) However, various sport-specific factors can adversely affect athletes' mental well being (Reardon, 2021). Elevated cognitive anxiety among football players raises the likelihood of fear related to losing status and underperforming during competition and also interferes with the focus required for executing tactical responsibilities-an observation supported by other studies (Kaplánová, 2019, 2020) Additionally, our findings revealed that somatic anxiety's physical manifestations, along with football players' self-esteem, serve as significant predictors for goal-setting behavior. The effective formulation of both immediate and future objectives is essential in athletic exercise routine (Bailey, 2017; Kapl, 2024; Kaplánová, 2020; Taylor & Wilson, 2019)

This research focuses on examining anxiety, specifically in the form of competitive anxiety, which is described as a type of trait anxiety that frequently emerges prior to or during competitive events (Nylandsted et al., 2018). The aim of this research is to explore the relationship between a particular Q-angle (quadriceps angle) and anxiety levels, assessed through the SAS-2, in relation to injury risk among amateur female soccer players. By gaining insight into this connection, it is expected that more comprehensive injury prevention strategies can be developed-incorporating both biomechanical and psychological factors-to enhance the overall performance and health of amateur women's soccer players.

METHODS

This study was conducted using an observational and correlational design to examine the association between the variables being studied. (Ginanjar et al., 2024). Including the Q-angle among female football athletes in Bandung City. The research procedure involved measuring the Q-angle and having all participants complete the Sport Anxiety Scale-2 questionnaire (Kaplánová, 2021) Both prior to and following their involvement in league matches, the gathered data were examined to identify whether a connection existed between the Q-angle and levels of anxiety, as well as to identify any other factors that might have influenced these variables. The research included 11 athletes from the Bandung City Women's Football team. One of the inclusion criteria was that participants must have trained consistently for A minimum of two hours per week. Participants who sustained injuries during the study period or had a prior history of lower limb surgery were not included in the research (Noon et al., 2018). All participants—and for those who were minors, their legal guardians—received both verbal and written information concerning the goals and methods of the study. Each athlete, along with their guardian, provided consent by signing an informed consent form, and permission was obtained to utilize their data and images for the purposes of this study.

The participants had a mean age of 16.9 years, with an age range between 14 and 21 years. The mean height of the subjects was recorded at approximately 1.59 meters, with measurements varying from 1.51 to 1.69 meters. Furthermore, the participants' average body weight was 49.13 kilograms, with a range spanning from 41 to 59 kilograms. The athletes held different roles within the team: 4 were Forwards, 3 were Goalkeepers, 2 were Midfielders, and 2 were Defenders. The duration of their training experience showed considerable variation, averaging 10.5 years and spanning from 5 to 16 years. The participants' Q-angle values were measured as follows: 14º, 22°, 11°, 11.2°, 9.5°, 25.25°, 25°, 24°, 13°, 10°, 29°.

All participants filled out the Sport Anxiety Scale-2 (Kaplánová, 2021). Every athlete provided consent for their data and images to be utilized in this research. Prior to taking photographs for Q-angle evaluation, measurements of weight and height were conducted. Body mass was assessed utilizing a calibrated digital scale (SECA® 861, Vogel and Halke, Hamburg, Germany), whereas stature was assessed with a stadiometer mounted on the wall (SECA® 222, Vogel and Halke, Hamburg, Germany). During the photo taking session, three reflective markers measuring 15 mm in diameter were affixed to each athlete's lower limb at these anatomical reference points: one positioned on the ASIS, one at the center of

the patella, and another on the front of the tibial tuberosity (Andica et al., 2024; Apriady et al., 2024; Arfi et al., 2024; Fitri et al., 2023; Ismail, 2024). Every player provided consent for the use of heir information and images within this research. Prior to image capture for Q-angle assessment, their height and weight were documented. Body mass was measured with a digitally calibrated scale to ensure accuracy. (SECA® 861, Vogel and Halke, Hamburg, Germany), and stature with a stadiometer mounted to the wall (SECA® 222, Vogel and Halke, Hamburg, Germany). For the imaging process, three reflective stickers (15 mm diameter) were applied on the athletes' lower limbs at the following points: One marker was positioned on the ASIS, another at the midpoint of the patella, and the third on the anterior aspect of the tibial tuberosity (Ashnagar et al., 2017).

The performance analysis camera was positioned at a distance of three meters from the athlete on a tripod adjusted to a height of 80 cm and leveled with the aid of a bubble level. Its vertical alignment was centered with the midpoint between the participants' distal extremities. The frames were optically enhanced to clearly visualize the markers and maintain consistent spatial framing throughout the recording.. The captured data was subsequently uploaded into a computer system for the digital assessment of the Q-angle evaluation using KINOVEA® software. To assess the consistency between different evaluators, Two independent observers analyzed an identical photograph for every individual subject. Within-rater consistency was evaluated through the involvement of a single observer who assessed a pair of distinct images corresponding to each athlete. The method used adhered to protocols utilized in earlier research studies. (A.febryani' et al., 2024; Safitri et al., 2023; Sepriani, R., Ockta, Y., Eldawaty, E., & Padli, 2024; sumbara hambali, 2023) The findings were shared with all participants. Following their participation in matches, players identified as being at risk of injury were asked to complete the Sport Anxiety Scale-2 questionnaire (Kaplánová, 2021). This study was conducted starting from the pre-season stage and continuing into the early part of the competition season.

The data set is represented as mean ± standard deviation for continuous variables. To evaluate the normality of distribution, the Shapiro Wilk assessment was applied and every parameter exhibited a normal distribution pattern. The independent sample t-test was utilized to evaluate differences between groups in both the baseline and post-test outcomes. To detect significant changes within each group between baseline and post-test, the paired sample t-test was utilized.

RESULTS AND DISCUSSION

The outcome of the normality test revealed that the data from both the pretest and posttest followed a normal distribution. This finding is affirmed by the significance values derived from the Shapiro-Wilk test, which were 0.336 for the pretest and 0.806 for the posttest. As both values exceed the 0.05 threshold, it can be inferred that the data did not significantly diverge from a normal distribution.

The Paired Samples Statistics section provides a summary of the descriptive results for the pretest as well as the posttest. The average score recorded during the pretest was 35.23, accompanied by a standard deviation of 7.214 and a mean standard error of 3.504. Meanwhile, the posttest recorded a mean score of 32.28, along along with a standard deviation measuring 8.485 and a standard error of the mean recorded at 2.2558.

The Paired Sample Test displays the findings of the paired t-test that evaluates the differences between pretest and posttest scores. The average variation observed between the pretest and posttest scores amounts to 2.951, with a standard deviation of 4.938. The analysis produced a t-value of 1.982 and a degree of freedom (df) of 10. The 2-tailed significance value is recorded at 0.076, which exceeds the threshold value of 0.05, suggesting that the difference observed between the pretest and posttest scores is not statistically significant.

This study presents two significant contributions to the current body of research on injury risk in women's football. Firstly, it integrates biomechanical and psychological dimensions specifically, the quadriceps angle (Q-angle) and competitive anxiety into a unified exploratory framework. Prior studies have largely examined these two domains independently. For example, Q-angle has been linked to lower limb malalignment and knee stress (Gant et al., 2024) while competitive anxiety has been associated with cognitive and somatic performance detriments (Kapl, 2024). Our study is among the first to consider the concurrent influence of these two variables and their potential interaction in shaping injury susceptibility. Secondly, this research targets adolescent and amateur female football players, a group often underrepresented in the literature, which tends to focus on adult or elite-level athletes. Yet, adolescents experience distinct developmental, anatomical, and psychological

characteristics that can heighten their injury risk and emotional volatility (Jagim et al., 2020; Tachom & Hauw, 2024). By addressing this gap, our study adds needed nuance and specificity to the growing field of women's sports science.

The urgency of this research is underscored by the exponential growth of female football worldwide. Participation is expected to surpass 60 million athletes by 2026, as reported by FIFA. Despite this expansion, injury incidence particularly in the lower extremities remains alarmingly high among female players (Mandorino et al., 2023; Torrontegui-Duarte et al., 2020). While recent studies have separately linked abnormal Q-angle to patellofemoral pain and ACL injuries (Shetty et al., 2024) and heightened competitive anxiety to impaired athletic performance and elevated risk behaviors (Fitri et al., 2021; Singh et al., 2023), very few investigations have explored how these two factors might interact. This study addresses that void by assessing both physical alignment and psychological readiness before and after competitive matches.

The study identified a decline in competitive anxiety levels following match participation, although this change did not reach statistical significance. Despite the lack of statistical confirmation, the observed downward trend may reflect a calming effect associated with actual game involvement, potentially due to greater task focus and reduced anticipatory stress. This aligns with previous research suggesting that both cognitive and somatic anxiety tend to peak before a competition and decline afterward (Kapl, 2024). From a biomechanical standpoint, participants exhibited considerable individual differences in Q-angle measurements. Larger Q-angles are generally linked to increased lateral force on the patella and suboptimal joint mechanics, especially in female athletes, which may heighten the risk of knee injuries (Shetty et al., 2024). Although this research failed to demonstrate a statistically meaningful association between the extent of the Q-angle and levels of anxiety, the simultaneous presence of extreme values in both variables for some participants suggests a possible combined risk factor that warrants additional exploration.

Nevertheless, A number of limitations should be recognized. The limited number of participants. (n = 11) and the narrow age range (14–21 years) limit the generalizability and statistical power of the findings. As a result, any observed trends should be interpreted cautiously. The cross sectional, pre test and post test design also prevents any causal inference between the studied variables and actual injury outcomes. It remains unclear whether high anxiety precedes injury, is a consequence of injury experience, or whether Q-angle deviations predict injury independently or in combination with psychological states. Moreover, the study focused on only one biomechanical parameter (Q-angle) and a single psychological scale (SAS-2). Although both are validated tools, current best practices advocate for multidimensional assessments. For example, dynamic motion analysis can provide more comprehensive biomechanical profiling (Skouras et al., 2022) and broader mental health inventories may capture emotional states more holistically (Reardon, 2021) Additionally, environmental factors such as game intensity, opponent level, or social support, which may influence both anxiety and injury risk, were not controlled in this study.

Given these limitations, future research should build on this foundational work by employing larger and more diverse samples drawn from multiple sites and competitive levels. Longitudinal designs are particularly needed to track how fluctuations in Q-angle and anxiety levels over time relate to actual injury incidence. This would allow for stronger causal inference and a deeper understanding of time sensitive risk patterns. Moreover, future studies should consider incorporating dynamic biomechanical assessments, such as gait and jump landing analyses, along with wearable sensor technologies to monitor real time joint loading. On the psychological front, integrating multiple validated instruments such as the CSAI-2 or the DASS-21 would provide a richer understanding of mental states under competitive stress.

In addition to observational research, interventional studies are urgently needed. Programs that integrate neuromuscular training to reduce Q-angle asymmetries (Nguyen et al., 2009). By employing psychological intervention methods, including cognitive-behavioral techniques and mindfulness-based approaches to stress management, a twofold method for preventing injuries could be implemented. The use of wearable sensors and ecological momentary assessments could further enable real time monitoring of both biomechanical loads and emotional fluctuations, offering more personalized and adaptive preventive strategies.

CONCLUSION

This study emphasizes the importance of evaluating both biomechanical and psychological elements—specifically the quadriceps angle (Q-angle) and competitive anxiety—in assessing

the risk of injury among amateur female football players. While the findings did not show a statistically significant change in anxiety levels before and after matches, the observed decreasing trend and the variability in Q-angle values reinforce the value of this dual-perspective approach.

The use of Q-angle measurements alongside the Sport Anxiety Scale-2 (SAS-2) provides accessible and applicable tools for coaches, trainers, and sports health professionals to detect early signs of potential injury risk. These insights allow for timely and focused interventions, such as neuromuscular conditioning and anxiety-reduction strategies, which can strengthen prevention programs.

For coaches, these findings recommend integrating psychological assessments into regular physical training to better support athlete development. For health professionals, the results underscore the need for personalized injury risk monitoring that accounts for both physical and emotional readiness. Sport organizations and policymakers can draw from this evidence to justify incorporating psychological and biomechanical screenings into youth football development frameworks, aiming to safeguard athlete well-being and performance.

Further studies are encouraged to build upon these findings by using broader and more varied sample groups, as well as longitudinal methods. Such research will enhance the understanding of the evolving interaction between Q-angle biomechanics, psychological states, and injury risk among female football players.

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