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Excessive Q-Angle and its association with sports injury risk: A literature review

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Abstract---*Background: The quadriceps angle (Q-angle) is an anatomical parameter reflecting lower extremity alignment and knee biomechanics. Abnormal or excessive Q-angle has been proposed as an intrinsic risk factor for sports-related injuries, particularly involving the knee joint. Objective: This review aimed to summarize current evidence regarding the association between Q-angle and the risk of sports-related injuries in athletes and physically active individuals. Methods: A narrative literature review was conducted using PubMed and Google Scholar databases. Articles published between 2020 and 2025 were identified using relevant keywords related to Q-angle, injury risk, and sport. Original research and review articles involving human participants were included and analyzed descriptively. Results: Most studies reported that increased and abnormal Q-angle values are associated with altered lower extremity alignment, increased patellofemoral stress, impaired patellar tracking, and a greater tendency toward dynamic knee valgus. These biomechanical alterations were linked to a higher risk of patellofemoral pain syndrome, iliotibial band syndrome, patellar instability, and knee ligament injuries. Higher and asymmetric Q-angle values were more frequently observed in female athletes and in sports involving repetitive and high-impact movements. Conclusion: Excessive Q-angle appears to be an important anatomical factor associated with increased lower extremity injury risk. Q-angle assessment may be useful in injury risk screening, although further longitudinal research is needed to establish causality and preventive effectiveness.*
Keywords---*Q-angle, quadriceps angle, knee biomechanics, sports injury, injury risk.*

Introduction

The human body consists of complex and interconnected systems that interact to enable optimal movement function. The muscular and skeletal systems are two primary components that work synergistically, in which the skeletal system serves as structural support and as the site of muscle attachment, while the muscular system generates force to move. Without the skeletal system, muscle contraction would not result in effective motion (Phatama et al., 2022).

The lower extremities play a crucial role in dynamic human movement, particularly in sports activities involving running, jumping, rapid changes of direction, and landing. During these activities, the lower limbs are subjected to repetitive loading and high ground reaction forces. Alterations in joint biomechanics, imbalances in muscle and ligament strength, and even minor deviations from normal alignment may result in suboptimal load distribution, thereby increasing the risk of lower extremity injuries. One intrinsic risk factor related to lower extremity alignment that remains relatively underexplored in the literature is the quadriceps angle (Q-angle). Knee joint disorders have frequently been associated with malalignment, highlighting the importance of Q-angle assessment in athletes as part of injury risk evaluation (Rashmika & Weerarathna, 2023).

The quadriceps angle (Q-angle) is defined as the angle formed by the line connecting the anterior superior iliac spine (ASIS) to the center of the patella and the line extending from the center of the patella to the tibial tuberosity, representing the force vector between the quadriceps muscle and the patellar tendon. The Q-angle is commonly used

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as an indicator of static knee alignment and is typically measured in a standing position with the knee in full extension. Average Q-angle values have been reported to be approximately 14° in males and 17° in females. Excessive Q-angle has been associated with various knee disorders, including patellofemoral pain syndrome, chondromalacia patellae, and patellar subluxation or dislocation. Additionally, asymmetry in Q-angle between the right and left lower extremities has been reported to increase injury risk due to muscle force imbalance and alterations in knee morphology (Sharma et al., 2023).

In the context of sports performance, Q-angle functions not only as a static anatomical parameter but also influences force distribution and knee stability during dynamic activities such as running, jumping, and rapid directional changes. Elevated Q-angle values may increase lateral stress on the knee joint and contribute to a higher risk of injury in athletes (Gant et al., 2024). Longitudinal studies in adolescent runners have demonstrated that individuals with Q-angle values ≥20° exhibit a higher risk of lower extremity injuries compared to those with normal Q-angle values, and that Q-angle asymmetry further increases injury risk (Rauh et al., 2007). Furthermore, abnormal knee alignment associated with increased Q-angle has been linked to a higher incidence of iliotibial band syndrome (ITBS) in runners (Kumarantini et al., 2025). In more severe injury contexts, elevated Q-angle, particularly when accompanied by dynamic valgus mechanics, has been reported to increase the risk of anterior cruciate ligament (ACL) injury, especially among female athletes (Saber et al., 2024).

Despite evidence suggesting an association between Q-angle and sports-related injury risk, existing findings remain inconsistent and have not yet reached a clear consensus regarding the role of Q-angle as a reliable and consistent injury risk factor. This review aims to provide a descriptive overview of findings reported in the existing literature without performing a quantitative synthesis. Therefore, the results and conclusions of this review are descriptive and exploratory in nature and are not intended to establish a causal relationship (Wido et al., 2022).

Method

This study employed a literature review methodology with a narrative review approach to examine the relationship between the quadriceps angle (Q-angle) and the risk of sports-related injuries. The literature search was conducted using the PubMed and Google Scholar databases. Relevant articles were identified using the keywords “Q-angle,” “quadriceps angle,” “risk factor,” “injury,” and “sport,” which were combined using the Boolean operators “AND” and “OR.”

Articles included in this review were limited to studies published between 2020 and 2025 to obtain the most recent scientific evidence. The inclusion criteria were as follows: (1) original research articles or review articles, (2) studies involving human subjects, particularly athletes or physically active individuals, (3) articles examining Q-angle as a biomechanical factor or a risk factor for lower extremity injuries, and (4) articles published in either Indonesian or English. The exclusion criteria comprised articles that did not address the relationship between Q-angle and sports injuries, duplicate publications, and opinion pieces or editorials.

The article selection process was conducted in stages, beginning with title and abstract screening, followed by full-text assessment to ensure relevance to the review topic. Articles that met the inclusion criteria were subsequently analyzed descriptively by extracting information related to study design, participant characteristics, types of injuries examined, and the main findings regarding the association between Q-angle and the risk of sports-related injuries.

Result

Table 1
Summary of Studies Examining the Association Between Q-angle and Lower Extremity Injury Risk

Author (Year)	Study Design	Participants	Sport/ Population	Key Variables	Main Findings
Gülfırat et al., 2025	Observational study	Physically active individuals	Athletes	Q-angle, lower extremity alignment	Higher Q-angles were associated with altered knee biomechanics and a greater tendency toward knee valgus, indicating biomechanical patterns that may be related to increased knee injury susceptibility.
Gant et al.,	Review	Female	Soccer and	Q-angle, knee	Variations in Q-angle were

Author (Year)	Study Design	Participants	Sport/ Population	Key Variables	Main Findings
2024		athletes	dynamic sports	biomechanics, injury risk	associated with differences in knee biomechanics. Larger Q-angles were linked to increased patellofemoral stress and biomechanical patterns related to knee injury during sport-specific activities.
Kumurantini et al., 2025	Observational study	Runners	Running	Q-angle, iliotibial band syndrome	Abnormal Q-angle was significantly associated with a higher incidence of iliotibial band syndrome in runners, suggesting that altered Q-angle may be related to overuse injury patterns of the lower extremity.
Chaturvedi & Khanvilkar., 2025	Observational study	Youth soccer players	Soccer	Q-angle, knee biomechanics	Increased Q-angle was associated with altered knee biomechanics, elevated patellofemoral stress, and an increased tendency toward knee valgus during dynamic sporting activities, which may be related to a higher susceptibility to knee injury.
Hikawa et al., 2025	Cross-sectional study	Elite athletes	Multiple sports	Q-angle, asymmetry, biomechanics	Athletes with high and asymmetric Q-angles demonstrated significantly different lower extremity biomechanical characteristics compared with those with normal Q-angles. Higher and asymmetric Q-angles were more prevalent in female athletes and certain sports, indicating biomechanical patterns that may be associated with increased injury susceptibility.
Sharma et al., 2023	Review	Athletes	Various sports	Q-angle, knee injury	Increased Q-angle was associated with greater lateral quadriceps pull and increased valgus stress at the knee joint. Larger Q-angles were linked to patellofemoral pain syndrome and altered patellar tracking.

ITBS: Iliotibial Band Syndrome, **PFPS**: Patellofemoral Pain Syndrome

Discussion

The synthesis of the literature in this study indicates that the quadriceps angle (Q-angle) is an important anatomical parameter that plays a significant role in influencing lower extremity biomechanics and is associated with an increased risk of injury, particularly at the knee joint, in both athletes and physically active individuals. Consistently, numerous studies have reported that increases and variations in Q-angle contribute to alterations in lower extremity alignment, increased patellofemoral stress, and a greater tendency toward knee valgus, which represents a key biomechanical mechanism underlying sports-related injuries.

Several studies have demonstrated that an increased Q-angle is closely associated with changes in lower extremity alignment. Gülfırat et al. (2025) reported a significant relationship between increased Q-angle and a greater tendency toward knee valgus, resulting in altered knee joint loading patterns. Knee valgus is widely

recognized as a major risk factor for knee injuries, particularly in sports involving cutting, pivoting, and landing movements. These findings are supported by Rashmika & Weerarathna (2023), who reported positive correlations between Q-angle and femoral anteversion, tibial torsion, and genu valgum, reinforcing the concept that Q-angle is an integral component of interconnected lower extremity alignment factors. Accordingly, Q-angle may be regarded as a structural indicator reflecting biomechanical vulnerability to knee injury.

The influence of Q-angle on knee biomechanics becomes more pronounced during dynamic sporting activities. In soccer players, Gant et al. (2024) and Chaturvedi & Khanvilkar (2025) reported that a larger Q-angle was associated with increased patellofemoral stress, altered knee mechanics, and a greater valgus tendency during athletic movements. These findings indicate that the impact of Q-angle is not merely static but also affects dynamic knee loading. The identification of these associations in youth athletes suggests that Q-angle–related injury risk may emerge early and potentially accumulate with increasing training loads and competitive demands.

The relationship between Q-angle and patellofemoral disorders, particularly Patellofemoral Pain Syndrome (PFPS), represents one of the most consistent findings in the literature. An increased Q-angle is known to enhance the lateral pull of the quadriceps muscle on the patella, thereby disrupting patellar tracking and increasing retropatellar pressure, especially on the lateral aspect of the knee (Sharma et al., 2023). Freedman et al. (2014) reported that increased contact pressure between the lateral femoral condyle and the lateral patella elevates the risk of PFPS and may contribute to long-term patellofemoral cartilage degeneration. Moreover, Almeida et al. (2016) demonstrated that a 10% increase in Q-angle can raise patellofemoral joint stress by up to 45%, highlighting the substantial biomechanical impact of relatively small changes in Q-angle. This mechanism is particularly relevant in sports that involve repetitive knee flexion and high mechanical loading, such as volleyball, soccer, and jump-landing activities.

Beyond PFPS, an increased Q-angle has also been associated with a higher risk of patellar dislocation, particularly lateral patellar dislocation. An in vitro knee simulation study by Van Gent et al. (2007), demonstrated that increases in Q-angle result in significant lateral patellar displacement, altered patellar inclination, and abnormal patellar rotation across various knee flexion angles. These findings support the biomechanical mechanism whereby a larger Q-angle amplifies lateral patellar forces, thereby compromising patellofemoral stability. Similarly, Gonzalez & Ramirez (2021) reported that increased Q-angle was associated with abnormal patellar tracking based on MRI and dynamic Q-angle assessments, which increased susceptibility to chondromalacia patellae and patellar tendinitis.

Several studies have indicated that an increased Q-angle may elevate biomechanical loading on knee ligament structures, particularly the anterior cruciate ligament (ACL) and medial collateral ligament (MCL). Sharma et al. (2023), explained that the increased valgus stress resulting from a larger Q-angle may heighten ligament injury risk, especially in female athletes who typically exhibit greater Q-angle values. Although the association between Q-angle and ACL injury is not as strong as that observed for PFPS, multiple studies have reported a tendency toward increased ACL injury risk in individuals with larger Q-angles (Mancino et al., 2023; Choudhary et al., 2019). These findings underscore the importance of including Q-angle assessment in knee ligament injury risk evaluation.

The role of Q-angle is also evident in overuse injuries, particularly Iliotibial Band Syndrome (ITBS). Kumarantini et al. (2025) reported a significant association between abnormal Q-angle values and increased ITBS incidence in runners. Altered lower extremity alignment resulting from abnormal Q-angle values is thought to increase repetitive lateral knee stress during the stance phase of running, thereby promoting iliotibial band irritation. These findings are consistent with reports by Aderem & Louw (2015) and Rais (2022), which identified knee deformities such as genu varum and genu valgum—closely related to abnormal Q-angle values—as major risk factors for ITBS. The high prevalence of ITBS among runners, particularly females (McKay et al., 2020), further emphasizes the clinical relevance of Q-angle in overuse injury mechanisms.

In addition to knee injuries, Q-angle has also been implicated in distal lower extremity injuries, such as ankle sprains. Rauh et al. (2007) and Araujo et al. (2017) reported that individuals with a history of ankle sprain exhibited larger Q-angle values compared with uninjured individuals. Furthermore, Jafari et al. (2017) found that runners with a Q-angle greater than 20° had a 1.7-fold higher risk of lower extremity injury compared with those with a Q-angle less than 15°. These findings indicate that the influence of Q-angle extends beyond the knee joint and affects tibial and ankle biomechanics through mechanisms involving increased internal rotation and overpronation.

Large-scale evidence provided by Hikawa et al. (2025), involving more than 11,000 elite athletes, demonstrated that elevated and asymmetric Q-angle values were associated with significantly different lower extremity biomechanical characteristics. Although this study did not directly assess injury incidence, the observed biomechanical alterations suggest a potential increase in injury risk and highlight the importance of assessing bilateral Q-angle symmetry. Overall, the consistency of findings across studies, sports, age groups, and sexes supports the clinical relevance of Q-angle as a screening tool for injury risk identification. Nevertheless, because

most existing studies are observational in nature, future longitudinal research is required to establish causal relationships and to evaluate the effectiveness of preventive interventions targeting Q-angle–related biomechanical factors, such as neuromuscular training, alignment correction, and orthotic interventions.

Conclusion

The Q-angle plays a significant role in influencing lower extremity biomechanics and represents an important anatomical factor associated with an increased risk of knee injury in athletes and physically active individuals. Increased and abnormal Q-angle values contribute to alterations in knee alignment, elevated patellofemoral stress, impaired patellar tracking, and a greater tendency toward knee valgus, which collectively increase biomechanical loading on the supporting structures of the knee joint.

Accumulating evidence indicates that an excessive Q-angle, particularly when accompanied by knee malalignment and impaired neuromuscular control, serves as a risk factor for the development of iliotibial band syndrome (ITBS), patellofemoral pain syndrome (PFPS), knee ligament injuries, and other patellofemoral pathologies. These associations are more pronounced in athletes exposed to repetitive and high-intensity loading, as well as in female athletes who anatomically tend to exhibit larger Q-angle values. Therefore, the assessment of Q-angle and comprehensive evaluation of lower extremity biomechanics should be integrated into injury risk screening and the design of preventive interventions to reduce injury risk and support long-term athletic performance.

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