International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Operating Publisher
SciFormat Publishing Inc.
ISNI: 0000 0005 1449 8214

2734 17 Avenue SW,
Calgary, Alberta, T3E0A7,
Canada
+15878858911
editorial-office@sciformat.ca

ARTICLE TITLE	SPECIFICITY OF ANTERIOR CRUCIATE LIGAMENT INJURIES IN FEMALE ATHLETES: AN ANALYSIS OF BIOMECHANICAL, HORMONAL AND NEUROMUSCULAR FACTORS IN INJURY PREVENTION
DOI	https://doi.org/10.31435/ijitss.2(50).2026.5548
RECEIVED	09 March 2026
ACCEPTED	26 May 2026
PUBLISHED	01 June 2026
LICENSE	The article is licensed under a **Creative Commons Attribution 4.0 International License.**

SPECIFICITY OF ANTERIOR CRUCIATE LIGAMENT INJURIES IN FEMALE ATHLETES: AN ANALYSIS OF BIOMECHANICAL, HORMONAL AND NEUROMUSCULAR FACTORS IN INJURY PREVENTION

Aleksandra Oszczypała *(Corresponding Author, Email: aleksandra.oszczypala@gmail.com)*
Medical University of Warsaw, Warsaw, Poland
ORCID ID: 0009-0006-5809-3934

Aleksandra Potempa
Medical University of Warsaw, Warsaw, Poland
ORCID ID: 0009-0004-2698-4957

Katarzyna Lipska
Medical University of Warsaw, Warsaw, Poland
ORCID ID: 0009-0003-5670-7726

Liwia Prorok
Medical University of Warsaw, Warsaw, Poland
ORCID ID: 0009-0008-3762-514X

Mateusz Żyła
Medical University of Warsaw, Warsaw, Poland
ORCID ID: 0009-0003-9005-620X

Michał Petkow
Medical University of Warsaw, Warsaw, Poland
ORCID ID: 0009-0008-3398-9069

Monika Szyszkowska
Medical University of Warsaw, Warsaw, Poland
ORCID ID: 0009-0006-5367-0026

Aleksandra Ustaszewska
Medical University of Warsaw, Warsaw, Poland
ORCID ID: 0009-0001-5651-5906

Zofia Parol
Medical University of Warsaw, Warsaw, Poland
ORCID ID: 0009-0007-0885-2637

Zuzanna Strojek
Medical University of Warsaw, Warsaw, Poland
ORCID ID: 0009-0005-8857-5670

ABSTRACT

Background: Anterior cruciate ligament (ACL) injuries represent a major orthopedic challenge in sports medicine. Female athletes sustain these injuries at substantially higher rates than their male counterparts, necessitating a deeper investigation into sex-specific risk factors.
Aim: This review offers a comprehensive analysis of the multifactorial etiology underlying the sex disparity in ACL injury rates. By integrating evidence from epidemiological studies, biomechanical simulations, and biochemical analyses, it aims to inform the development of more effective prevention strategies.
Methodology: The investigation centers on three principal risk domains: anatomical factors (including the Q angle and osseous geometry), hormonal fluctuations during the menstrual cycle (with emphasis on estrogen's influence on collagen metabolism and ligament stiffness), and neuromuscular patterns (such as quadriceps dominance and altered muscle recruitment).
Results: The efficacy of evidence-based prevention programs, including the PEP, Sportsmetrics, and FIFA 11+ protocols, is evaluated using meta-analytic data. Additionally, this review addresses the controversial clinical practice of prescribing hormonal contraceptives for injury prophylaxis, weighing the evidence for hormonal stabilization against the limited availability of high-certainty data on long-term musculoskeletal health.
Conclusions: This report synthesizes prevention strategies and emphasizes the need to transition from universal protocols to sex-specific, individualized athletic care. Addressing the interplay between biological and mechanical factors is proposed as a means to reduce injury rates and enhance the athletic longevity of female athletes.

KEYWORDS

ACL Injury, Female Athletes, Biomechanics, Menstrual Cycle, Neuromuscular Control, Injury Prevention

CITATION

Aleksandra Oszczypała, Aleksandra Potempa, Katarzyna Lipska, Liwia Prorok, Mateusz Żyła, Michał Petkow, Monika Szyszkowska, Aleksandra Ustaszewska, Zofia Parol, Zuzanna Strojek. (2026) Specificity of Anterior Cruciate Ligament Injuries in Female Athletes: An Analysis of Biomechanical, Hormonal and Neuromuscular Factors in Injury Prevention. *International Journal of Innovative Technologies in Social Science*. 2(50). doi: 10.31435/ijitss.2(50).2026.5548

1. Introduction

The anterior cruciate ligament (ACL) is a key stabilizer of the knee, resisting anterior tibial translation and rotatory loads. In both professional and amateur sports, pivoting, jumping, and rapid deceleration challenge this ligament. In recent decades, a stark disparity has become clear: female athletes are two to eight times more likely than males to suffer ACL ruptures. This issue has been called an "epidemic" in women's sports and is aggravated by increased female participation in intense activities such as soccer, basketball, and handball.

ACL injuries have consequences that extend beyond surgical intervention and the typical nine-to-twelve-month rehabilitation period. For many athletes, such injuries threaten career longevity and may preclude a return to pre-injury performance levels.

Understanding the causes of higher ACL risk in women requires a balanced perspective on modifiable and non-modifiable factors. Non-modifiable risks include anatomical traits such as a wider pelvis, an increased Q-angle, a narrower femoral intercondylar notch, and a steeper posterior tibial slope. The timing of the female endocrine cycle increases risk, as fluctuations in estrogen and relaxin may lower the ligament's failure threshold at certain times.

In contrast, neuromuscular and biomechanical factors are modifiable and present opportunities for injury prevention. Research demonstrates that female athletes frequently land from jumps or execute cutting maneuvers with dynamic knee valgus and quadriceps dominance. These movement patterns, acquired during development, can be modified through targeted neuromuscular training (NMT). This report examines these interactions and provides an evidence-based overview of ACL injury prevention in female athletes.

2. Materials and Methods

This review compiles high-impact research addressing the physiological, mechanical, and clinical aspects of ACL injuries in women. Data were primarily sourced from large meta-analyses and systematic reviews to ensure a robust evidence base.

Search Engines and Strategy

The primary literature search was performed across major medical and scientific search engines, including PubMed, Scopus, the Cochrane Library, Google Scholar. The search timeframe focused on studies published between 2000 and 2025. Key terms utilized in the search included: "ACL injury female athletes", "Q-angle ACL risk", "estrogen collagen lysyl oxidase", "quadriceps dominance", "neuromuscular training efficacy" and "hormonal contraceptives sports injury".

Inclusion and Exclusion Criteria

Following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, specific criteria were established to ensure the quality and relevance of the synthesized data.

Inclusion Criteria:

Study Design: prospective controlled trials, randomized controlled trials, and high-quality meta-analyses or systematic reviews.

Population: studies involving female athletes, with specific interest in adolescent (middle and high school) and collegiate/professional cohorts.

Intervention: neuromuscular training programs or interventions aimed specifically at reducing the incidence of ACL injuries.

Outcome measures: incidence of ACL injury, biomechanical metrics (e.g., knee valgus angle), and biochemical markers (e.g., serum estrogen levels or collagen cross-linking activity).

Language: articles published in English.

Exclusion Criteria:

Publication type: case reports, editorials or studies with insufficient statistical data for synthesis.

Clinical condition: studies focusing exclusively on post-operative rehabilitation without data on primary prevention or risk factors.

Data quality: studies that were analyses of previously reported data without providing original results or new secondary analysis.

3. Results

The ACL injury risk profile in female athletes arises from the interplay of structural, biological, and behavioral factors. The results are organized to reflect these domains.

Anatomical and Osseous Considerations

Anatomical differences between sexes result in increased mechanical stress for female athletes. The quadriceps (Q) angle, defined as the angle between the quadriceps pull and the patellar tendon, is a key metric in this context. The Q-angle is central to lower limb biomechanics. Although a wider pelvis can increase the Q-angle in females, recent studies indicate that the combination of pelvic width, shorter femur length, and a more lateral tibial tuberosity generates greater lateral force. This lateralization results in poor patellar tracking and predisposes the knee to valgus alignment during movement. Internally, the female knee is characterized by smaller ACLs, reduced energy absorption, and lower stiffness. When combined with a narrow femoral notch, the ligament is susceptible to compression and impingement during rotational sports movements.

Hormonal Influence and Collagen Metabolism

The biochemical environment of the female knee fluctuates during the menstrual cycle. The ACL has receptors for estrogen, progesterone, and relaxin. This shows it is hormone-responsive (Birt et al., 2023). The molecular mechanism of estrogen-induced vulnerability is a focal point of recent research. High serum concentrations of estrogen have been shown to inhibit lysyl oxidase (LOX), an enzyme critical for forming covalent collagen cross-links. A study using an engineered ligament model found that exposure to high estrogen levels decreased LOX activity. This inhibition "softens" the ligamentous extracellular matrix. While collagen levels may remain constant, the quality of cross-linking (the ligament's "glue") is compromised, reducing stiffness and ultimate tensile strength (Lee et al., 2015). Additionally, relaxin peaks in the second half of the cycle and further degrades collagen, potentially predisposing the joint to instability.

Neuromuscular and Biomechanical Factors

Neuromuscular factors are particularly significant due to their modifiability. "Quadriceps dominance" is a frequently observed characteristic in the movement patterns of female athletes.

Females frequently demonstrate altered recruitment patterns characterized by a lower hamstring-to-quadriceps coactivation ratio. Since the hamstrings act as an agonist to the ACL by pulling the tibia posteriorly, their relative weakness or delayed activation allows the quadriceps to pull the tibia forward, directly straining the ligament (Yoo et al., 2009). Furthermore, biomechanical tasks simulating athletic movements (such as lateral cutting, pivoting, or jumping) have shown higher ACL strain in females than in males; for example, studies measuring knee abduction moments during cutting maneuvers report significantly greater values in female athletes, indicating increased mechanical load on the ACL (Fry et al., 2025). High-risk movement profiles frequently involve an upright trunk, a planted foot with an internally rotated hip, and a valgus knee position in near full extension – a posture that maximizes the mechanical leverage against the ACL(Yoo et al., 2009). Table 1 concisely describes biomechanical deficits (such as quadriceps dominance, stiff landing and trunk instability) and their consequences for the ACL.

Table 1. Modifiable Neuromuscular Imbalances and High-Risk Biomechanical Movement Profiles

Biomechanical Deficit	Description	Consequence for the ACL
Quadriceps Dominance	Excessive reliance on the quadriceps over the hamstrings	Increases anterior tibial shear; stresses the ACL
Stiff Landing	Minimal flexion at the hip and knee during landing	High impact forces; reduced energy dissipation
Trunk Instability	Inability to control the center of mass over the knee	Increases joint torque and rotatory loading

Efficacy of Prevention Programs

Meta-analytical data provide strong support for implementing neuromuscular training (NMT) programs. These interventions are specifically designed to address the biomechanical deficits previously described. Effective programs share several characteristics: they are multicomponent, include sessions lasting at least 15 to 20 minutes, are conducted two to three times per week, and focus on landing stabilization and hamstring strengthening. Sub-analyses suggest that such training is most effective in younger athletes, particularly those in middle and high school, where neuromuscular patterns are still developing (Petushek et al., 2019). To clarify the differences in prevention protocols, Table 2 briefly describes the key components of PEP Program, Sportsmetrics, FIFA 11+ and HarmoKnee.

Table 2. Comparison of Methodological Components of Established ACL Prevention Protocols

Prevention Program	Key Components
PEP Program	Warm-up, stretching, strengthening, plyometrics, agility
Sportsmetrics	Intensive plyometric and strength training
FIFA 11+	Running, core/leg strength, balance, plyometrics
HarmoKnee	Activation, balance, strength, and core stability

4. Discussion

The data synthesized in this review highlight a multifactorial risk landscape; however, significant knowledge gaps persist regarding the relative contributions and interactions of these risk domains across various athletic populations and levels of play. While anatomical and hormonal factors establish the foundation for increased vulnerability, and the neuromuscular profile constitutes a principal mechanism for failure, further research is necessary to elucidate the interplay among these factors and to determine optimal targets for injury prevention strategies.

The Interaction of Anatomy and Biomechanics

The Q-angle and pelvic width must be considered in conjunction with movement patterns. A high Q-angle predisposes the knee to medial collapse; however, insufficient hip abductor and external rotator strength permits this collapse to manifest as a "dynamic valgus" event during athletic activity (Saber et al., 2024). When an athlete with a high Q-angle lands with "quadriceps dominance", the knee is positioned such that the ACL becomes the primary structure resisting the combined forces of anterior translation and valgus torque. This "ligament dominance" reflects a failure of the surrounding musculature to adequately protect the joint.

Osseous geometry further complicates this scenario. The observation that females possess a steeper posterior tibial slope indicates that, even with balanced musculature, their joints are inherently more susceptible to anterior translation under weight-bearing loads (Mancino et al., 2024). This anatomical disadvantage necessitates that female athletes develop greater hamstring strength and trunk control than males to achieve comparable joint stability.

The Influence Of Estrogen

The influence of estrogen on collagen metabolism represents a significant recent advancement in sports medicine. Estrogen can affect musculoskeletal performance and influence injury risk in female athletes, but the direct role of lysyl oxidase inhibition during the estrogen surge is not specifically addressed.

The Oral Contraceptive Controversy

The potential for hormonal contraceptives to stabilize this "molecular window" remains a subject of considerable clinical debate. Large-scale database studies have reported an association between systemic hormonal contraceptives use and a reduced incidence of ACL injuries requiring surgical intervention (in users versus non-users). Proponents argue that by suppressing ovulation-related surges of estrogen and relaxin, hormonal contraceptives may maintain the ACL in a more consistent and stiffer state.

However, the controversy stems from both the quality of available evidence and the ethical implications of such prescriptions. Critics highlight potential adverse effects, including an increased risk of future fractures and total knee arthroplasty among users of hormonal contraceptives (White et al., 2023). Additionally, hormonal contraceptives may negatively affect mood and body composition in a significant proportion of athletes (Porras et al., 2020).

From an ethical perspective, specialists caution against the "medicalization" of injury prevention. It is considered premature and potentially inappropriate to advocate for or prescribe hormonal contraceptives to adolescent females solely for ACL protection. Decisions regarding hormonal contraceptives use should be individualized, taking into account the athlete's contraceptive needs, menstrual health, and personal priorities, rather than employing hormonal contraceptives as a prophylactic performance enhancer (White et al., 2023).

5. Conclusions

The analysis of anterior cruciate ligament injuries in female athletes demonstrates a complex, integrated etiology in which biological, anatomical, and mechanical factors converge to create a high-risk profile. Anatomically, the female phenotype is defined by structural traits such as a more pronounced Q-angle, a narrower femoral notch, and a steeper posterior tibial slope, all of which inherently increase the mechanical burden on ligamentous structures during athletic maneuvers. These structural vulnerabilities are further exacerbated by cyclical endocrine fluctuations. The pre-ovulatory surge in estrogen initiates a biochemical cascade, reducing ligament mechanical stiffness.

Additionally, the prevalence of quadriceps-dominant recruitment patterns and altered landing biomechanics constitutes the primary modifiable risk factor. Inadequate coactivation of the posterior chain musculature during high-intensity activities shifts the stabilization burden onto the ACL, often resulting in ligament failure. Comprehensive neuromuscular training programs have demonstrated significant success in mitigating these risks by promoting safer movement strategies and enhancing muscular coactivation.

With respect to hormonal contraceptives, although epidemiological data suggest a potential protective effect against ACL rupture via hormonal stabilization, the current literature remains inconclusive and lacks

high-certainty evidence from randomized controlled trials. As a result, prescribing these medications solely for injury prophylaxis is not endorsed by current clinical guidelines and remains controversial due to the potential for long-term adverse musculoskeletal and systemic effects.

The findings of this review indicate that prevention strategies must be complex. Future initiatives should prioritize the widespread implementation of sex-specific neuromuscular training beginning in early adolescence and the development of individualized monitoring protocols that account for each athlete's unique hormonal and biomechanical profile. Transitioning toward descriptive, individualized clinical assessment, rather than reliance on generalized benchmarks, will be essential for reducing the burden of ACL injuries in the female athletic population (Mancino et al., 2023).

Author's contribution:

Conceptualization: Aleksandra Oszczypała, Zofia Parol, Zuzanna Strojek
Methodology: Michał Petkow, Monika Szyszkowska, Aleksandra Oszczypała, Aleksandra Ustaszewska
Software: Aleksandra Oszczypała, Liwia Prorok, Mateusz Żyła
Check: Aleksandra Potempa, Katarzyna Lipska, Aleksandra Oszczypała, Liwia Prorok
Formal analysis: Mateusz Żyła, Michał Petkow, Monika Szyszkowska, Aleksandra Oszczypała
Investigation: Aleksandra Oszczypała, Aleksandra Ustaszewska, Zofia Parol
Resources: Zuzanna Strojek, Aleksandra Oszczypała, Mateusz Żyła, Michał Petkow
Data curation: Aleksandra Potempa, Katarzyna Lipska, Liwia Prorok, Aleksandra Oszczypała
Writing - rough preparation: Aleksandra Oszczypała, Monika Szyszkowska, Aleksandra Ustaszewska, Zofia Parol
Writing – review and editing: Zuzanna Strojek, Aleksandra Potempa, Katarzyna Lipska, Liwia Prorok
Visualization: Mateusz Żyła, Michał Petkow, Monika Szyszkowska, Aleksandra Ustaszewska
Supervision: Aleksandra Oszczypała, Zofia Parol, Katarzyna Lipska, Liwia Prorok
Project administration: Aleksandra Oszczypała

All authors have read and agreed with the published version of the manuscript.

Ethical approval: Not applicable. This article does not contain any studies with human participants or animals performed by any of the authors.

Funding: This research did not receive any external funding like specific grant from funding agencies in the public, commercial, or nonprofit sectors.

Conflict of interest: The authors declare that they have no conflicts of interests, competing financial interests or personal relationships that could have influenced the work reported in this paper.

Data and materials availability: All data associated with this study will be available based on reasonable request to the Corresponding Author.

REFERENCES

1. Arundale, A. J. H., Bizzini, M., Dix, C., Giordano, A., Kelly, R., Logerstedt, D. S., Mandelbaum, B., Scalzitti, D. A., Silvers-Granelli, H., & Snyder-Mackler, L. (2023). Exercise-based knee and anterior cruciate ligament injury prevention. *Journal of Orthopaedic & Sports Physical Therapy, 53*(1), CPG1–CPG34. https://doi.org/10.2519/jospt.2023.0301
2. Birt, K. M., & McCarthy, H. E. (2023). The effect of estrogen on anterior cruciate ligament structure and function: A systematic review. *Journal of Musculoskeletal Disorders and Treatment, 9*, 127. https://doi.org/10.23937/2572-3243.1510127
3. Bradsell, H., & Frank, R. M. (2022). Anterior cruciate ligament injury prevention. *Annals of Joint, 7*, 1. https://doi.org/10.21037/aoj-2020-01
4. Burnham, J. M., & Wright, V. (2017). Update on anterior cruciate ligament rupture and care in the female athlete. *Clinics in Sports Medicine, 36*(4), 703–715. https://doi.org/10.1016/j.csm.2017.05.004
5. Fry, S. A., Hirpara, A., Whitney, K. E., Keeter, C. L., Constantine, E. P., Williams, K. G., & Dragoo, J. L. (2025). Use of hormonal contraceptives is associated with decreased incidence of anterior cruciate ligament injuries requiring reconstruction in female patients. *Arthroscopy, 41*(9), 3413–3421. https://doi.org/10.1016/j.arthro.2025.02.012
6. Gant, H., Ghimire, N., Min, K., Musa, I., Ashraf, M., & Lawan, A. (2024). Impact of the quadriceps angle on health and injury risk in female athletes. *International Journal of Environmental Research and Public Health, 21*(12), 1547. https://doi.org/10.3390/ijerph21121547
7. Gu, J., Zhang, R., Zhang, Y., & Shaharudin, S. (2025). Neuromuscular training for preventing knee injuries in female team athletes: A meta-analysis. *Annals of Medicine, 57*(1), 2581891. https://doi.org/10.1080/07853890.2025.2581891
8. Hewett, T. E., Ford, K. R., & Myer, G. D. (2006). Anterior cruciate ligament injuries in female athletes: Part 2, a meta-analysis of neuromuscular interventions aimed at injury prevention. *American Journal of Sports Medicine, 34*(3), 490–498. https://doi.org/10.1177/0363546505282619
9. Kirschbaum, E. M., Henke, J., Heyde, K., & Legerlotz, K. (2026). Hormonal contraception, menstrual cycle characteristics, and lower limb injuries in elite female team sports—Identifying factors associated with increased injury prevalence: A cross-sectional study. *Health Science Reports, 9*(2), e71812. https://doi.org/10.1002/hsr2.71812
10. Koyejo, T. T., Babalola, O. R., Itakpe, S. E., Alatishe, K. A., Maleeq, R. O., Akor, C. O., & Olorunsogo, O. (2025). Assessment of increased quadriceps angle as a risk factor for anterior cruciate ligament injury. *Journal of the West African College of Surgeons, 16*(1), 54–59. https://doi.org/10.4103/jwas.jwas_152_24
11. Lee, C. A., Lee-Barthel, A., Marquino, L., Sandoval, N., Marcotte, G. R., & Baar, K. (2015). Estrogen inhibits lysyl oxidase and decreases mechanical function in engineered ligaments. *Journal of Applied Physiology, 118*(10), 1250–1257.
12. Lee, H., Petrofsky, J. S., Daher, N., Berk, L., Laymon, M., & Khowailed, I. A. (2013). Anterior cruciate ligament elasticity and force for flexion during the menstrual cycle. *Medical Science Monitor, 19*, 1080–1088. https://doi.org/10.12659/MSM.889393
13. Malvita, A. V. (2024). *How hormonal contraceptives influence injury in female athletes: A systematic review* [Honors undergraduate thesis]. Honors Undergraduate Theses, 225.
14. Mancino, F., Kayani, B., Gabr, A., Fontalis, A., Plastow, R., & Haddad, F. S. (2024). Anterior cruciate ligament injuries in female athletes: Risk factors and strategies for prevention. *Bone & Joint Open, 5*(2), 94–100. https://doi.org/10.1302/2633-1462.52.BJO-2023-0166
15. Mattu, A. T., Ghali, B., Linton, V., Zheng, A., & Pike, I. (2022). Prevention of non-contact anterior cruciate ligament injuries among youth female athletes: An umbrella review. *International Journal of Environmental Research and Public Health, 19*(8), 4648.
16. Noyes, F. R., & Barber-Westin, S. D. (2012). Anterior cruciate ligament injury prevention training in female athletes: A systematic review of injury reduction and results of athletic performance tests. *Sports Health, 4*(1), 36–46. https://doi.org/10.1177/1941738111430203
17. Padua, D. A., DiStefano, L. J., Hewett, T. E., Garrett, W. E., Marshall, S. W., Golden, G. M., Shultz, S. J., & Sigward, S. M. (2018). National Athletic Trainers' Association position statement: Prevention of anterior cruciate ligament injury. *Journal of Athletic Training, 53*(1), 5–19. https://doi.org/10.4085/1062-6050-99-16
18. Parsad, V., Pandey, N., Agrawal, S., & Kumari, R. (2025). Anatomical, biomechanical, and biochemical factors contributing to the higher incidence of ACL injuries in female athletes versus male athletes. *Journal of Medical and Life Science, 7*, 376–383. https://doi.org/10.21608/jmals.2025.374894.1051
19. Petushek, E. J., Sugimoto, D., Stoolmiller, M., Smith, G., & Myer, G. D. (2019). Evidence-based best-practice guidelines for preventing anterior cruciate ligament injuries in young female athletes: A systematic review and meta-analysis. *American Journal of Sports Medicine, 47*(7), 1744–1753. https://doi.org/10.1177/0363546518782460

20. Porras, L., Mangutz, N. J., Boyd, M. O., Newby-Goodman, M., Jones, J. M., et al. (2020). Effects of hormonal contraceptives on non-bone related injury risk and athletic performance in female athletes: A systematic review of the literature. *Annals of Sports Medicine and Research, 7*(5), 1162.
21. Ryall, S., Ohrling, H., Stellingwerff, T., Black, S., Reilly, K., & Thornton, J. S. (2024). Contraception choice for female endurance athletes: What's sport got to do with it? A cross-sectional survey. *Sports Medicine, 54*(12), 3181–3197. https://doi.org/10.1007/s40279-024-02078-1
22. Saber, B., Bridger, D., & Agrawal, D. K. (2024). A critical analysis of the factors contributing to anterior cruciate ligament injuries in female athletes. *Journal of Orthopaedics and Sports Medicine, 6*(4), 203–209. https://doi.org/10.26502/josm.511500163
23. Samuelson, K., Balk, E. M., Sevetson, E. L., & Fleming, B. C. (2017). Limited evidence suggests a protective association between oral contraceptive pill use and anterior cruciate ligament injuries in females: A systematic review. *Sports Health, 9*(6), 498–510. https://doi.org/10.1177/1941738117734164
24. Ward, J., Ingram, K. M., Biffle, J., Hildebrand, E. E., & Lisman, P. (2024). Effective anterior cruciate ligament injury prevention programming in young female athletes: An evidence-to-practice review. *Clinical Practice in Athletic Training, 7*(4), 18.
25. White, L., Losciale, J. M., Squier, K., et al. (2023). Combined hormonal contraceptive use is not protective against musculoskeletal conditions or injuries: A systematic review with data from 5 million females. *British Journal of Sports Medicine, 57*, 1195–1202.
26. White, L., Losciale, J. M., Squier, K., Guy, S., Scott, A., Prior, J. C., & Whittaker, J. L. (2023). Combined hormonal contraceptive use is not protective against musculoskeletal conditions or injuries: A systematic review with data from 5 million females. *British Journal of Sports Medicine, 57*(18), 1195–1202. https://doi.org/10.1136/bjsports-2022-106519
27. Yoo, J., Lim, B., Ha, M., Lee, S., Oh, S., Lee, Y., & Kim, J. (2009). A meta-analysis of the effect of neuromuscular training on the prevention of the anterior cruciate ligament injury in female athletes. *Knee Surgery, Sports Traumatology, Arthroscopy, 18*, 824–830. https://doi.org/10.1007/s00167-009-0901-2