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THE RELATIONSHIP BETWEEN HIGH-PERFORMANCE SPORTS AND ANTERIOR CRUCIATE LIGAMENT (ACL) INJURIES: A SYSTEMATIC REVIEW

A RELAÇÃO ENTRE ESPORTES DE ALTO RENDIMENTO E LESÕES DO LIGAMENTO CRUZADO ANTERIOR (LCA): UMA REVISÃO SISTEMÁTICA

LA RELACIÓN ENTRE LOS DEPORTES DE ALTO RENDIMIENTO Y LAS LESIONES DEL LIGAMENTO CRUZADO ANTERIOR (LCA): UNA REVISIÓN SISTEMÁTICA

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ABSTRACT

This article investigates the relationship between high-performance sports and Anterior Cruciate Ligament (ACL) injuries. The high incidence of these injuries, especially in modalities that involve rapid changes of direction, highlights the need to understand their mechanisms, risk factors, and prevention strategies. The research was conducted through an integrative literature review, with the objective of understanding the main risk factors, clinical consequences and prevention strategies related to ACL injuries. Articles published between 2020 and 2025, selected from the PubMed and Virtual Health Library (VHL) databases, were analyzed. After applying inclusion and exclusion criteria, eight relevant studies were examined. The results indicate that most ACL injuries occur without direct contact, being attributed to biomechanical and neurocognitive factors,

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such as incorrect landings, inadequate hip flexion, and cognitive distractions during play. Specific cases reveal that, in badminton, scissor jumping is often associated with injury; in rugby, 75% of breaks occur in the first 40 minutes of play; and in the WNBA, the average return time after injury is 375 days. In addition, genetic studies suggest the possible influence of loci such as COL22A1 on susceptibility to ruptures. ACL injuries have a significant impact on the sports career and quality of life of athletes, leading to prolonged absences and a high risk of recurrence. In view of this, the importance of adopting prevention programs focused on muscle strengthening, neuromotor control and re-education of movements is reinforced, as a way to preserve the performance and health of high-performance athletes

Keywords: LCA. High-performance sports. Non-contact injuries. Injury prevention. Risk factors.

RESUMO

Este artigo investiga a relação entre esportes de alto rendimento e lesões do Ligamento Cruzado Anterior (LCA). A alta incidência dessas lesões, especialmente em modalidades que envolvem mudanças rápidas de direção, destaca a necessidade de compreender seus mecanismos, fatores de risco e estratégias de prevenção. A pesquisa foi conduzida por meio de uma revisão integrativa da literatura, com o objetivo de compreender os principais fatores de risco, consequências clínicas e estratégias de prevenção relacionadas às lesões do LCA. Foram analisados artigos publicados entre 2020 e 2025, selecionados nas bases de dados PubMed e Biblioteca Virtual em Saúde (BVS). Após a aplicação dos critérios de inclusão e exclusão, oito estudos relevantes foram examinados. Os resultados indicam que a maioria das lesões do LCA ocorre sem contato direto, sendo atribuídas a fatores biomecânicos e neurocognitivos, como aterrissagens incorretas, flexão inadequada do quadril e distrações cognitivas durante o jogo. Casos específicos revelam que, no badminton, o salto tesoura é frequentemente associado a lesões; no rúgbi, 75% das quebras ocorrem nos primeiros 40 minutos de jogo; e na WNBA, o tempo médio de retorno após uma lesão é de 375 dias. Além disso, estudos genéticos sugerem a possível influência de loci como COL22A1 na suscetibilidade a rupturas. As lesões do LCA têm impacto significativo na carreira esportiva e na qualidade de vida dos atletas, levando a afastamentos prolongados e a um alto risco de recidiva. Diante disso, reforça-se a importância da adoção de programas de prevenção focados no fortalecimento muscular, no controle neuromotor e na reeducação dos movimentos, como forma de preservar o desempenho e a saúde dos atletas de alto rendimento.

Keywords: ACV. Esportes de alto rendimento. Lesões sem contato. Prevenção de lesões. Fatores de risco.

RESUMEN

Este artículo investiga la relación entre los deportes de alto rendimiento y las lesiones del ligamento cruzado anterior (LCA). La alta incidencia de estas lesiones, especialmente en modalidades que implican cambios rápidos de dirección, destaca la necesidad de comprender sus mecanismos, factores de riesgo y estrategias de

prevención. La investigación se realizó a través de una revisión integrativa de la literatura, con el objetivo de comprender los principales factores de riesgo, las consecuencias clínicas y las estrategias de prevención relacionadas con las lesiones del LCA. Se analizaron artículos publicados entre 2020 y 2025, seleccionados de las bases de datos PubMed y Virtual Health Library (BVS). Después de aplicar los criterios de inclusión y exclusión, se examinaron ocho estudios relevantes. Los resultados indican que la mayoría de las lesiones del LCA ocurren sin contacto directo, atribuyéndose a factores biomecánicos y neurocognitivos, como aterrizajes incorrectos, flexión inadecuada de la cadera y distracciones cognitivas durante el juego. Casos específicos revelan que, en bádminton, el salto de tijera a menudo se asocia con lesiones; en rugby, el 75% de los quiebres ocurren en los primeros 40 minutos de juego; En la WNBA, el tiempo promedio de recuperación tras una lesión es de 375 días. Además, estudios genéticos sugieren la posible influencia de loci como COL22A1 en la susceptibilidad a las roturas. Las lesiones del ligamento cruzado anterior (LCA) tienen un impacto significativo en la carrera deportiva y la calidad de vida de los atletas, lo que provoca bajas prolongadas y un alto riesgo de recurrencia. Por ello, se refuerza la importancia de implementar programas de prevención centrados en el fortalecimiento muscular, el control neuromotor y la reeducación de movimientos, como forma de preservar el rendimiento y la salud de los atletas de alto rendimiento.

Palabras clave: LCA. Deportes de alto rendimiento. Lesiones sin contacto. Prevención de lesiones. Factores de riesgo.

INTRODUCTION

The knee is a complex joint set, which involves a wide network of ligaments and muscles and its main function is the support and mobility of the lower limbs (AGUR et al., 2021). In high-performance sports, the efficiency of the lower limbs is crucial and subject to considerable wear and tear, and to avoid the risk of injury, it is essential to understand the conditions that can compromise the health and performance of athletes (SILVA & OLIVEIRA, 2024). Like Anterior Cruciate Ligament injury, current evidence indicates that the average incidence of Anterior Cruciate Ligament tears in athlete populations is approximately 1 case per 3,500 individuals (LARWA et al., 2021).

Anterior Cruciate Ligament (ACL) injuries are the most frequent within the knee ligament system, they usually occur during movements such as landings, sudden decelerations, quick cuts and rotations, and are common in activities that require sudden changes of direction (BODEN et al., 2000; LARWA et al., 2021). These injuries represent a worldwide concern in the sports environment, due to their serious consequences, such as the higher risk of developing early post-traumatic osteoarthritis in the knee, the high rate of new injuries in the graft or opposite knee, in addition to the decrease in sports performance (OLIVARES-JABALERA et al., 2021). Studies demonstrate that the risk of ACL tear is higher among female football players and American football players, but several other sports, such as gymnastics, rugby, and lacrosse, demonstrate an equally high incidence of ACL injury (BRAM et al., 2021).

These injuries are very frequent in young athletes, there are estimates that describe the occurrence as 400 to 100,000 young athletes per year (BRAM et al., 2021). Thus, it is essential that coaches and doctors know how to identify and diagnose ACL tears, since continuing to play with a torn ligament can aggravate injuries to the meniscus and cartilage of the knee (DINGEL et al., 2019). Thus, these injuries can be with or without contact, the rate of non-contact injuries occurs at a frequency of two to eight times higher in female patients than in male patients participating in similar sports and activities (OLIVARES-JABALERA et al., 2021).

Thus, this article aims to: analyze the incidence of Anterior Cruciate Ligament injuries in high-performance sports athletes, identifying the main associated risk factors; explore the consequences of ACL injuries, such as impact on sports careers, risks of recurrence, and development of early osteoarthritis; and to investigate prevention

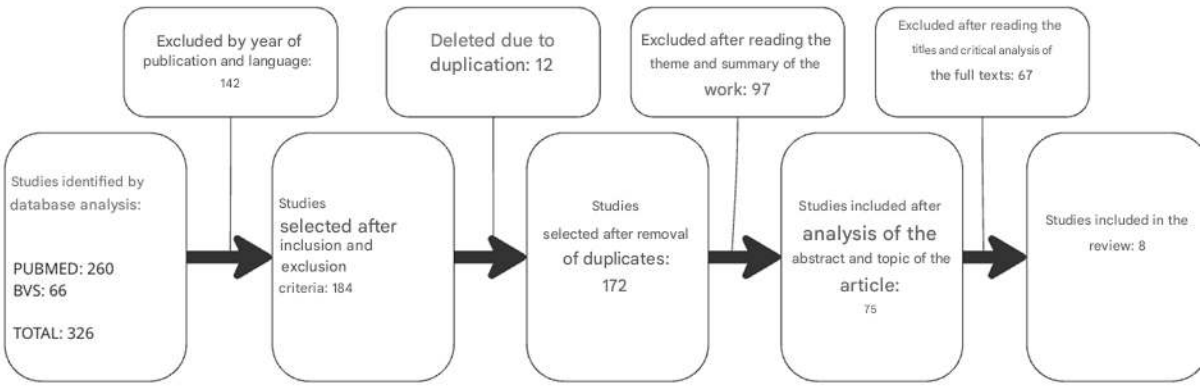
strategies to minimize the occurrence of ACL injuries in high-impact sports and rapid changes of direction.

METHODOLOGY

This study represents an integrative review that began with the scientific question "What is the relationship between high-performance sports and anterior cruciate ligament (ACL) injuries?", and after choosing the theme, scientific articles present in the Virtual Health Library (VHL) and in the National Library of Medicine (PUBMED) Database were analyzed. through inclusion and exclusion criteria, such as year of publication (2020-2025) in addition to the adequacy of English as an official language. In addition, in the exclusion criteria, duplicate studies and those that did not answer the question proposed by the theme were removed from this research. In addition, it is worth mentioning that the descriptors used were: "Anterior Cruciate Ligament Injuries", "ACL breakup" and "High performance exercise", linked by the particle "AND" found in the Health Science Descriptors (DECS).

After checking the studies, 326 published studies related to the topic were found on the aforementioned platforms, which were then thoroughly analyzed according to the aforementioned parameters, so that 142 were excluded due to the date of publication and language. In addition, duplicates were tracked using the Endnote platform, and the theme and abstract of the work were later analyzed, allowing the exclusion of 109 texts. Finally, after the complete reading of 67 articles, 8 articles that influenced the writing of this study were selected and will be cited in the reference section. All the above information can be seen in the flowchart in figure 1.

Flow Chart 1



RESULTS

AUTHOR/YEAR	COUNTRY	SAMPLE STUDIED	FINDINGS
KAUDAL et al., 2024	Denmark	investigated ACL tears in a cohort of 90,610 participants	Most reported that the main sport they played was Badminton and 155 played at a competitive level. Regarding the location, the most reported court position was the rear and the injuries were distributed between the backhand side and the forehand side, in addition to the fact that this type of rupture was described by young people between 18 and 29. Therefore, the most recurrent movement prior to the injury was the scissor jump on the back court, in addition the dominant leg was harmed mainly on the forehand side and the non-dominant leg mainly backhand.
AXELROD et al., 2022	United States	Reports of 99 WNBA Injury Athletes	According to the study, 37 athletes suffered ACL injuries. In addition, the highest rate/duration of return to play (RTP) was found in anterior cruciate ligament injuries being 375 days, the most devastating when comparing

			meniscus tear (231 days) and MCL strain (124 days). In this way, the positions that suffered the most knee injuries were point guards and point guards. In addition, when analyzing videos of ACL and MCL injuries, it was observed that (83%) were non-contact injuries, hip flexion was the most reported (92%) and finally all the injuries analyzed occurred with the leg in the flexed position and with the knee flexed in the valgus position.
BROPHY et al., 2021	United States	140 Videos of ACL Tears Occurring in National Football League (NFL) Games	The research reports that 70% of the injuries observed were non-contact, and these injuries are more likely to occur in athletes with lower BMI, with direct contact injuries being observed in players with higher BMI. Thus, it was reported that ACL tears that occurred during the 8 weeks of the season resulted more frequently from direct contact, third trimester tears were the most likely to occur by direct contact, but

			those that occurred in the fourth trimester were the least likely to occur by direct contact.
DELLA VILLA et al., 2021	It used an online database of championships from several countries (Super Rugby, Premiership, Top 14 and Pro 12/14)	A total of 62 ACL injuries have been identified in players from the four most important rugby leagues over the course of four consecutive seasons.	The research reported that most of the injuries occurred during the attack. In addition, most of the breaks occurred without contact (24), and the situations identified that culminated in this type of complication were change of offensive direction (18), being knocked down (10) and pressing/tacklar (8). Furthermore, it was observed that most injuries are associated with knee loading in the sagittal plane, accompanied by valgus loading of the knee. Thus, 75% of the ruptures observed occurred in the first 40 minutes of the match.
LUCARNO et al., 2021.	Italy	A systematic search was conducted in online databases over three seasons (2017-2018, 2018, 2019, and 2019-2020 until December) to identify ACL injuries that occurred in matches involving female players from 6 of the	The research reports that most injuries (94%) occurred due to direct load on the injured leg, and in relation to the dynamics of movement, horizontal displacement was considered the most frequent. The lesions were classified as: direct (11%),

		top 15 leagues in the FIFA Women's World Rankings.	indirect (34%) and non-contact (54%). Therefore, most ACL injuries occurred without direct contact, indicating that biomechanical movements or actions, such as incorrect landings or abrupt changes in direction, were the main factors.
BEZUGLOV et al., 2024.	**Russia**	The study looked at all anterior cruciate ligament (ACL) tears suffered by Russian Premier League (RPL) players who required surgery between 2010 and 2022. 12 seasons of competition were included.	The study finds that there were 100 ACL injuries in 85 players over 12 competitive seasons (2010-2022), spanning 21 teams. There was an average of 8.3 injuries per season, which equates to approximately 1 ACL injury for every 2 teams. The most common injuries occurred during official games (58 cases) and team training (29 cases). Of the total number of players, only 3 (3.5%) ended their careers due to injuries, while the vast majority, 96.5%, managed to return to football.
EBERT et al., 2023.	**Australia**	The sample was composed of athletes from the Estonian National Team, including Olympic	The study analyzed positive genetic associations between several genes and categories of

		competitors and participants in international championships, from 2017 to 2018. 126 athletes were included in the study, of which 104 were men.	musculoskeletal disorders (AT, PT, HS and LCA). Among the genes identified, PAPPA 2, DOK5, DAP, GNG12, PLXNA2 and COL22A1 demonstrated relevance. The COL22A1 gene, in particular, plays a key role in collagen production, contributing to the stabilization of myotendinous junctions and strengthening skeletal muscle insertions during contractions. The study was unable to identify specific markers for specific categories of injuries (such as ACL), due to the limited sample. However, the identification of loci that indicate nonspecific susceptibility serves as an important basis for future studies.
GOKELER et al., 2024.	**United Kingdom**	The study analyzed videos of non-contact ACL injuries in a cohort of male professional soccer athletes, totaling 57 cases. Of these, 47 videos presented quality for clear identification of the moments and	The article reveals that neurocognitive errors played a significant role in the events that led to non-contact ACL injuries. Of the 47 injuries analyzed, 26 were associated with some type of pressure, and in 19 of these

		mechanisms involved in the injuries.	situations (73%), the opponent performed a deceptive action, indicating a weak inhibitory motor response on the part of the defender. Most injuries occurred during offensive (81%) and defensive (19%) actions. In 16 cases (76%), the players diverted their attention from the dynamics of the game, which evidences attentional inhibition. In addition, the study highlighted that errors in inhibitory control of motor response and attention were common during non-contact injury events.

DISCUSSION

The analysis of the selected studies reveals a marked predominance of anterior cruciate ligament injuries caused without direct contact, which reinforces the relevance of biomechanical and neuromuscular factors in the genesis of these injuries. Data show that more than 70% of ACL rupture episodes manifest during movements such as sudden changes in direction, deceleration, and poorly executed landings, often with the knee valgus and the hip flexed. These positions have a biomechanically vulnerable character because they increase the tension on the ligament and, consequently, favor rupture. Understanding these patterns is critical for the development of specific preventive protocols for different modalities and risk groups (AXELROD et al., 2022; BROPHY et al., 2021; DELLA VILLA et al., 2021; LUCARNO et al., 2021).

Such mechanisms of ACL injury vary according to the sport and the nature of the competitive practice, since each one has its own movements and strategies that end up favoring this type of injury. In sports such as badminton, the Danish study identified scissor jumping and displacements at the back of the court as the most risky movements, especially among young athletes (KAUDAL et al., 2024). In the NFL, a correlation was observed between body mass index (BMI) and the type of injury, with athletes with higher BMI being more likely to have contact injuries and those with lower BMI being more likely to have non-contact injuries (BROPHY et al., 2021). In rugby, they highlight the predominance of injuries during offensive actions without contact, especially in changes of direction and tackle situations (DELLA VILLA et al., 2021). Finally, in European women's football, an Italian study pointed to horizontal displacement as the most common context for ACL injuries, often in scenarios without direct contact (LUCARNO et al., 2021).

In addition to biomechanical factors, neurocognitive elements also play a crucial role in the occurrence of ACL injuries. Most of the cases analyzed occurred under cognitive pressure, such as in situations of unexpected dribbling by the opponent, which require quick and accurate responses. This finding highlights the importance of skillful preparation in athlete training, incorporating exercises that simulate game scenarios with the requirement of divided attention, decision-making, and motor control under stress (GOKELER et al., 2024).

Although still in its early stages, the investigation of genetic factors related to ACL injury has made progress. The Australian study identified the presence of genetic loci, such as COL22A1, with a potential influence on the integrity of muscle and skeletal structures, which includes tendons and ligaments. This gene, associated with collagen production, can affect the strength of myotendinous junctions. Although the authors were unable to isolate specific markers for ACL tears, the results pave the way for future studies that may identify individuals with greater susceptibility to this type of injury, enabling personalized prevention strategies (EBERT et al., 2023).

In terms of prognosis, most injured athletes are able to return to competitive sport after ACL reconstruction surgery, with a return rate of 96.5% among players in the Russian league (BEZUGLOV et al., 2024). However, the time required for rehabilitation varies widely between modalities and according to the severity of the injury in question. In an American study, WNBA athletes require significantly longer recovery time. This

may be associated with biomechanical factors, type of sport, competitive level, and specific functional demands of each modality. Still, the rate of career termination after injury is low, suggesting that, with adequate follow-up, a return to high performance is feasible for most cases (AXELROD et al., 2022).

CONCLUSION

The studies analyzed demonstrated that high-performance sports are strongly associated with a high incidence of Anterior Cruciate Ligament (ACL) injuries, especially in modalities that require intense and unstable movements, such as soccer, rugby, American football, women's basketball and badminton. Factors such as genetic predisposition, neurocognitive aspects, and type of movement are determinants of the risk of injury. ACL ruptures significantly impact the career and quality of life of athletes, and can cause prolonged absences, recurrence and early osteoarthritis. Thus, preventive strategies — such as muscle strengthening, neuromotor control, and movement reeducation — are essential to reduce the incidence of these injuries. It is recommended to develop personalized prevention protocols, taking into account the specificities of each modality and athletic profile, in order to preserve the performance and health of high-performance athletes.

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