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Injuries and Prevention of Knee and Shoulder Joints in Badminton

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Abstract. With the development and popularization of badminton, the number of participants has surged rapidly, and correspondingly, the number of injuries has also continued to rise. However, most people are unable to take adequate preventive measures and accurately assess injuries. This paper analyzes and discusses the injury mechanisms and preventive strategies for the shoulder and knee joints, which are particularly susceptible to injury in badminton. The findings of this study indicate that movements such as the lunge step and single-leg landing are prone to cause Anterior Cruciate Ligament (ACL) injuries. Incorrect or excessive execution of the backhand clear and consecutive smash shots can easily lead to rotator cuff injuries in the shoulder joint. Recovery from both types of injuries requires a significant amount of time, and even after recovery, it is often difficult to return to pre-injury athletic performance levels. In addition, preventive measures regarding knee injuries including warming up thoroughly before exercise, wearing knee pads during exercise, stretching appropriately according to one's needs after exercise and choosing professional badminton courts are the most effective and easy to implement. For preventing shoulder joint injuries, besides the aforementioned measures, the risk can also be reduced by training to increase core and shoulder strength and by standardizing hitting techniques. As the number of people participating in badminton increases, the significance of this research and discussion lies in enabling badminton enthusiasts to enhance their self-protection awareness through the explanations provided herein and to gain a clear understanding of the movement mechanics and force generation principles in badminton.

Keywords: Badminton sports injuries, Knee joint, Anterior cruciate ligament (ACL), Shoulder joint, Rotator cuff.

1. Introduction

Since badminton was included as an Olympic sport in 1992, it has gained widespread popularity worldwide. By 2025, the number of participants in this sport has exceeded 200 million [1]. Despite badminton being a non-contact sport, its injury rate is remarkably high. Research indicates an injury frequency of approximately 1 to 4 injuries per 1000 hours of play, even among professional badminton athletes [2]. Among badminton injuries, lower limb injuries account for about 55%-75%, while upper limb injuries comprise approximately 20% [3]. Currently, most domestic research on badminton focuses on badminton techniques and match analysis. Studies specifically addressing

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badminton-related injuries, particularly those involving the knee and shoulder joints, are relatively scarce. Internationally, research on knee and shoulder injuries caused by badminton is more extensive than domestically, but the overall quantity remains limited.

Although research on badminton techniques has yielded results, and studies on knee and shoulder injuries have produced findings and treatment protocols, there is currently a lack of articles that integrate and analyze why badminton causes injuries to these joints. This paper will focus on the ACL of the knee joint and the rotator cuff muscles of the shoulder joint—the two most vulnerable areas—analyzing the causes of injury in relation to badminton footwork and swing mechanics and proposing specific preventive measures.

2. Knee joint injury analysis

The primary structural functions of the knee joint are load-bearing, stabilization, cushioning and shock absorption. Its roles in badminton include bearing weight, performing flexion-extension movements, executing limited rotation and providing dynamic stability. Due to the high speed of the game, the knee joint undergoes frequent movement and load-bearing, making it susceptible to injury. Common current injuries include Anterior Cruciate Ligament (ACL) injury, meniscus injury, and Medial Collateral Ligament (MCL) injury. ACL injury is particularly common and is the most frequently injured ligament in the knee joint [4].

2.1. ACL anatomy & function

The Anterior Cruciate Ligament is one of the four primary ligaments of the knee joint, originating anterior to the tibial intercondylar eminence and inserts on the posteromedial aspect of the lateral femoral condyle. Its main functions are to inhibit the anterior translation of the tibia relative to the femur and provide stability during knee flexion, extension, and rotation, while working in conjunction with the posterior cruciate ligament (PCL) to control axial rotation and sagittal stability during rapid motion [5]. Due to the lack of direct vascular supply within its structure, the ACL has almost no capacity for natural healing once ruptured. Reconstruction typically requires autograft or allograft tendon transplantation [6].

2.2. ACL—vulnerable movements

High-risk maneuvers in badminton mainly include extreme lunges and single-leg landings that stop abruptly with a change in direction. The extreme lunge is frequently employed when rapidly responding to shots and is a major source of high stress and strain on the ACL [7]. Research shows that greater lunge distances correlate with higher ground reaction forces acting on the knee joint, accompanied by significant increases in knee external rotation and varus angles, thereby increasing ACL load. Single-leg landings, such as after a backhand overhead stroke in the rear court, impose substantial impact on the knee joint during the initial landing phase before it is fully flexed. Moreover, electromyographic (EMG) activation patterns during these landings differ significantly between genders [8]. Finally, injuries from sudden stops and directional changes mainly stem from the shear forces generated during rapid deceleration and pivoting after running, which are common causes of non-contact ACL injuries [5]. Notably, over 70% of ACL injuries are non-contact injuries, closely related to technical errors and neuromuscular control imbalances [6].

Within the specialized footwork of badminton, these movements correspond to the net lunge, single-leg landing after a jump smash, and rapid lateral push-off and rotation. In simpler terms, these

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actions place enormous pressure on the knee joint and generate significant tensile forces on the ACL. Professional badminton athletes, in particular, undergo very high training volumes. During footwork and multi-shuttle drills, the ACL is constantly engaged to restrict excessive anterior translation of the tibia relative to the femur. Common training drills include, but are not limited to: retrieving deep shots passively at the net, lunging aggressively at the net, and performing jump smashes from two rear-court positions. These movements pose immense challenges to the ACL, involving high pressure and extreme stretching. Under prolonged high-intensity training, the ACL and surrounding muscles experience severe fatigue. The flexibility and elasticity of the ACL, as well as the protective and force-generating functions of the surrounding muscles, decline drastically. With reduced flexibility and insufficient muscular protection, the ACL becomes highly vulnerable to sprains or ruptures. Therefore, inappropriate training loads and erroneous training methods are the primary causes of ACL injuries among professional badminton players. For amateur badminton enthusiasts, the causes of injury lean more towards insufficient strength to support the execution of movements or inadequate warm-up before engaging in high-intensity activity. This leaves the ACL and surrounding muscles unprepared for the demands of play. Additionally, many enthusiasts lack professional training and have not established correct technical movement patterns. Faulty technique and insufficient warm-up are the main reasons for ACL injuries within the enthusiast group.

2.3. ACL injury management and outcome

ACL rupture or tear is one of the most common sports injuries of the knee joint. The most prevalent treatment for a complete ACL rupture is Anterior Cruciate Ligament Reconstruction (ACLR) surgery. In the United States alone, over 200,000 ACLR surgeries are performed annually. In China, with its large population and the rise of national fitness campaigns driving popularity in sports like badminton, basketball, and football, the number of ACLR procedures has also increased rapidly. Data from the Sports Medicine Department of Peking University Third Hospital shows that the annual number of ACLR cases surged from 136 in 2001 to 2,561 in 2020 [9]. This clearly demonstrates the vulnerability of the ACL, especially during high-intensity sports involving the knee joint, such as badminton. Furthermore, because the ACL lacks direct blood vessels nearby, its nutrients primarily come from synovial fluid and capillaries attached to it. This scarcity of substantial nutrient supply results in very slow recovery and makes self-healing after a tear almost impossible [2]. This injured population includes many professional badminton athletes. While the fundamental goal for athletes is to return to sports as quickly as possible and regain pre-injury performance levels, post-ACLR, only about 80% of individuals can return to sports participation, fewer than 68% regain their pre-injury athletic level, and less than 60% return to competitive standards [4].

3. Shoulder joint injury analysis

The primary structural functions of the shoulder joint include performing flexion, abduction, internal rotation, external rotation, and circumduction. In badminton, the shoulder joint acts as a core power hub and control center. It must generate explosive power for smashes while also enabling precise joint control for delicate net shots. However, the sport requires athletes to perform high-frequency, high-intensity repetitive motions of extension, internal rotation, external rotation, and circumduction. This leads to overuse of the shoulder joint, making it highly susceptible to injury. Common badminton-related shoulder injuries include subacromial impingement syndrome, rotator cuff tears, and biceps long-head tendinitis. Due to a biomechanical paradox in badminton—requiring

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the glenohumeral joint to achieve rapid internal rotation during the smash while also demanding high-speed external rotation—the supraspinatus tendon endures significant shear forces between the humeral head and the acromion. Consequently, severe shoulder injuries can occur under extreme playing conditions. Among serious shoulder injuries, rotator cuff tears account for over 40% [10]. Regarding shoulder injuries, shoulder pain caused by badminton is very common among young athletes [11]. Epidemiological studies indicate that most shoulder pain in badminton results from overuse injuries. Comparing the ratio of overuse injuries to traumatic injuries, multiple studies show that overuse injuries are three times more common than traumatic ones [11].

3.1. Rotator cuff injuries

3.1.1. Biomechanical function of the rotator cuff in badminton

Shoulder sleeves have two main functions during badminton hitting, one is power transmission and control. During the swing process, force transmission is generated, including explosive internal rotation during dunking and eccentric to concentric transition during the back swing, and external rotation conversion power is provided after hitting the ball to counteract swing inertia. The second is humeral head stability and joint control. Lower and stabilize the humeral head when hitting the ball to prevent impact below the acromion; Maintain appropriate shoulder joint translation (neither excessive nor insufficient) during the rapid internal and external rotation transition required for net shooting, which typically must occur within 50ms.

3.1.2. Analysis of movements prone to causing rotator cuff injury

The first movement highly likely to cause rotator cuff injury is the backhand clear. During this stroke, limitations in range of motion and/or incorrect technique by the player often lead to insufficient shoulder external rotation. This increases the eccentric contraction load on the supraspinatus muscle, potentially causing eccentric overload. The second movement is consecutive smashes. When performing smashes, both athletes and amateurs may abduct the shoulder beyond 90° due to inadequate core strength. This reduces the subacromial space by up to 34%, causing repeated friction and impingement between the supraspinatus tendon and the acromion, leading to rotator cuff injury[12]. The risk is significantly higher for amateurs with weaker core strength compared to professional athletes. It is noteworthy that rotator cuff injuries in badminton are typically chronic rather than acute. Research shows that the most common injuries in badminton are overuse injuries, and rotator cuff damage is a classic example. Long-term use of non-standard hitting postures is a major cause of rotator cuff tears. Most studies indicate that across different age groups and skill levels in badminton, the prevalence of rotator cuff injuries due to overuse exceeds 70% [13].

3.2. Rotator cuff injury management & outcome

Following a rotator cuff tear, surgical intervention is often required. Research indicates that for partial-thickness rotator cuff tears in overhead athletes like badminton players, arthroscopic debridement is currently the preferred surgical option [14]. However, a return to sport is not immediate post-surgery. Recovery typically involves four phases: healing, range-of-motion exercises, strength training, and return to sport. For the general population, returning to badminton after such an injury usually takes 9 months to a year. For athletes, regaining full joint range of motion takes approximately 84 days [14]. This timeframe merely signifies the ability to engage in a

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certain level of badminton training. Achieving a full return to the pre-injury training regimen requires significantly more time.

4. Preventive measures for knee and shoulder injuries in badminton

4.1. Knee injury prevention

This paper proposes four methods for preventing knee joint injuries, The first method is to warm up the knee joint and the muscles around it before exercising, warming up effectively enhances physical performance, activates muscles around the joint causing them to engorge with blood, and protects the joint. This allows athletes to engage more quickly at the start of play and increases joint mobility, as activated muscles and joints exhibit greater flexibility. Methods include jogging, high knees, side shuffles, and carioca drills to engage the muscles surrounding the knee joint. The second method is wearing knee braces during Play Knee braces provide targeted protection and support for knee movement and function. They reduce vibration and impact forces on the knee during lunges, offering better stability. Non-professionals can better maintain knee stability with a brace, helping prevent ACL tears. The third is Post-Exercise Stretching and Relaxation, developing good stretching habits after play helps reduce the load on the knee joint caused by exercise. A badminton match typically lasts 40-60 minutes, during which the menisci endure significant acceleration, deceleration, and rotational forces, leading to severe compression. Failure to stretch and relax the muscles around the knee after intense exercise allows muscle fatigue to accumulate, progressively diminishing the endurance of the surrounding musculature. This increases the load on the ACL incrementally, raising the long-term risk of ACL rupture. The last method is Choose Professional Courts, whenever possible, select badminton courts with sprung wooden flooring systems. Some venues still have courts laid directly on concrete. This offers no shock absorption, resulting in direct impact between the menisci and the hard concrete surface, causing significant stress and accelerating meniscal damage. Choosing professional courts with sprung wooden flooring and specialized non-slip vinyl surfaces helps the flooring system absorb impact and reduce stress on the menisci.

4.2. Shoulder injury prevention

Based on extensive sports training practice and research, this paper summarizes three preventive measures to help reduce shoulder injuries, The first approach is the Optimize Technique, when hitting clears and smashes, avoid relying excessively on arm strength. Ensure complete kinetic chain transfer, use the correct and standardized technique, and generate power through body rotation driving the arm. Additionally, minimizes over-reliance on the backhand clear technique, as it places a substantial load on the rotator cuff. Lack of professional training and incorrect force generation methods will accelerate rotator cuff damage. The second approach is to Strengthen Shoulder and Core Muscles, and perform specific internal and external rotation exercises to strengthen the rotator cuff muscles. Combine this with core strengthening exercises like planks, Russian twists, and medicine ball rotational throws to enhance core power while simulating swing force patterns. The third approach is Adequate Warm-up and Cool-down, Activate the shoulders before play or matches using resistance bands for internal and external rotation exercises. Combine this with animal crawl movements like bear crawls to activate the core and thoracic spine, improving rotation efficiency and reducing compensatory shoulder movements. Perform static stretching after exercise. Following high-intensity training or matches, especially if there is pre-existing shoulder inflammation, apply ice for ten minutes to suppress inflammation spread and relieve muscle spasms.

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5. Conclusion

This paper has discussed the common causes, treatments, and preventive measures for injuries to ACL in the knee joint and the rotator cuff in the shoulder joint resulting from badminton participation. Different participant groups have distinct injury causes. For the general population, ACL injuries primarily stem from insufficient lower limb strength or inadequate warm-up and muscle activation before play. For athletes, injuries are mainly due to chronically inappropriate training loads or prolonged high-intensity training without adequate rest and recovery for the knees, leading to accumulated fatigue and weakening the muscles supporting the ACL. This leaves the ACL bearing excessive load, resulting in injury or tear. Post-injury, ACL reconstruction (ACLR) is the primary repair method, but post-surgical recovery often only restores a portion of pre-injury athletic ability. Movements particularly prone to causing shoulder joint injury, especially to the rotator cuff, include clears, backhand clears, and consecutive smashes. The reason is the significant biomechanical demands these movements place on the rotator cuff, as outlined in the text. For amateur players, injury causes are primarily insufficient core strength or incorrect technique leading to rotator cuff damage. For athletes, rotator cuff injuries mainly result from suboptimal technique or the long-term, high-intensity overuse inherent in repetitive overhead motions like smashes, clears, and backhand clears. Treatment for rotator cuff tears may involve arthroscopic debridement. However, the postoperative recovery period to return to training or low-intensity sport is lengthy. For professional athletes, regaining the ideal competitive form requires an even longer duration. Finally, the paper provides relevant prevention and recovery methods for the injured joints, such as thorough warm-ups before play, adequate stretching after exercise, and even icing. Incorporating joint-specific strength training outside of playing or training sessions helps protect the joints and reduce injury risk. Research on sports injuries among badminton players remains relatively scarce to date. Some data and literature, particularly concerning shoulder injuries, are derived from studies of sports with similar biomechanics or force generation patterns to badminton, such as tennis and baseball. Therefore, future research needs to delve deeper into shoulder joint injuries specifically within badminton.

References

[1] Cabello-Manrique, D., Lorente, J. A., Padial-Ruz, R., & Puga-González, E. (2022). Play badminton forever: A systematic review of health benefits. International journal of environmental research and public health, 19(15), 9077.

[2] Stepper, B., Hecksteden, A., Stagge, H., Faude, O., & Donath, L. (2025). Systematic review on badminton injuries: incidence, characteristics and risk factors. BMJ Open Sport & Exercise Medicine, 11(1), e002127.

[3] Phomsoupha, M., & Laffaye, G. (2020). Injuries in badminton: A review. Science & Sports, 35(4), 189-199.

[4] Kotsifaki, R., Korakakis, V., King, E., Barbosa, O., Maree, D., Pantouveris, M., ... & Whiteley, R. (2023). Aspetar clinical practice guideline on rehabilitation after anterior cruciate ligament reconstruction. British journal of sports medicine, 57(9), 500-514.

[5] Li Caimei, Dong Guangxin & He Jianhao. (2021). Analysis of Anterior Cruciate Ligament Injury Mechanisms in Different Sports. Contemporary Sports Technology, 11(15), 12-14. doi: 10.16655/j.cnki.2095-2813.2009-1579-6601.

[6] Qin Yuyang & Su Min. (2024). A Case Study on ACL Injury and Recovery in a Badminton Player. In (eds.) Proceedings of the 2024 Guangzhou International Symposium on Sports and Health (pp.96-97). Department of Physical Education, Northwestern Polytechnical University; doi: 10.26914/c.cnkihy.2024.066889.

[7] Zhang Wang. (2023). The Influence of Badminton Players' Lunge Step Distance and Foot External Rotation on Knee Joint Load and Cruciate Ligament Strain (Master's thesis, Shanghai University of Sport). https://link.cnki.net/doi/10.27315/d.cnki.gstyx.2023.000365doi: 10.27315/d.cnki.gstyx.2023.000365.

DOI: 10.54254/2753-8818/2025.AU25371

[8] Hu Zhe & Shan Xinhai. (2022). Gender Differences in Lower Limb Electromyographic Activity during Single-Leg Landing after Backhand Overhead Stroke in Rear Court in Badminton Players------Research on ACL Injury Mechanism. In (eds.) Abstracts of the 22nd National Conference on Sports Biomechanics(pp.622-623). Jeonbuk National University Department of physical education; School of Physical Education, Shandong Normal University; doi: 10.26914/c.cnkihy.2022.021887.
[9] Wang Cheng, Meng Lingyu, Chen Nayun, Li Dai, Wang Jianquan, & Ao Yingfang. (2021). Diagnosis and treatment strategies for knee joint infection after anterior cruciate ligament reconstruction. Journal of Peking University (Health Sciences), 53(5), 850.
[10] Murrell, G. A., & Walton, J. R. (2001). Diagnosis of rotator cuff tears. The Lancet, 357(9258), 769-770.
[11] Cejudo, A. (2022). Risk factors for, and prediction of, shoulder pain in young badminton players: a prospective cohort study. International Journal of Environmental Research and Public Health, 19(20), 13095.
[12] Escamilla, R. F., Hooks, T. R., & Wilk, K. E. (2014). Kinematic and kinetic comparisons of American and Korean professional baseball pitchers. Journal of Sports Sciences, 32(10), 945--956.
[13] Zhang Xinbi, Huang Mingming, Shen Zhichao, Zhu Lei & Jiang Changhao. (2024). Research Progress on Biomechanical Risk Factors for Non-Contact ACL Injuries in Female Athletes. In (eds.) Abstracts of the 2nd Shaanxi Provincial Sports Science Conference (Poster) (pp.133-134). Capital University of Physical Education and Sports; Yunnan Vocational and Technical College of Communications; doi: 10.26914/c.cnkihy.2024.023715.
[14] Reinholz, A. K., et al. (2023). Advances in the treatment of rotator cuff tears: Management of rotator cuff tears in the athlete. Clinics in Sports Medicine, 42(1), 69.