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The most common injuries in male volleyball players, physiotherapy treatment and prevention

Bachelor's Thesis

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I hereby declare that my bachelor's thesis titled “The most common injuries in male volleyball players, physiotherapy treatment and prevention” is written by me. All sources used are listed in the reference.

In Olomouc, 20 May 2025

Ding Fan

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Abstract : This thesis focuses on common injuries among male volleyball players, including rotator cuff tendinopathy/rotator cuff-related shoulder pain (RCRSP), shoulder instability, patellar tendinopathy, and lateral ankle sprain (LAS). It describes the relevant definitions, risk factors, classifications, and other related aspects. It mainly focuses on evidence-based physical therapy and prevention.

Abstract in Czech: Tato práce se zaměřuje na častá zranění u mužských volejbalistů, včetně tendinopatie rotátorové manžety/bolesti ramene související s rotátorovou manžetou (RCRSP), nestability ramene, tendinopatie pately a laterálního podvrtnutí kotníku (LAS). Popisuje příslušné definice, rizikové faktory, klasifikace a další související aspekty. Zaměřuje se především na fyzioterapii založenou na důkazech a prevenci.

Key words: Rotator cuff tendinopathy/Rotator cuff-related shoulder pain (RCRSP), Shoulder instability, Patellar tendinopathy, physiotherapy, prevention, Return to sports (RTS)

Key words in Czech: Tendinopatie rotátorové manžety/bolest ramene související s rotátorovou manžetou (RCRSP), nestabilita ramene, tendinopatie patelární, fyzioterapie, prevence, návrat ke sportu (RTS)

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Introduction

Volleyball is a fast-paced team sport involving dynamic actions, such as jumping and quick changes in direction. Although often considered safer than high-contact sports (Bere et al., 2015), its repetitive and intense nature poses injury concerns for male players (Young et al., 2023). The global popularity of volleyball highlights the need to study injury patterns, risk factors, and prevention strategies for player health and performance.

Volleyball shows a different injury pattern compared to other team sports because direct contact is rare. Nevertheless, frequent jumping, repeated overhead actions, and quick defensive moves still place stress on players (Bere et al., 2015). It has been reported that about 10.7 injuries occur per 1,000 player hours in matches. This figure is lower than the rates in basketball, at 19.1, and football at 36.9 injuries per 1,000 player hours (Bahr & Bahr, 1997). Therefore, volleyball is considered relatively safe because little body-to-body contact occurs. However, injuries caused by contact with the net, other athletes, or repeated mechanical stress are still common (Beneka et al., 2009).

Injury patterns are influenced by the age and skill of the players. Professional senior male athletes have higher injury rates (11.9 vs. 9.0 per 1,000 hours) and time-loss injury risks (2.04 times greater) than junior athletes (Young et al., 2023; Bere et al., 2015). This is attributed to more intense competition, heavier training loads, prolonged strain, and age-related changes (Bahr & Bahr, 1997; Young et al., 2023).

Most volleyball injuries are not severe: 26.8% are mild (1–7 days recovery), 44% are moderate (8–28 days), and severe injuries (>4 weeks absence) are rare (0.3 per 1,000 hours) (Beneka et al., 2009; Bere et al., 2015). However, even minor injuries can lead to long-term problems, particularly in the shoulder and knee (Young et al., 2023). The ankle and knee are the most frequently injured sites in male players, each accounting for approximately 25.9% of injuries; shoulder and lower back injuries are also common (~8.9%) (Verhagen et al., 2004). These patterns are consistent across training and matches, reflecting the repetitive nature of the sport (Beneka et al., 2009).

Position-specific demands create different injury profiles. Liberos, with less jumping, have lower ankle injury rates (~8%) but the highest finger/thumb injury rates due to digging/passing (Bahr & Bahr, 1997). Setters jump less, resulting in half the knee injury rate of other positions (Beneka et al., 2009). Middle hitters, who perform frequent jumping and blocking, face higher ankle/knee risks (Young et al., 2023). This necessitates position-tailored prevention strategies.

The causes of injuries are complex, involving player contact (23.0%), overuse (20.7%), and non-contact trauma (17.3%) (Kilic et al., 2017). Ankle injuries are often contact-related (landing on opponents' feet), while knee injuries result more from overuse/non-contact (repeated jumping, poor landing) (Bere et al., 2015). Shoulder injuries in high-level male players are commonly overuse-related and stem from repetitive spiking/serving (Seminati & Minetti, 2013). Prevention must address both acute and cumulative injury.

Key risk factors include age (senior players), playing position, training volume and load intensity (especially matches, where 62.5% of injuries occur vs. 37.5% in training), and poor biomechanics (e.g., bad landing form, weak core) (Bahr & Bahr, 1997; Kilic et al., 2017; Verhagen et al., 2004).

Focusing on common injuries, shoulder issues such as rotator cuff tendinopathy/impingement or instability are linked to repetitive overhead motions and overuse (Seminati & Minetti, 2013). Knee injuries, such as patellar tendinopathy, result from repetitive jumping, often through non-contact or overuse mechanisms (Young et al., 2023). Ankle sprains are frequently contact-related and often occur when landing on another player's foot (Bahr & Bahr, 1997). These injuries significantly impact performance and can lead to long-term issues if not properly managed.

Although male volleyball players have lower injury rates than those in some other sports, common injuries to the ankle, knee, and shoulder pose significant challenges. Understanding the specific patterns and causes of these conditions is crucial for effective physical therapy and prevention. This thesis examines the conservative treatment of these prevalent injuries in men's volleyball.

1. Shoulder injuries

The anatomical structure of the shoulder allows volleyball players to achieve the wide range of motion needed for the sport. However, this flexibility makes athletes more prone to instability and overuse injury (Young et al., 2023). These risks are particularly significant for positions that involve frequent overhead motion. Outside hitters and setters demonstrate higher vulnerability due to their repetitive arm movements (Kilic et al., 2017; Young et al., 2023). Understanding how shoulder anatomy interacts with physical demands of volleyball is important. This knowledge provides a basis for developing effective injury prevention methods and rehabilitation approaches. The relationship between structure and function must be considered when creating player-specific protection strategies.

1.1. Basic anatomy and kinetic chain

The shoulder complex is a complex biomechanical structure. It includes four joints: the glenohumeral, acromioclavicular, and sternoclavicular joints. The scapulothoracic joint is also included, which is physiological and not synovial (Neumann, 2016). These joints work together to connect the upper limbs to the chest. They allow many movements required for daily tasks, enabling complex movements such as throwing, lifting, and reaching (Kibler et al., 2013).

The glenohumeral (GH) joint has a ball-and-socket design that connects the humerus to the scapula. It is a ball-and-socket joint with a small contact area between the humeral head and the glenoid fossa. This joint has the highest mobility among all human joints (Veeger & van der Helm, 2007). Its structure favors mobility over that of stability. If the shoulder is not well supported, the shoulder complex is prone to injury (Wilk et al., 2006), rotator cuff injuries, and shoulder instability. These issues are common, especially in activities involving repetitive overhead movements if not well-supported (Kibler et al., 2013). Dynamic stabilization is important. It involves coordinated muscle activity throughout the range of motion. This helps balance mobility and stability in the shoulder complex (Neumann, 2016).

Dynamic stabilization manages the balance between mobility and stability of the shoulder complex. This process is primarily supported by coordinated muscle activity (Wilk et al., 2006). The rotator cuff muscles, including the supraspinatus, infraspinatus, teres minor, and subscapularis, are essential for maintaining stability of the humeral head within the glenoid fossa during movement (Neumann, 2016). These muscles work in collaboration with other muscles, such as the deltoid, trapezius, and serratus anterior. Together with other scapular stabilizers, they ensure proper joint alignment and prevent excessive movements (Kibler et al., 2013). The concept of the scapulohumeral rhythm describes this type of teamwork. It was observed that the scapula rotated upward in a 2:1 ratio with humeral elevation. This coordination helps maintain joint position and reduces stress on the rotator cuff (Veeger & van der Helm, 2007).

The shoulder joint kinetic chain is a biomechanical system. It involves the coordinated interaction of body segments, such as the lower limbs, trunk, scapula, and shoulder. This interaction produces efficient movement and maintains joint stability (Kibler et al., 2013). This concept is important for understanding shoulder function. This is especially true in dynamic activities like throwing, serving, or weightlifting. In these activities, force moves sequentially from the ground to the upper limbs. Efficient kinetic chain function helps players produce maximum force with minimal stress on a single joint (Kibler et al., 2006). A disruption or inefficiency in the kinetic chain can interrupt smooth force transfer. This often results in compensatory movement, which places excessive stress on the shoulder joint (Kibler et al., 2006;). For example, inadequate force or stability from the legs or core may force the shoulder muscles to work more. This is often observed during overhead actions in volleyball, such as spiking and serving (Kibler et al., 2006). Serving and spiking actions in volleyball require intricate body movements (Seminati & Minetti, 2013). These overhead motions involve a coordinated chain of movements starting from the ground, moving through the legs and body core, and ending at the shoulder.

Shoulder movement can be broken down into three key phases:

In the initial phase, the shoulder rotates outward to its maximum position.

In the acceleration phase, the arm moves forward at a high speed. This places a significant pressure on the shoulder structures.

In the deceleration phase, the shoulder inward rotation and adduction, arm crossing over the body , the rotator cuff and scapular stabilizer muscles work to safely slow down the arm’s motion.

These movements require precise timing and coordination of multiple muscle groups. The back shoulder muscles and shoulder blade stabilizers play essential roles in controlling these actions (Seminati & Minetti, 2013).

Volleyball players often perform repetitive, high-force movements hundreds of times during practice and during matches. This can lead to cumulative stress and various shoulder issues (Seminati & Minetti, 2013). Overusing the shoulder may cause muscle fatigue and microtrauma, and increase the risk of injuries like impingement syndromes, rotator cuff problems, and shoulder instability (Sciascia & Cromwell, 2012).

Understanding the entire kinetic chain is crucial for assessing and treating shoulder conditions. Factors that are not directly related to the shoulder can significantly contribute to shoulder dysfunction and injury risk. Therefore, a comprehensive approach is essential for managing these conditions effectively.

1.2. Rotator cuff tendinopathy/ Rotator cuff-related shoulder pain (RCRSP)

Our understanding of rotator cuff tendinopathy remains limited. While initially considered an inflammatory condition, recent research indicates that it is primarily a degenerative process. This condition commonly occurs in overhead sports and presents with rotator cuff tendon pain.

Research has demonstrated that traditional orthopedic shoulder examinations show low reliability. Specific tests have been found to be inadequate in accurately identifying targeted injuries (Gismervik et al., 2017; Hegedus et al., 2012; Salamh & Lewis, 2020). Additionally, imaging results often show poor correlation with patient symptoms (Gill et al., 2014; Tran et al., 2018). The condition may be further complicated by involvement of neighboring joints.

To address these diagnostic challenges, international experts have introduced the term rotator cuff-related shoulder pain (RCRSP), which encompasses four conditions: subacromial pain syndrome, subacromial impingement syndrome, rotator cuff tendinopathy, and subacromial bursitis (Requejo-Salinas et al., 2022). This approach reduces emphasis on pathological aspects, which helps decrease patient anxiety and promotes confidence in conservative treatment methods (Zadro et al., 2021).

In the absence of standardized diagnostic protocols, a functional diagnosis is essential. The diagnostic process for RCRSP requires comprehensive evaluation of patient history and symptoms; key indicators include (Requejo-Salinas et al., 2022):

- Possible traumatic or non-traumatic onset
- Pain during elevation, abduction, or overhead movements
- Weakness, arm fatigue, and deltoid area pain
- Pain worsens with movement and improves with rest
- Absence of neurological symptoms
- Sleep disturbances, poor sleep quality, increased smoking, and heightened stress

Imaging is not necessary without trauma history, warning signs, or when conservative treatment fails after three months. While clinical assessment forms the diagnostic foundation, physical examinations are required for confirmation. These should assess active range of motion limitations and include full-range muscle strength testing to identify pain or weakness, particularly during abduction and external rotation.

Functional testing is considered valuable in certain situations (Desmeules et al., 2025). It is particularly useful when standard physical examinations do not provide clear findings. This may occur if symptoms are mild or during the later phases of rehabilitation. Additionally, functional testing can be used to establish baseline measures for monitoring treatment progress.

The complexity of diagnosing RCRSP often leads to a preference for non-invasive treatments over surgery (Desmeules et al., 2025). After a detailed evaluation, the treatment plans were customized to address the unique symptoms and functional constraints of the patient. Physiotherapy plays a central role in this approach (Desmeules et al., 2025). Moving from diagnosis to treatment highlights the need for a multidisciplinary strategy to reduce pain and enhance shoulder function (Desmeules et al., 2025).

1.2.1. Physiotherapy

Physiotherapy interventions can be divided into manual therapy, therapeutic exercise, taping, and physical modalities.

Manual therapy can provide short-term symptom relief but appears to be most effective when combined with an individualized exercise program (Desmeules et al., 2025; Pieters et al., 2020).

Therapeutic exercises, such as long-term (12 months) progressive supervised practice, have been shown to be no more effective than unsupervised self-training (Hopewell et al., 2021).

A systematic review and meta-analysis on shoulder pain found that progressive and personalized rehabilitation programs are superior to non-targeted muscle-strengthening programs. In the medium term (2–6 months), scapular exercises can provide significant pain relief, eccentric exercises have been shown to provide clear pain relief, and scapular exercises can significantly reduce pain and disability. Nevertheless, in the short term (less than two months), no analgesic effect is observed; in the medium term, the effects of motor control exercises on pain management at 2–6 months and 12 months were found to be considerable (Lafrance et al., 2024).

According to a recent scoping review study on FITT (frequency, intensity, time, type), no optimal standards have been found yet in terms of intervention type, intensity, number of sets, frequency, and duration. However, narrowing the scope may provide better results within this range:

Motor control exercises group 5-12week duration 1-3sets of 10-15reps.

Scapula-focused exercise group: 6-12week duration 1-3sets of 10-15reps.

Eccentric exercises 4-12 weeks duration 1-3sets of 8-20 reps.

Nonspecific exercises 4-16 weeks duration 1-3sets of 4-30 reps (Dubé et al., 2024).

A recent randomized controlled trial (RCT) study has revealed that training into pain did not demonstrate greater efficacy than pain-free training in reducing disability, pain, and fear beliefs (Cavaggion et al., 2024).

To complement exercise-based interventions, other therapeutic options are considered to enhance pain relief and recovery.

There is limited high-quality evidence demonstrating the efficacy of taping. The effectiveness of taping, whether used alone or in combination therapy, in reducing pain and disability in patients with RCRSP remains unclear when compared to placebo or other conservative interventions (Desmeules et al., 2025).

Physical modalities

Acupuncture may be effective, but the effectiveness of the intervention remains uncertain; it may relieve patients' pain. Therapeutic ultrasound, extracorporeal shockwave, and combination of laser and other modes have not been shown to relieve pain or disability (Desmeules et al., 2025).

1.3. Shoulder instability

These biomechanical demands in volleyball can lead to several shoulder problems. Shoulder instability (SI) is a major concern for athletes. This is due to the sport's need for both movement and stability during overhead actions (Young et al., 2023; Eerkes, 2012). An increased risk of shoulder injuries is associated with joint instability and excessive activity. This connection has been highlighted in recent studies (Liaghat et al., 2021).

Shoulder instability (SI) is described as a loss of joint stability. It can occur in one direction or multiple directions. Symptoms include pain, sensory issues such as numbness in the arm, and psychological effects such as fear (Lewis et al., 2004).

Non-traumatic shoulder instability (NTSI) is defined as instability without a history of obvious trauma and may involve abnormal joint position or motion.

Shoulder instability is characterized by several key symptoms that affect athletic performance and daily activities. Patients commonly report unstable shoulder movements and hear unusual sounds like clicking, popping, and rubbing. These symptoms often occur alongside various types of pain, including pressure pain in the rear shoulder joint, pain in the biceps muscle tendon and radiating down the arm (Tisserand et al., 2025).

The patient's ability to control unstable episodes is an important assessment factor. Studies have shown that 78% of shoulder instability cases are positional, meaning they occur during arm movement, while the remaining cases are non-positional, occurring at rest or during muscle contraction (Tisserand et al., 2025). The ability to control the shoulder directly affects patient function.

Clinicians must use established classification systems. These systems categorize conditions based on their characteristics and guide suitable treatment methods.

1.3.1. Classification system

There is no universally accepted classification system for shoulder instability. Several systems have been commonly used to classify these conditions. These systems typically assess time, direction, and damage, which help clinicians in diagnosis and treatment. (Lewis et al., 2004).

Thomas and Matsen's taxonomy build on Rockwood's classification of traumatic and non-traumatic dislocations:

“AMBRI (atraumatic multidirectional instability, bilateral, rehabilitation and inferior capsular shift)

TUBS (traumatic unidirectional instability , Bankart lesion, surgery)” (Thomas & Matsen, 1989)

The Gerber classification expands on the previous concepts of Rockwood and Thomas and Matsen: “static instability (lack of typical symptoms, may be related to the rotator cuff), dynamic instability (trauma-induced), and voluntary subluxation (the patient can control its occurrence)” (Lewis et al., 2004).

Stanmore classification:

“The Polar type I (true TUBS, traumatic, structural),

The Polar type II (true AMBRI, atraumatic, structural)

The Polar type III (muscle patterning, habitual non-structural)” (Lewis et al., 2004)

Epidemiology of the Frequency, Etiology, Direction, and Severity (FEDS) system: “

frequency (solitary, occasional, or frequent); etiology (traumatic or atraumatic); direction (anterior, posterior, or inferior); and severity (subluxation or dislocation).” (Fernández-Matías et al., 2024)

The Stanmore classification is more commonly used in Europe and the UK (Jaggi & Alexander, 2017). Conversely, the FEDS system currently has limited application in physiotherapy practice(Fernández-Matías et al., 2024). Adopting an evidence-based classification system would help to reduce confusing terminology in research, improve prognostic accuracy, and enhance rehabilitation program development (Fernández-Matías et al., 2024). In addition to classifying shoulder instability, it is also important to identify potential factors that cause or increase shoulder instability. Understanding these factors is key to the prevention and development of targeted intervention strategies.

1.3.2. The risk factor

Muscle dysfunction, including strength differences and tonal imbalances. For instance, one side might exhibit hypertonicity while the other shows hypotonicity and reduced activation during movements towards unstable positions (hypertonicity in internal rotation, hypotonicity in external rotation) (Tisserand et al., 2025)

In patients, because of instability, the deep stabilizing muscles around the humeral head are inhibited, and overactivation of the superficial motor muscles can result in greater translation of the humeral head in all aspects of mobility compared to a shoulder without instability (Tisserand et al., 2025).

Abnormal body posture may have deficits in neuromotor control, and the static and dynamic position of the scapula can affect shoulder stability, as can poor core stability (Jaggi & Alexander, 2017)

Several other risk factors have been identified. Excessive joint laxity is a significant risk factor. This condition involves a range of motion greater than normal, such as excessive external rotation of the shoulder joint (Liaghat et al., 2021; Jaggi & Alexander, 2017), and if one shoulder's internal rotation is more than 25 degrees less than that of the other shoulder, it is also a risk factor (Tisserand et al., 2025).

Considering the risk factors and patient history, clinicians employ various diagnostic procedures. These procedures are used to confirm shoulder instability and rule out other conditions. They typically include specific physical examinations, such as special tests

The diagnosis of shoulder instability involves several clinical tools but their reliability varies (Hegedus et al., 2012). Recently, the accuracy of several shoulder tests has been questioned. Some studies have suggested that these tests may overestimate the diagnostic accuracy (Hegedus et al., 2012; Gismervik et al., 2017). However, the apprehension and relocation test have demonstrated good reliability (Tzannes & Murrell, 2002; Valencia Mora et al., 2017). The tests rely on patients' fear or anxiety as a positive signal (Tzannes & Murrell, 2002).

As single tests often lack high accuracy and no single test is a definitive standard, a comprehensive subjective assessment and evaluation of shoulder joint function is crucial

(Hegedus et al., 2012; Tisserand et al., 2025).

Imaging is often not needed for the initial diagnosis. Research has shown that findings from imaging studies may not match a patient's actual symptoms (Jaggi & Alexander, 2017; Sanders et al., 2000). Unnecessary imaging can have negative effects. In some cases, it may increase patient fear and pain. This can lead patients to pursue surgical options too quickly and reduce their chances of successful non-surgical recovery.

Although these diagnostic challenges, physiotherapy remains the recommended first-line approach for treating many forms of shoulder instability (Jaggi & Alexander, 2017; Warby et al., 2014). Non-surgical management is typically attempted before considering more invasive approaches. This approach is supported by clinical evidence, even when diagnostic certainty is limited.

1.3.3. Physiotherapy

There is limited research on shoulder joint instability and there is a lack of high-quality evidence (Griffin et al., 2023; Warby et al., 2014). Physical therapy interventions typically include posture education, core stability exercises, movement control exercises for the rotator cuff and scapulothoracic muscles, strengthening of weak muscles, stretching of relatively tight muscles, and manual therapy techniques targeting the joints (Griffin et al., 2023; Jaggi & Alexander, 2017; Watson et al., 2017).

Burkhead and Rockwood developed the program in 1992, and it was an early structured program (Bateman et al., 2015). Recently, structured rehabilitation programs have been developed, such as the Derby program, Watson Instability Program (WIP), and Neuromuscular Exercise for Shoulder Instability (SINEX).

The Rockwood program focuses on stabilizing the shoulder joint by strengthening the shoulder girdle muscles (Warby et al., 2018). Study results indicate that most patients who participate in the program experience beneficial effects. (Bateman et al., 2015; Warby et al., 2018). It is divided into two phases.

"Phase 1: Strength through progressive levels of TheraBand resistance.

Phase 2: Strength through resistance with weights, exercises as above with a weights-and-pulley system." (Warby et al., 2018)

In 2015, British researchers published a study on the Derby Shoulder Instability

Rehabilitation Program. It focuses on proprioception, strength, and resistance exercises for the GH joint, requiring up to 100 repetitions per day, divided into two sections:

"Section 1: Working on the speed of muscle activation, plyometrics, and deceleration of fast movements.

Section 2: Working on proprioception, muscle balance, trunk stability"(Bateman et al., 2015)

At almost the same time, researchers in Australia established The Watson Instability Program (WIP), which focuses on training the position of the scapula and GH joint through movement control and then training the muscles of the shoulder girdle. The program is divided into an assessment and six training phases.

First manually restricted the movement of the humeral head to align it with the scapula and evaluate whether it is suitable for the WIP program. Then followed by training:

"Phase 1: Scapular control and coronal plane control,

Phase 2: Posterior muscle development,

Phase 3: Flexion and extension control,

Phase 4: Sagittal and coronal control with elevation,

Phase 5: Isolated deltoid exercises,

Phase 6: Sport-specific and function-specific stages." (Watson et al., 2016, 2017)

Comparative studies of the WIP, Derby, and Rockwood programs found that while the WIP may be more effective, the Derby and Rockwood programs show better patient compliance (Bateman et al., 2015; Griffin et al., 2023; Warby et al., 2018), and the Derby program has good results in the short term (Bateman et al., 2015).

Additionally, a study tracking outcomes at 52 weeks after a 12-week rehabilitation period showed that the WIP had better MISS (Melbourne Instability Shoulder) Score WOSI (Western Ontario Shoulder Index) and pain scores compared to the Rockwood Program (Warby et al., 2024)

A study published in 2020 further confirmed the role of neuromuscular training in the rehabilitation treatment of shoulder joint instability. The study showed that in a 12-week controlled study with a home-based muscle training group, the neuromuscular group achieved better results, and launched the SINEX program, which includes proprioception, movement control, joint dynamic stability, and strength (Eshoj et al., 2020): The program features a set of 7 exercises specifically crafted to boost the strength of the glenohumeral and scapular muscles. According to strength training principles, each exercise is organized into 7 levels of progressive difficulty, beginning with the basic level and culminating in the elite level. At the basic level (low-load), exercises are performed daily, with participants completing 2 sets of 20 repetitions. Conversely, at the elite level (high-load), the exercises are executed three times a week, with 2 sets of 10 repetitions.

In 2021, a Delphi survey study conducted by nine leading international experts in the field of shoulder instability showed that the experts reached a consensus, launched functional guidelines for shoulder instability, and emphasized the importance of proprioception and motor control training (Festbaum et al., 2021).

1.4. Return to sport (RTS)

Physical therapy for shoulder joint instability in volleyball players should consider the specific demands of the sport. It is recognized that athletes require both stability and the ability to perform explosive overhead movements (Jaggi & Alexander, 2017; Schwank et al., 2022). A proper balance needs to be carefully maintained between restoring sufficient stability and preserving the range of motion and strength necessary for competitive performance. Rehabilitation training should progress gradually from basic stability exercises to sport-specific activities (Festbaum et al., 2021; Schwank et al., 2022). These activities are designed to mimic the physical demands of serving and spiking the ball (Schwank et al., 2022).

Therefore, return to sport (RTS) should be viewed as a continuous and gradual process rather than a discrete event and must be considered from the initial stages of rehabilitation. The process is broadly divided into three stages: return to participation, return to sport, and return to performance.

Return to participation involves athletes performing rehabilitation, training, or sport-related activities at a relatively low level. While athletes are physically active, they are not yet fully prepared to return to competition from a medical, physiological, or psychological perspective. Although they can participate in training, this does not necessarily indicate that they have achieved their RTS objectives. First, return to sport means that the athlete resumes their sport but does not perform at their previous or desired level. On the other hand, return to performance means that the athlete participates in a full game without limitations and can achieve or exceed their pre-injury level (Ardern et al., 2016).

There are six main areas to consider for RTS criteria:

Pain: training should be performed in a pain-free state,

Active shoulder mobility: This important type is related to the requirements of specialization; some programs do not require full mobility, whereas some specific programs require full, extreme mobility.

Power, Strength, and Endurance: Shoulder sports programs usually require a basic level of power, which must meet the requirements of the relevant specialties and is essential for preventing injuries and restoring athletic performance.

Kinetic chain: It involves the entire transmission of power. If any link in the chain is dysfunctional, other parts must compensate, which can negatively affect the athlete's performance following an injury.

Psychological preparation: Athletes eliminate or reduce their fear of re-injury or opponent contact.

Sport-specific considerations: Taking into account the special needs of the program and the location of the game, volleyball requires extreme mobility, the need to take on the pressure brought about by high ball speeds, and at the same time, volleyball's demands for endurance, strength, and explosive power during a large number of powerful actions (e.g., serves, spikes) are very high, while also taking into account the different positions of different fields of the game on the different physical and psychological needs(Schwank et al., 2022).

1.5. Prevention

Effective injury prevention and risk management, particularly overall load management, are of paramount importance.

Based on the 2022 Bern Consensus Statement on Shoulder Injury Prevention, Rehabilitation, and Return to Sport for Athletes at All Participation Levels, primary prevention should begin in adolescence, and secondary prevention exercise programs are best started as soon as possible after a shoulder injury or during return to activity or competition. Generally, a prevention program needs to address the following areas:

- Exercises should be performed based on sport-specific requirements.
- Exercises should be organized in kinetic chains involving the joints of the entire body.
- The program should ideally not require any equipment.
- The program should include an element of team competition,
- The program should include at least two sessions per week, ideally without adding increasing training load, and can be integrated into warm-up or training.
- The program duration should not exceed 15 minutes and should include 5 minutes of shoulder-specific exercises(Schwank et al., 2022).

1.5.1. Specific prevention programs

The OSTRC Shoulder Injury Prevention Program is based on a handball program designed to increase shoulder internal rotation mobility, strength of the shoulder girdle, and specifically, both shoulder external rotation and scapular musculature. The training consisted of shoulder and thoracic spine mobility, external rotation strength, surrounding muscles of the scapula, and kinetic chain integration. The entire exercise was oriented to the quality of movement and maintaining core stability. and good scapular position and posture. The program was validated in a handball program involving 660 participants (Andersson et al., 2017). Handball and volleyball have similar sport-specific requirements; therefore, they may have similar effects on volleyball players.

FIFA 11+ has been shown to be effective in preventing shoulder injuries in goalkeepers, and a study involving 32 professional volleyball players showed that it can effectively prevent shoulder injuries in volleyball players as well (Zarei et al., 2021).It is designed to last approximately 20-25 minutes and can be used in place of a regular warm-up program. The entire program consists of three parts:

1. general warm-up exercises
2. exercises to develop upper limb muscle strength and balance
3. exercises for core stability and neuromuscular control

Part 2 of the program consists of 10 exercises corresponding to three levels of difficulty, using opened and closed chains to train the upper extremity strength. Part 3 has six exercises that challenge the upper body's ability to engage the core in stabilizing situations (Zarei et al., 2021).

The Liège University program was also set up as a warm-up exercise. The program is based on the structure of FIFA 11+, and changes were made according to the specialized needs of volleyball. In this study of 93 amateur volleyball players, the prevention group showed a significant decrease in the number and severity of shoulder injuries. Among male players, the incidence of injury in the prevention group also decreased significantly (Tooth et al., 2023).

The program consists of three phases, totaling at least 24 minutes: basic preparation (3 minutes), specific prevention exercises (18 minutes), and agility drills exercises (3 minutes). The prevention program focuses on engaging the whole body and the kinetic chain for shoulder training, incorporating strength and proprioceptive exercises. There are seven types of exercises Include core stability, upper body strength and power, scapular stability, proprioception of the shoulders and ankles, whole-body integration of strength, and sport-specific exercises, each exercise with three levels of difficulty, allowing athletes to choose the level of difficulty according to their needs(Tooth et al., 2023).

2 Lower limb injuries

Volleyball, which requires coordinated high-force movements. Similarly, the lower limbs play a critical role in force generation and stability; however, they are also susceptible to injuries due to the repetitive and dynamic demands of such activities. Patellar tendinopathy and lateral ankle sprains are common overuse injuries.

2.1 Patellar tendinopathy

Tendinopathy, as a clinical diagnostic term, specifically denotes persistent tendon pain accompanied by functional limitations resulting from mechanical stress (Millar et al., 2021). Patellar tendinopathy, a prevalent form of tendinopathy, is a typical overuse injury characterized by localized pain below the patella, particularly during stress on the knee extensor muscles (Malliaras et al., 2015). This condition exhibits a high incidence among young male athletes engaged in high-intensity activities involving repetitive knee flexion and extension (Zwerver et al., 2011). Sports such as basketball and volleyball, which involve rapid changes in direction or jumping, predispose individuals to this injury because these movement patterns require the patellar tendon to undergo mechanical energy storage and release processes repeatedly (Lian et al., 2005; Sprague et al., 2018).

2.1.1. Risk factors

The type of competition venue is considered a risk factor. Softer surfaces may be more effective in reducing patellar tendinopathy (PT) incidence rates. Volleyball players on non-concrete surfaces have a 20% incidence rate, while those on concrete surfaces have a 38% incidence rate (Malliaras et al., 2006). Beach volleyball players have significantly lower incidence rates, likely due to the softer sand surface reducing the impact forces (Malliaras et al., 2006).

Landing stiffness has also been described as a risk factor. Symptomatic athletes tend to adopt stiffer landing strategies compared to asymptomatic athletes (Bisseling et al., 2007). A smaller range of ankle dorsiflexion during vertical landing is associated with PT, as better mobility can absorb impact forces better, reducing patellar tendon load (Backman & Danielson, 2011; Malliaras et al., 2006; Sprague et al., 2018). Trunk flexion angle during landing can also reduce the patellar tendon load and pain (Janssen et al., 2013).

The flexibility of the hamstring and quadriceps muscles has been identified as a potential risk factor for PT (Mendonça et al., 2018). These factors are related to the landing technique, and proper landing techniques may help control PT symptoms (Bisseling et al., 2007; Janssen et al., 2013).

Insufficient hip extension, greater hip adduction, greater knee internal rotation, greater knee external rotation at peak (which creates strong torsional forces), and foot/ankle eversion are primary risk factors (Mendonça et al., 2018; Sprague et al., 2018). All these factors are associated with load accumulation (Malliaras et al., 2015). Insufficient activation of the hip muscles may lead to an increased load on the patellar tendon, causing excessive forward and lateral movements of the hip and knee during landing (Mendonça et al., 2018). Excessive knee valgus and varus may increase the load on the patellar tendon, and these excessive loads accumulate during repeated poor landing patterns, increasing the risk of PT in athletes (Sprague et al., 2018). Additionally, patient-specific factors play a significant role in the development of PT, such as tibial internal and external rotation imbalances (Mendonça et al., 2018; Van der Worp et al., 2011).

Understanding the biomechanics and environmental risk factors of patellar tendinopathy is crucial. These factors are linked to the biological processes behind tendon injuries. Repeated mechanical stress and load accumulation can lead to specific pathological responses in the patellar tendons. Over time, these reactions can result in structural and cellular changes (Cook & Purdam, 2009; Millar et al., 2021). A comprehensive framework helps classify tendinopathy into different stages of severity. This approach provides valuable insights into the clinical presentation and management of this condition (Cook & Purdam, 2009) and helps to understand the progression of tendon injuries and their treatment.

2.1.2. Pathological model

Understanding these different risk factors provides background information on the potential tissue changes associated with patellar tendinopathy. In their foundational work, Cook and Purdam (2009) introduced a comprehensive framework for understanding tendon pathology through a continuum model developed to fulfill the demand for a system capable of explaining diverse clinical presentations while offering practical clinical utility. This framework synthesizes data from clinical observations, histological analyses and imaging studies. The proposed classification establishes three progressive stages: reactive tendinopathy, tendon dysrepair (characterized by impaired healing), and degenerative tendinopathy.

Reactive Tendinopathy

This stage demonstrated potential reversibility through controlled mechanical loading. Acute tensile or compressive overload triggers inflammatory hyperplasia within tendon cells and the extracellular matrix, elevating protein synthesis and causing tendon thickening. This transient adaptation enhances tissue rigidity and mitigates stress concentrations.

Tendon Dysrepair

This stage is marked by heightened matrix breakdown during attempted repair and features cellular proliferation with excessive proteoglycan and collagen production. These changes precipitate disordered collagen arrangement and matrix destabilization, frequently coinciding with vascular proliferation and neural invasion.

Degenerative Tendinopathy

The pathological reversibility potential is markedly constrained at this advanced stage, although targeted loading strategies and therapeutic exercises may promote matrix remodeling. Distinct zones of cellular necrosis arising from apoptosis or mechanical trauma become evident, displaying matrix disintegration with vascular infiltration, accumulated degradation byproducts and minimal collagen content. The pathological stages of patellar tendinopathy, from reactive changes to degenerative destruction, provide a foundation for effective clinical assessment of the condition (Cook & Purdam, 2009; Malliaras et al., 2015). As the structural state of the tendon influences pain presentation and functional limitations, recognizing a patient's position along this continuum provides a basis for effective diagnostic approaches (Malliaras et al., 2015). This requires targeted physical examinations to identify specific symptoms and correlate them with the underlying pathology, thereby guiding appropriate intervention strategies (Malliaras et al., 2015).

2.1.3. Physical examination

Because of the continuity of pathology, a thorough physical examination is important for accurate diagnosis and staging. Patellar tendinopathy (PT) is characterized by pain that is precisely localized to a specific area, specifically the weight-bearing region directly beneath the patella. Notably, the location of the pain remains constant, irrespective of changes in the applied load (Malliaras et al., 2015; Rio et al., 2016). Clinical assessment should prioritize pain localization under load conditions rather than tenderness caused by palpation, which has limited diagnostic sensitivity for patellar tendon issues. Healthy tendons may also present tenderness during palpation (Cook et al., 2001). Pain associated with patellar tendinopathy worsens with an increased load on the tendon (Malliaras et al., 2015).

A progressive loading assessment is recommended, starting with activities that apply minimal pressure (bilateral squats) and gradually progressing to movements that require significant load on the patellar tendon (single-leg jumps) (Malliaras et al., 2015; Sanchis-Alfonso, 2023). During the assessment, consistent localization of pain (which should remain localized) must be recorded, and the severity of pain should be measured using a numerical pain rating scale. Movement patterns should also be analyzed, with particular attention to any atypical compensatory movements (Malliaras et al., 2015). The knee flexion angle at the point of the pain should be recorded; these data are of significant clinical importance for rehabilitation progress (Zwerver et al., 2007).

Based on the results of physical examinations and an understanding of pathological continuity, clinicians can develop appropriate physical therapy intervention strategies. Treatment methods should be personalized according to the specific stage of the pathology and the patient's specific symptoms, with progressive loading as the foundation for effective management (Malliaras et al., 2015; Rudavsky & Cook, 2014).

2.1.4. Physiotherapy

After a comprehensive physical examination and diagnosis, physical therapy is the cornerstone of treatment for patellar tendinopathy. Selective rest allows tendon recovery while avoiding immobilization, which may cause muscle atrophy. Patients reduce high-impact activities, such as jumping, and engage in low-impact alternatives, such as cycling. A pain-monitoring model recommends that pain during activity should not exceed 3/10 on a numerical pain rating scale and should resolve within 24 hours (Malliaras et al., 2015).

Manual therapy

Except for general activity management, manual therapy techniques, such as deep massage, were also explored. Deep massage has low-quality evidence, suggesting a short-term pain-relieving effect (Ragone et al., 2024).

Patellar strapping and Taping

Another adjunctive method for symptomatic relief is the use of patellar strapping and taping, which may provide short-term pain relief by redistributing the tendon load. While evidence is limited, they are often used as adjuncts to exercise therapy, particularly during rehabilitation or return to sports (Čobec & Kozinc, 2022; Theodorou et al., 2023).

Exercise therapy

Active exercise plays an important role in PT rehabilitation.

Eccentric exercises, such as decline squats, involve muscle lengthening under tension. Performed on a decline board, these exercises entail slow lowering over 3–5 seconds, with 3 sets of 15 repetitions twice daily. Systematic reviews support their efficacy, although PTLE may offer superior outcomes (Malliaras et al., 2015; Čobec & Kozinc, 2022).

Isometric exercises, such as quadriceps sets or wall sits, involve static muscle contractions to reduce pain during the acute phase. Research has found that isometric exercises decrease pain and improve corticospinal control. For example, quad sets involve tightening the quadriceps for 5–10 seconds, repeated 10–15 times (Rio et al., 2015).

Heavy slow resistance training uses high loads (6–15 repetition maximum) that are performed slowly to maximize tendon loading. Exercises like leg presses or barbell squats are performed in 4 sets of 6–15 repetitions, 3 times per week. This approach enhances tendon load tolerance (Malliaras et al., 2015).

Progressive tendon-loading exercises (PTLE) involves structured progression of exercises to enhance tendon resilience. Breda et al. (2021) reported that PTLE resulted in a 28-point improvement in the Victorian Institute of Sport Assessment–Patella (VISA-P) score compared to 18 points for eccentric exercise therapy after 24 weeks, with trends toward higher return-to-sport rates (43% vs. 27%). PTLE starts with isometric exercises, progresses to isotonic loading, and includes energy-storing exercises, such as jumping (Breda et al., 2021; Theodorou et al., 2023).

Tendon Neuroplastic Training

As a supplement to these biomechanics-focused exercise methods, tendon neural plasticity training uses externally paced strength exercises with auditory or visual cues to optimize neuroplasticity, alter pain perception, and corticospinal control (Rio et al., 2016).

In addition to these active exercise methods and neuroplasticity training, various physical modalities are sometimes used, but the supporting evidence varies.

Physical modalities

1. Extracorporeal shock wave therapy (ESWT) is a safe option for patients who are unresponsive to exercise therapy, often combined with eccentric exercises. However, its efficacy is inconsistent, with some studies showing no significant benefit over placebo (Čobec & Kozinc, 2022).
2. Ultrasound and low-level laser therapy is lack strong evidence and are not recommended as primary treatments (Andres & Murrell, 2008; Babatunde et al., 2017).

3. Dry needling is a popular technique, but randomized controlled trials have not established its efficacy in PT (Čobec & Kozinc, 2022). A systematic review suggested potential benefits when combined with exercise, but high-quality evidence is lacking(Nuhmani et al., 2023).

Except for these treatment methods, pain education is a critical component of PT rehabilitation, addressing patient understanding of pain mechanisms to reduce disability and fear of movement. The Dutch multidisciplinary guideline on anterior knee pain emphasizes patient education on injury mechanisms and pain management, recommending a minimum of 12 weeks of conservative treatment before considering alternatives (Ophey et al., 2025). Pain education reduces kinesiophobia and improves outcomes, as evidenced by studies showing decreased disability when education is integrated into rehabilitation (Louw et al., 2016). However, specific pain education protocols are not detailed in the Dutch guideline, indicating a gap in standardized implementation.

After rehabilitation, a prevention plan should be established to prevent the recurrence of patellar tendinopathy.

2.1.5. Prevention

A 2023 review showed that the effectiveness of existing preventive interventions is unclear (Theodorou et al., 2023). A meta-analysis of 23 studies on the effectiveness of prevention programs showed that, when using trial sequence analysis (TSA), prevention programs may even increase the risk of PT in beginners. Conversely, for elite athletes, prevention may reduce the risk of PT, and prevention may still be effective, with personalized prevention programs targeting risk factors potentially being more effective. When validated using random-effects and fixed-effects models, there was no significant difference between the prevention and control groups (Wang & Lyu, 2023).

2.2 Lateral ankle sprain (LAS)

It occurs when the ankle undergoes forceful inversion, which may lead to stretching or tearing of the lateral ligament complex. The mechanism of injury typically involves a combination of forefoot adduction, hindfoot inversion, and tibial external rotation, often occurring at the subtalar joint (Hubbard, 2010).

Classification system

Currently, the commonly used three-tier classification system is Grade I injuries, in which the ligaments are only stretched and there is no macroscopic tear; Grade II injuries show partial tears of the ligaments; and Grade III injuries are associated with complete tears of the ligaments (Lacerda et al., 2023). Multiple ligaments can also be categorized according to severity.

The classification system does not provide a good prediction of prognosis and guides the clinic, while it must be objective, reproducible, consistent, simple, and easy to operate clinically, based on factors affecting prognosis and treatment-oriented (Lacerda et al., 2023). The current approach to grading is confusing, not standardized, and predicts an unclear prognosis, which has a particular impact on athletes. Consequently, understanding the factors that predispose individuals to LAS is crucial for its prevention and management.

2.2.1. Risk factors

Internal Risk Factors and biomechanical factors significantly contribute to lateral ankle sprain (LAS) risk, including decreased ankle dorsiflexion mobility and external rotation of the talus (indicated by navicular-inner ankle distance exceeding 4.65 cm at maximal dorsiflexion, increasing LAS risk 4.14 times).

Neuromuscular deficiencies, such as local sensory deficits, poor postural control, and balance issues, also increase the risk. Hip muscle weakness plays a crucial role, with decreased hip abductor strength increasing the risk of LAS, particularly in male soccer players, while reduced hip extensor strength significantly increases LAS vulnerability in adolescent soccer players.

Additional internal risk factors include prolonged time for single-legged continuous jumps, lower BMI, slower peroneal muscle reaction time, and abnormal alignment of the lower limb and ankle joint (Martin et al., 2021).

Although classification helps categorize the severity of injuries, identifying specific risk factors for patients is crucial to understand the causes of injuries and develop targeted prevention strategies. The risk factors for lateral ankle sprains can be divided into two categories: internal (patient-specific) and external (environmental) factors.

External risk factors, including environmental and behavioral factors, also influence

LAS risk, including game participation intensity (higher exposure correlates with increased injury risk), improper landing techniques after jumps, player-to-player contact situations, and specific field positions that may place athletes at higher vulnerability (Martin et al., 2021).

To assess the severity of an ankle sprain and develop an appropriate treatment plan, clinicians need to conduct a comprehensive assessment, including ruling out fractures and testing ligament integrity (Vuurberg et al., 2018; Martin et al., 2021).

Many individuals with acute lateral ankle sprains experience a rapid decrease in pain and improvement in function within the first two weeks after injury (Martin et al., 2021). However, a substantial number of individuals experience persistent symptoms that do not resolve over time (Martin et al., 2021; Vuurberg et al., 2018). Many patients develop a pattern of recurrent sprains over time, which can lead to progressive ankle instability and anterior impingement (Vuurberg et al., 2018; Hubbard, 2010). Height has been identified as an intrinsic risk factor for ankle sprains in some athletic populations (Willems et al., 2005; Martin et al., 2021). Ankle sprains can lead to chronic problems, and an accurate diagnosis is important for guiding management strategies. Standardized assessment tools for identifying severe injuries.

2.2.2. Physical examination

Ottawa Ankle Rule: Used to rule out fractures that may be present in severe sprains. These rules provide a critical first step in the diagnostic process, ensuring that fractures are not missed before a more detailed assessment of soft tissue injuries is performed.

Clinical decision rules, such as the Ottawa Ankle Rules, guide initial treatment and determine whether imaging studies are necessary. These rules help to effectively rule out fractures in cases of severe sprains, thereby avoiding unnecessary radiographic examinations. After these initial assessments, a comprehensive physical examination must be performed to determine the extent of ligament injury and associated functional deficits.

Range of motion (ROM)test: This test not only assesses the injured side but also compares it with the healthy side.

The anterior drawer test and anterolateral drawer test evaluate the lateral ligament of the ankle for injury. Usually, the best accuracy is achieved 4-5 days after injury. Subtalar instability testing assesses whether the subtalar joint is stable (Chen et al., 2019).

In the absence of serious injury, the focus shifts to rehabilitation. Physical therapy is the main treatment for LAS, and it aims to reduce pain and swelling, restore function, and prevent recurrence.

2.2.3. Physiotherapy

RICE (Rest, Ice, Compression, Elevation) is a traditional conservative treatment modality (Vuurberg et al., 2018), and there is growing evidence questioning the efficacy of RICE, with limited strong evidence for its effectiveness in reducing acute symptoms of LAS. Similarly, PRICE (Protection, Rest, Ice, Compression, Elevation) and POLICE (Protection, Optimal Loading, Ice, Compression, Elevation) have been proposed. Early optimal loading, as suggested by POLICE, aims to facilitate recovery. However, further research has shown that these principles do not fully reflect the recovery process of the tissues involved in LAS, especially in the subacute and chronic phases (Bleakley et al., 2012). A new approach to the PEACE (Protect, Elevate, Avoid anti-inflammatory drugs, Compress, Educate) principle has been proposed. Emphasizing a comprehensive tissue recovery process, patient education, pain education, pain medication, and cryotherapy approaches can instead slow down the tissue recovery cycle, which is also in line with the new trends in musculoskeletal physical therapy today (Dubois & Esculier, 2020). It has also been said that the PEACE principle is effective for minor sprains, and that for moderate to severe sprains, the CARE (Cryotherapy and Compression, Avoidance, Rehabilitation, Elevation) emphasizes the importance of cryotherapy in the first 48 hours of an acute injury (Fousekis & Tsepis, 2021).

After an LAS injury, external support such as bandaging, taping, or braces should be the first choice. Functional support is more effective than other external supports and may be the current best option; however, these external supports should not be used alone (Martin et al., 2021; Vuurberg et al., 2018).

For Grade III injuries, at least four weeks of plaster cast immobilization can help reduce pain and swelling. However, a four-week regimen of functional support and exercise yields better recovery outcomes and prognosis compared to prolonged immobilization. Evidence suggests that plaster cast immobilization for no more than ten days achieves the same effect in promoting pain and edema recovery while avoiding the drawbacks of prolonged immobilization (Halabchi & Hassabi, 2020; Martin et al., 2021; Vuurberg et al., 2018).

Although protective measures can control the acute phase of injury, rehabilitation should focus on active interventions aimed at restoring function. Therapeutic exercise is the cornerstone of effective rehabilitation for ankle sprains and can promote recovery in many ways.

2.2.4. Therapeutic Exercise

The effectiveness of exercise therapy in LAS recovery has been confirmed. Combining exercise therapy with other treatment methods (functional support and manual therapy) can achieve better results, shorten the recovery period before injury, and increase joint stability (Chen et al., 2019; Halabchi & Hassabi, 2020; Martin et al., 2021).

A good exercise therapy program should include mobility exercises, strength exercises, proprioception, neuromuscular exercises, and relevant specialized exercises, all with progression, exact dosage, type of muscle contraction, and duration. Since specific parameters lack consensus, there is no standard for best-practice exercises.

It is recommended to perform basic mobility exercises as early as possible, either starting with an open chain approach and then adding seated, standing exercises, or switching to a closed chain approach, all of which need to be practiced on a pain-free basis and at a high enough frequency to achieve a high number of repetitions per day (Halabchi & Hassabi, 2020).

It should begin after the normal range of motion has been restored, starting with isometric exercises and gradually progressing to eccentric and concentric exercises. The program begins with sagittal plane exercises and then moves on to coronal plane exercises, ensuring that there is no pain and no risk of reinjury. The risk factors mentioned earlier include reduced strength in the peroneal muscles and decreased reaction time; therefore, strength training should be a key focus. Therefore, neuromuscular and proprioceptive exercises should be incorporated to enhance body posture and balance control. These exercises should be initiated early in the rehabilitation process and continued throughout the return-to-play phase with a focus on prevention. Specialized exercises should consider the specific requirements of volleyball, such as jumping and vaulting, which require more plyometric exercises to increase lower limb stiffness and neural recruitment. Additionally, dynamic core stability must be addressed to maintain body stability in the air and effectively transfer lower-limb force to the upper limbs (Halabchi & Hassabi, 2020).

The addition of visual feedback can enhance the effectiveness of exercise therapy. Visual feedback can enhance vestibular reflexes and can be achieved using VR or by fixating on a target (Cerbezer et al., 2023). This also matches the specific needs of volleyball players, who use their line of sight to track the movement of the ball.

Research has shown that using smartphones to display real-time joint positions during proprioceptive training can also achieve better results, improving patients' joint position sense through external cues (S. Edwards et al., 2016).

Although many types of exercises and assistive devices have been discussed, current research on exercise varies widely, and there is no consensus on the best training methods, number of sets, intensity, and dosage for structured rehabilitation programs.

A recent randomized controlled trial evaluated the rehabilitation outcomes of the SMART (Sensory Stimulation, Mobilization, Activation and Balance, Resistance and Reintegration) rehabilitation program at 6 weeks, 6 months, and 12 months post-intervention. The entire training program focused on different areas of training (sensory stimulation and mobilization) over six weeks, with five sessions per week, each lasting 30–45 minutes. During the six-week period, patients gradually transitioned to unsupervised home exercises. This study may help establish a foundation for the development of standardized rehabilitation programs (Tennler et al., 2023).

Besides planned exercise, other physiotherapy interventions contribute to recovery, such as appropriate weight-bearing strategies and manual therapy.

Weight bearing

Early progressive weight-bearing with device assistance (crutches, walkers) helps reduce LAS symptoms, accelerates the recovery of normal range of motion, and can even be used for grade III injuries to shorten recovery time without worsening the condition (Ardèvol et al., 2002; Halabchi & Hassabi, 2020).

Mobilization

Joint mobilization, which reduces pain and increases joint mobility, can only produce short-term results with manipulation alone; evidence suggests that combining it with exercise produces better results than manipulation or exercise alone (Vuurberg et al., 2018).

It has been shown that mobilization with movement (MWM) in a weight-bearing position yields better recovery outcomes for athletes (Sankaravel et al., 2021).

Manipulation usually consists of anterior-posterior (AP) mobilization of the talus and traction (Halabchi & Hassabi, 2020; Martin et al., 2021; Vuurberg et al., 2018), but can also be performed in the weight-bearing position with active ankle dorsiflexion, and can also incorporate soft-tissue massage or lymphatic drainage maneuvers to incorporate the elimination of swelling (Halabchi & Hassabi, 2020).In addition to active interventions such as exercise and mobilization, various physical modalities may be considered as adjuncts in LAS management.

Physical modalities

Ultrasound therapy is generally not recommended for LAS because of the lack of evidence supporting its efficacy.

Pulsed shortwave diathermy may help reduce edema and can be considered an adjunctive therapy.

A study showed that the use of light-emitting diodes with an energy density of 10 J/cm² in combination with PRICE treatment resulted in a significant reduction in pain and swelling in the early stages compared to the control group (De Moraes Prianti et al., 2018).

As rehabilitation begins and athletes seek to return to competition, it is necessary to focus on determining whether athletes are ready to resume sports activities (Smith et al., 2021). Objective and subjective criteria must be carefully considered to ensure that athletes can return to competition quickly and safely without increasing the risk of re-injury (Tassignon et al., 2019; Smith et al., 2021).

2.2.5. Return to sport (RTS)

The decision to return to sports (RTS) after a concussion is generally based on the severity of the injury and the time required for recovery. A framework for returning to sports should be developed based on a multidimensional and continuous concept (Tassignon et al., 2019).

For athletes, this is lacking and incomplete. Traditional grading does not reflect the full extent of the injury, especially as the indications for acute-phase grading can be rapidly affected by a number of interventions, leading to unreliable results on specific tests due to inflammatory swelling and pain. Athlete recovery is highly individualized and can be influenced by factors such as the level of medical/rehabilitation support available (e.g., team medical staff coverage) (Halabchi & Hassabi, 2020). Based on these circumstances, the timing of RTS based on existing grading systems seems unreliable.

An interprofessional international Delphi study in 2019 reached a consensus on a recovery framework. PAASS (pain, ankle injury, athlete perception, sensorimotor, specific sports activities). This framework encompasses pain occurring during or within 24 hours prior to participation in sports, including ankle joint injuries involving range of motion, muscle strength, endurance, and power; athlete perception involving ankle joint confidence, stability, and psychological readiness; sensory-motor control involving proprioception and dynamic postural control/balance; and motor/functional performance assessed through jumping, hopping, agility, and specific sports activities, as well as the ability to complete a full training program (Smith et al., 2021).

Ankle GO scoring is a new return-to-sport testing procedure based on the PAASSS framework using four functional tests and two patient self-report questionnaires to assess a patient's level of physical ability based on an objective score that predicts the level of physical ability to return to play at 2 and 4 months (Picot et al., 2024).

One study proposed an evidence-based LAS algorithm to provide athletes with a more individualized rehabilitation program that provides them with a roadmap for evaluating tests based on pain and swelling, limiting factors, and stability tests, in an attempt to reduce time lost and return them to the field faster (Halabchi & Hassabi, 2020). The program does not consider the RTS continuum probability and does not provide an answer on how to return to the field and resume athletic performance

A new clinical guideline-based rehabilitation algorithm for lateral ankle sprains in professional soccer players was developed in 2024(Flore et al., 2024). The algorithm is based on an injury pyramid with four levels: return to activity (RTA), return to sport (RTS), return to play (RTP), and return to competition (RTC). RTA is the most fundamental stage.

Progression through the overall framework (RTA to RTC) involves distinct phases that can be independent or overlapping. Evaluation is based on the Ankle Function Score (AFS), clinical examination, and functional performance testing. These three standardized tools can be monitored throughout the entire rehabilitation process to understand the athlete's mental and physical condition (Flore et al., 2024). These staged algorithms ultimately aim to reduce reinjury rates and optimize long-term function. Even the best RTS pathway must be paired with strategies that prevent first-time and recurrent sprain.

2.2.6. Prevention

Neuromuscular training can reduce the risk of recurrence to the same level as in the healthy group, and coordination and balance training can also prevent recurrence of ankle sprains. These training methods are more effective in athletes than in the general population, but exercise therapy does not reduce the risk of ankle sprains; support (tape, braces) can reduce the risk of initial sprains and recurrence (Vuurberg et al., 2018), These findings were further confirmed in clinical guidelines published by the American Physical Therapy Association in 2021 (Martin et al., 2021).

A 2023 meta-analysis showed that preventive measures for LAs should focus on proprioceptive training. Wearing protective braces was not significantly more effective than not wearing them and had a preventive effect similar to proprioceptive training confirming the effectiveness of exercise therapy (Wang et al., 2023).

Discussion

This thesis provides a detailed overview of the common injuries encountered by male volleyball players, with a particular focus on the shoulder, knee (especially patellar tendinopathy), and ankle (lateral ankle sprain). In the following sections, we conduct an in-depth analysis of the key points mentioned in this thesis, incorporating the referenced literature to place these concepts within a broader academic context. We identified the strengths and weaknesses of this study and explored its implications for clinical treatment and future research.

Diagnosing rotator cuff-related shoulder pain (RCRSP) is challenging. Traditional shoulder examination methods are often unreliable and certain specific tests may fail to accurately identify the underlying issue (Gismervik et al., 2017; Hegedus et al., 2012; Salamh & Lewis, 2020). A further challenge is that imaging findings sometimes do not match the patient's actual symptoms (Gill et al., 2014; Tran et al., 2018), which is why the term RCRSP was introduced as a new term. Using this term reduces the emphasis on the severity of the condition, helps to alleviate patient anxiety, and makes patients more willing to accept conservative treatment (Requejo-Salinas et al., 2022; Zadro et al., 2021). Now, doctors focus more on functional diagnosis through detailed medical history inquiries and symptom assessments (Desmeules et al., 2025).

Studies have found that manual therapy can provide short-term symptom relief, but it is best used in combination with exercise therapy (Desmeules et al., 2025; Pieters et al., 2020). Personalized progressive rehabilitation programs are significantly more effective than blind intensive training (Lafrance et al., 2024). However, there are no standardized guidelines for the specific implementation of these exercises (including frequency, intensity, duration, and type) (Dubé et al., 2024), which poses significant challenges for clinical treatment and requires physicians to adjust the protocols according to individual patient needs. It is worth noting that pain training and pain-free training have similar effects (Cavaggion et al., 2024), which are important to consider when guiding patients. While acupuncture may help reduce pain (Desmeules et al., 2025), other physical therapies, such as taping, have limited effects, confirming that exercise therapy is the key.

Shoulder instability (SI) is a complex condition. There are various classification systems (Fernández-Matías et al., 2024; Lewis et al., 2004; Thomas & Matsen, 1989), the Stanmore system is more commonly used in Europe (Jaggi & Alexander, 2017). Experts want to establish a more scientifically based classification to improve treatment outcomes and prognostic judgment (Fernández-Matías et al., 2024). While many specific tests are not highly reliable, apprehension tests and relocation tests are relatively more reliable (Hegedus et al., 2012; Tzannes & Murrell, 2002; Valencia Mora et al., 2017), comprehensive subjective assessments and functional tests are particularly important. Existing rehabilitation programs, such as Delphi, SINEX, WIP, Derby, Rockwood (Bateman et al., 2015; Eshoj et al., 2020; Festbaum et al., 2021; Warby et al., 2018; Watson et al., 2016, 2017) offer standardized protocols

In volleyball players who regularly perform overhead movements, the kinetic chain plays a key role in shoulder function and injury (Kibler et al., 2006; Seminati & Minetti, 2013), and if the kinetic chain does not function well, the shoulder is subjected to additional stress (Sciascia & Cromwell, 2012). Therefore, there is a need to pay attention to kinetic chain training.

When it comes to lower limb injuries, one of the most feared conditions for volleyball players is probably patellar tendinopathy. Research has shown that this injury is particularly common in sports involving frequent jumping (Lian et al., 2005; Malliaras et al., 2015; Zwerver et al., 2011). It may be associated with risk factors (Malliaras et al., 2006), landing posture (Bisseling et al., 2007; Janssen et al., 2013; Sprague et al., 2018), and an imbalance in muscle strength and flexibility (Mendonça et al., 2018; Van der Worp et al., 2011). Clinically, the three-stage model proposed by Cook and Purdam (2009) is widely used to determine prognosis.

Rehabilitation therapy primarily focuses on load management and progressive training. Isometric exercises for pain relief (Rio et al., 2015), progressive tendon-loading exercises (Breda et al., 2021), eccentric training (Malliaras et al., 2015), and heavy slow resistance training (HSRT) (Malliaras et al., 2015) have all shown promising results. Current treatment protocols incorporate neuroplasticity training (Rio et al., 2016) and pain education (Louw et al., 2016), reflecting the modern medical approach to comprehensive management of tendinopathies. Regarding ESWT, the evidence is limited (Čobec & Kozinc, 2022), while ultrasound and low-intensity laser therapy currently lack evidence (Andres & Murrell, 2008; Babatunde et al., 2017).

Lateral ankle sprains (LAS) are among the most common injuries on sports fields. Existing classification systems are insufficient for predicting recovery outcomes and guiding treatments (Lacerda et al., 2023). Acute management protocols have evolved significantly over the years, from the original RICE principle to the POLICE protocol and are now more commonly recommended as PEACE and LOVE (Bleakley et al., 2012; Dubois & Esculier, 2020). Functional braces or taping are more effective than long-term immobilization (Halabchi & Hassabi, 2020; Martin et al., 2021; Vuurberg et al., 2018). Physical therapy includes joint range of motion exercises, strength training, balance training, and neuromuscular control (Chen et al., 2019; Halabchi & Hassabi, 2020). New methods include joint position sense training using visual feedback (Cerbezer et al., 2023) and mobile applications (S. Edwards et al., 2016). Although there is no universally accepted optimal training protocol, the SMART program (Tennler et al., 2023) may provide guidance for future practice.

Return to Sport (RTS) plays a crucial role in the management of these injuries, but related research and practice remain limited. RTS is viewed as a continuum (Schwank et al., 2022; Tassignon et al., 2019) requiring a multidisciplinary team of physicians, physical therapists, strength and conditioning coaches, psychologists, and nutritionists. Attempts have been made to establish objective RTS criteria for ankle sprains (LAS), including the PAASS framework (Smith et al., 2021), Ankle-go scoring system (Picot et al., 2024). Algorithms tailored to professional soccer players (Flore et al., 2024) have also been developed to establish similar protocols. In volleyball, the high demands on the shoulders require a comprehensive assessment of pain, joint range of motion, strength, and other multidimensional indicators during rehabilitation. Additionally, attention must be paid to the coordination of the kinetic chain and the athlete's psychological state (Schwank et al., 2022).

An international expert team reached a consensus on the core elements of preventive measures: specialized training, integration of the kinetic chain, and ease of implementation, which are all clearly. outlined in the Bern Consensus Statement (Schwank et al., 2022). The

Liège Uni program, OSTRC Shoulder Program, and FIFA 11+ training systems have all demonstrated effectiveness in practice.

The main challenges identified include the lack of diagnostic gold standards and clear rehabilitation parameters, necessitating clinical judgment and personalized plans. Clinicians must accept diagnostic uncertainty, rely on personalized physical therapy, address pain education and psychological factors, implement comprehensive evidence-based plans, and integrate prevention into daily training across all levels of sports.

Conclusion

A comprehensive review of shoulder injuries, patellar tendon disorders, and lateral ankle sprains in male volleyball players highlighted the significant impact of these conditions on athletes' health and performance. Based on current knowledge, we can identify a multifaceted issue, with the most critical aspects being diagnostic accuracy, evidence-based rehabilitation, structured return-to-play protocols, and proactive prevention strategies.

Limitations in the current knowledge have led to diagnostic uncertainty and challenges in determining the optimal RTS and optimal FITT, standardization, and effectiveness of these interventions. Future research should prioritize these areas to generate more high-quality studies.

Translating research findings into easily implementable and sustainable clinical practices remains an ongoing challenge.

There is still significant room for improvement in addressing common injuries among male volleyball athletes. However, it remains essential to commit to rigorous, high-quality research while consistently applying evidence-based findings in clinical practice to ensure athlete health, optimize performance, and facilitate long-term participation in volleyball sports. Maximizing the reduction in injury burden and enhancing athlete performance in volleyball requires collaborative efforts among clinicians, researchers, coaching staff,and athletes.

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