Injury Risk Management Plan for Volleyball Athletes

Lachlan P. James · Vincent G. Kelly · Emma M. Beckman

Abstract Volleyball is an increasingly popular team sport. As with any competitive sport, there is an inherent risk of injury that must be recognized and collaboratively managed. This article provides a practical approach to the management of volleyball injuries within a team or organization. A brief review of the epidemiological data is presented which establishes (i) ankle sprain, (ii) shoulder overuse injury, (iii) patella tendinopathy, and (iv) anterior cruciate ligament injury as the primary injuries to address amongst these athletes. The interaction of modifiable and non-modifiable risk factors for these injuries are used to classify athletes into high-, medium- and low-risk groups. Targeted training interventions are suggested, based upon the risk level of the athlete, to minimize the occurrence of these injuries. Practical methods for integrating these activities into a training plan are also discussed.

1 Introduction

Volleyball is recognized as one of the most popular sports in the world amongst men and women [1], in large part due to its accessibility to a wide age group, minimal equipment requirements and the ability to play both indoors and outdoors [2]. The sport involves repeated, whole-body maximal ballistic actions in addition to rapid lateral movement in response to external stimuli. As such, there is an inherent risk of injury that must be recognized. In order to manage this risk, specific injury prevention strategies are needed and should serve as an essential component to the training plan for volleyball athletes. However, untargeted methods aimed at reducing injuries may misdirect resources and training time, thereby limiting the benefit of the intervention. An effective injury prevention plan must be directed towards those athletes at greatest risk [3]. However, a targeted injury risk management plan that denotes at-risk volleyball athletes has yet to be presented in the literature. The purpose of this article is to assist the sports medicine professional in categorizing these athletes into low-, medium- or high-risk groups based upon the interaction of modifiable and non-modifiable risk factors for the major injuries amongst volleyball athletes. Furthermore, a detailed theoretical programming strategy has been designed to manage and reduce the occurrence of injuries. This article is intended to provide a practical solution to decrease injury rates in volleyball players with recommendations underpinned by the current body of literature.

2 Search Methods

Searches were performed of academic databases including PubMed, SPORTDiscus and MEDLINE. Google Scholar was also accessed. The search period extended from January 1970 to March 2014. Search terms included the following: volleyball, injuries, epidemiology, ankle, sprain, overuse, shoulder, ACL, risk factors, tendinopathy, patella, and prevention. Additional key terms used included plyometric, neuromuscular, and motor control. The reference
lists from resources obtained through database searches were also consulted.

3 Epidemiological Research

An injury is commonly considered to be a physical complaint sustained by a player as a result of match-play or training [4–6]; however, other studies use differing methodology to define this term. Similar injury patterns have been noted amongst both male and female volleyball players [2]. Of these injuries, it has been reported that ankle sprains predominate, accounting for nearly half of all reported incidents [1, 2, 7–9]. A high rate of reoccurrence exists for these injuries [10] and, in the majority of cases, symptoms for a lateral ankle sprain may linger for up to 18 months following the incident [11] and typically result in 4.5 weeks away from training and competition [1].

Patella tendinopathy (PT) is reported to affect approximately 50% of male volleyball athletes [12] and represents 88% of all knee injuries in some studies [13]. Due to its insidious onset, these injuries may go undetected, making it challenging to fully determine the impact on lost playing time [14]. Regardless, the high frequency of patella tendinopathies makes it an important consideration when designing an injury prevention plan. Although less common, this injury is also pervasive amongst women, with abnormal patella tendon imaging, indicative of possible tendinopathy, appearing in 43% of female volleyball athletes [15].

Shoulder overuse injury is common amongst high-level volleyball athletes. Specifically, 16% of injuries to elite US national volleyball players [5] and 32% of injuries to English division one players were to the shoulder [16]. Mjaaes et al. [17] determined that these injuries represented 24.8% of all injuries to elite US players.

Although less common, anterior cruciate ligament (ACL) injuries can be particularly devastating to an athlete. Verhagen et al. [1] reported only 5% of all volleyball injuries were acute knee injuries, while Agel et al. [14] noted 3.7% of injuries were to the ACL. However, an extended rehabilitation period exists for such an injury, represented by an 11-month return-to-play duration [18], in addition to potentially permanent disability [19] and should therefore be included in an injury prevention plan for these athletes. Taken together, the injuries to be targeted within this population are (i) ankle sprain, (ii) PT, (iii) shoulder overuse injury, and (iv) ACL injury.

4 Risk Factors

An essential step in the process of establishing injury causation is the identification of risk factors. These may be categorized as modifiable through physical or behavioural interventions, or non-modifiable through such interventions [20]. Presented here is a detailed description for these risk factors drawn from both volleyball and other relevant populations. Table 1 provides a summary of these influences for each of the aforementioned injuries.

4.1 Ankle Sprain

Prospective analysis has reported that 80% of volleyball players who have experienced an ankle injury will have that injury reoccur [21]. For this reason, those athletes with a history of such injuries are at a considerably increased risk. Such athletes have notable deficits in ankle kinaesthesia and joint position sense (JPS) [22]. Additionally, in a prospective investigation, Beynon et al. [23] concluded that men with an increased talar tilt and women with increased tibial varum and calcaneal eversion range of motion (ROM) are at greater risk of suffering ankle ligament trauma. Lower neuromuscular control about the ankle also contributes to an increased likelihood of ankle injury [24], while a higher ROM through extension at the first metatarsophalangeal joint is a documented risk factor preceding ankle sprains amongst female athletes [25]. A lower dorsiflexion ROM has been reported to be a strong predictor of ankle sprain [26]. However, when a previous history of ankle inversion sprains is controlled for, this factor becomes less clear. In populations that have not suffered a grade one or two ankle inversion sprain, Willems et al. reported that reduced dorsiflexion ROM was not a strong predictor of ankle injury amongst athletic women [25], yet it was amongst men [27].

Volleyball ankle injuries mainly occur at the net due to unsafe blocking or striking methods; thus, middle, left- and right-side hitters are most susceptible [7, 14, 28]. The primary mechanism for this injury is a spiking strategy at a trajectory that displaces that athlete on or over the centre line [8], resulting in foot contact with an opposing team’s player [8, 14]. Additionally, it has been reported that incorrect lateral movement and take-off technique causing the athlete to land on the foot of a teammate following a two-person block is another major mechanism for ankle injury [8, 14].

4.2 Patella Tendinopathy

Repeated ballistic and stretch-shortening cycle actions that result in high levels of eccentric loading on firm surfaces, such as the activities commonly found in volleyball, have been proposed as the primary cause of PT [29, 30]. Ferretti et al. [31] determined that the rate of incidence increased with the number of playing years in volleyball athletes. Similarly, it is understood that large increases in training
4.3 Shoulder Overuse Injury

The overhead striking and serving strategies in volleyball require a high degree of dynamic stabilization to secure the glenohumeral joint. Due to the playing time accumulated, high-level volleyball athletes with an average of 11.5 years of playing experience are at increased risk of overuse injuries [5, 40]. A previous shoulder injury and dramatic increase in training load are also considered risk factors [2]. Reeser et al. [40] reported that non-traditional serving styles put the athlete at increased risk for shoulder injury, while middle, left- and right-side hitters execute more asymmetrical actions which lead to greater risk of injury to the dominant shoulder [5]. Muscular imbalances whereby the external relative to internal shoulder rotation strength is proportionally weak, and increased external rotation with reduced internal rotation are risk factors for volleyball athletes [5]. Due to the biomechanical similarities between the overhead actions in volleyball and other overhead sports [41], it has been suggested that athletes expressing the condition characterized by scapula malposition, inferior medial boarder prominence, coracoid pain and malposition, and scapular dyskinesis (SICK) are at increased risk of shoulder injury [2, 5]. Furthermore, it has been suggested

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**Table 1** Modifiable and non-modifiable risk factors for the most common volleyball injuries

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Modifiable</th>
<th>Non-modifiable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ankle sprain</td>
<td>Striking technique with excessive horizontal displacement [8]</td>
<td>Previous ankle injury [10]</td>
</tr>
<tr>
<td></td>
<td>Faulty two-person blocking strategy [14]</td>
<td>Increased tibial varum ROM [23]</td>
</tr>
<tr>
<td></td>
<td>Lower weight-bearing ankle dorsiflexion ROM (men) [26]</td>
<td>Increased calcaneal eversion ROM [23]</td>
</tr>
<tr>
<td>Patella tendinopathy</td>
<td>Large increases in training load [32]</td>
<td>Less accurate passive joint position sense in eversion [25]</td>
</tr>
<tr>
<td></td>
<td>Lower flexibility in hamstrings [36]</td>
<td>Higher range of motion through extension at the first metatarsophalangeal joint (women) [25]</td>
</tr>
<tr>
<td></td>
<td>Lower flexibility in quadriceps [36]</td>
<td>Playing history duration (exposure to repetitive low body ballistic efforts) and previous patella tendinopathy [31]</td>
</tr>
<tr>
<td></td>
<td>Less knee flexion upon vertical landings [38]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Faulty horizontal landing strategy [39]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reduced dorsiflexion [15]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increased waist to hip ratio [15, 35]</td>
<td></td>
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<tr>
<td></td>
<td>Greater vertical jump performance [79]</td>
<td></td>
</tr>
<tr>
<td>Shoulder overuse injuries</td>
<td>Serving or spiking style [40]</td>
<td>Previous shoulder injury [2]</td>
</tr>
<tr>
<td></td>
<td>Weakness in external shoulder rotation strength [5]</td>
<td>Age [40]</td>
</tr>
<tr>
<td></td>
<td>SICK [2]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weak core stability [42]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Large increases in training load [2]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Position [5]</td>
<td></td>
</tr>
<tr>
<td>ACL injury</td>
<td>Faulty landing and take-off technique (knee valgus collapse combined with excessive internal or external knee rotations, and insufficient knee flexion) [44]</td>
<td>Family history [46]</td>
</tr>
<tr>
<td></td>
<td>Weakness in hamstring to quadriceps ratio [45, 80, 81]</td>
<td>Previous ACL injury [19]</td>
</tr>
<tr>
<td></td>
<td>Fatigue [47]</td>
<td></td>
</tr>
<tr>
<td>Overall injury occurrence</td>
<td>Preseason practice</td>
<td>Playing in either middle, left- or right-side hitting position [14]</td>
</tr>
<tr>
<td></td>
<td>Regular season games [14]</td>
<td></td>
</tr>
</tbody>
</table>

ACL anterior cruciate ligament, ROM range of motion, SICK scapula malposition, inferior medial boarder prominence, coracoid pain and malposition, and scapular dyskinesis
that deficits in spinal stability, whereby the ability to transfer forces effectively throughout the kinetic chain is compromised, causes greater stress upon the musculature about the shoulder and therefore should be considered a risk factor for shoulder overuse injury in volleyball athletes [42]. Finally, it is unclear whether gender is a risk factor for such injuries amongst these athletes [5, 17, 40, 43].

4.4 Anterior Cruciate Ligament (ACL) Injury

The leading cause of ACL injuries amongst volleyball athletes are via non-contact mechanisms such as jumping actions, in particular the landing phase of a spike or block [14, 18]; therefore, middle, left and right hitters are most at risk [18]. The combination of multi-planar movement factors is suggested to be involved in non-contact ACL injuries. In addition to a large knee valgus collapse, this includes excessive internal or external rotation and shallow knee flexion angles [44]. Additionally, hamstring relative to quadriceps weakness can increase the potential for anterior tibial shear [45]. Goshima and colleagues [46] noted that many of the risk factors for ACL injuries are passed through families. Thus, a family history of ACL injuries places the athlete at increased risk. It is important to recognize that fatigue can further increase the threat of these traumas also [47].

4.5 Timing of Injuries

It has been reported that injuries are considerably more likely to occur during games than practices [1, 14, 48]. Furthermore, injury rates amongst female volleyball athletes during regular season games were significantly higher than post-season games, while preseason practice session injuries occurred more than twice as frequently as they did in regular-season practices [14]. The timing of injuries may suggest that lower fatigue resistance due to a decreased level of physical fitness contributes to an increased injury risk.

5 Interaction Between Modifiable and Non-Modifiable Risk Factors

A synthesis of both modifiable and non-modifiable risk factors of these injuries provides a means by which to classify athletes into high-, moderate- and low-risk groups. Similarly, the convergence of intrinsic risk and extrinsic factors creates a susceptible individual which, when exposed to an injury mechanism, leads to a high risk of injury [20]. Table 2 defines a construct to denote low-, medium- and high-risk athletes for each of the aforementioned injuries. The interaction between risk factors to theoretically determine high-risk players is described below.

5.1 Ankle Sprain

Intrinsic risk factors such as a previous ankle injury, poor postural control and JPS in addition to the ROM indicators presented earlier combine to designate a predisposed athlete. If such an athlete is a right, middle or left hitter with unsafe striking and blocking strategies, they are at a high risk of injury. It is also proposed that a hitter with a previous ankle injury without other intrinsic risk factors would also be at high risk when combined with unsafe blocking and striking strategies.

5.2 Patella Tendinopathy

The repetitive ballistic actions executed by middle, left- and right-side hitters place these athletes at increased risk of PT. When combined with a previous diagnosis of tendon disrepair or degeneration and hazardous landing techniques, such athletes are considered to be at a high risk of developing tendinopathies. As these factors alone are a potent combination for this pathology, athletes both with and without higher waist-to-hip ratio, lower hamstring and quadriceps flexibility, reduced dorsiflexion, and a history of tendon loading are included in this category.

5.3 Shoulder Overuse Injury

The increased exposure of middle, left- or right-side hitters to overhead actions, places such athletes with a previous shoulder overuse injury at high risk when combined with mobility impairment, muscular imbalances and SICK. Additionally, athletes playing in these positions with an extensive playing history who present with SICK, and a weaker external shoulder rotation strength with reduced internal rotation, are considered at high risk of injury.

5.4 ACL Injury

An athlete predisposed to ACL injury would possess attributes such as weak hamstring to quadriceps ratio, and poorer physical fitness. A predisposed athlete becomes further susceptible executing faulty movement strategies which cause increased valgus torque about the knee, excessive internal or external rotations and shallow knee flexion angles, particularly when landing and jumping. A predisposed hitter with this movement strategy is at high risk of ACL injury. Even without the predisposed factors, a hitter demonstrating this movement dysfunction is classified as high risk.
Injury Prevention Plan

6.1 Integration of Injury Prevention Strategies

Athletes tend to have hectic training schedules, thus simply adding on additional sessions may not be the most effective method for integration. Additionally, Myklebust et al. [49] reported low compliance rates for injury prevention training. To address these issues, it is proposed that the following injury prevention tasks be delivered in the form of a dynamic warm-up within training sessions and games. This programming strategy has been effectively employed during practice sessions for soccer players [50–52] and resistance training sessions of recreational athletes [53]. In addition to long-term injury prevention, many of these exercises may provide acute benefits, through pre-activation of inhibited musculature, and opportunities to immediately apply newly learned movement strategies in practice and game situations. Superior increases in measures of lower body strength over 7 weeks have also been reported using this session design when compared with a traditional dynamic warm-up [53].

6.2 Ankle Injuries

Significant decreases in firing frequency of the peroneus longus have been reported in individuals with chronic ankle instability (CAI) [54]. When coupled with reports of low correlations between strength and ankle stability [23, 55], these findings suggest that motor control, rather than strength, is an important factor in preventing ankle injuries. It has been reported that deficits in neuromuscular control [56–58] and joint force sense (JFS) [59] are present in athletes with CAI. Therefore, prevention programmes, particularly for moderate- and high-risk athletes, should focus on functional neuromuscular control in addition to

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**Table 2 Risk factors for volleyball athletes**

<table>
<thead>
<tr>
<th>Injury</th>
<th>High risk</th>
<th>Medium risk</th>
<th>Low risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ankle injury</td>
<td>Right, middle or left hitter with previous ankle injury employing unsafe blocking or striking strategies</td>
<td>Hitters with no history of ankle injury with unsafe blocking and striking tactics</td>
<td>Setter or libero with no history of ankle injury</td>
</tr>
<tr>
<td></td>
<td>With or without: poor postural control, poor JPS, ROM indicators</td>
<td>A setter or libero with a previos ankle injury</td>
<td>Hitters with safe blocking and striking strategies without previous ankle injuries</td>
</tr>
<tr>
<td>Patella tendinopathy</td>
<td>Middle, left- and right-side hitters with history of PT who display hazardous landing techniques</td>
<td>All remaining hitters</td>
<td>Setter, libero without history of PT</td>
</tr>
<tr>
<td>Shoulder overuse injury</td>
<td>Hitters with a previous shoulder overuse injury who possess mobility impairment, weakness through external rotation and SICK scapula, regardless of serving style</td>
<td>All remaining hitters with a history of shoulder overuse injury</td>
<td>All remaining players</td>
</tr>
<tr>
<td></td>
<td>Hitters with extensive playing history, who demonstrate mobility impairment, weakness through external rotation and SICK, regardless of serving style</td>
<td>All remaining hitters with an extensive playing history</td>
<td></td>
</tr>
<tr>
<td>ACL injury</td>
<td>Any hitter demonstrating valgus collapse about an internally or externally rotated and excessively extended knee</td>
<td>A setter or libero demonstrating valgus collapse about an internally or externally rotated and excessively extended knee</td>
<td>Hitters who are not predisposed and execute healthy jumping and landing strategies</td>
</tr>
<tr>
<td></td>
<td>A hitter with weak hamstring to quadriceps ratio or poorer physical fitness, and healthy landing mechanics</td>
<td>A hitter with weak hamstring to quadriceps ratio or poorer physical fitness, and healthy landing mechanics</td>
<td>Liberos and setters with optimal jumping, landing technique, with or without predisposition</td>
</tr>
</tbody>
</table>

PT patella tendinopathy, JPS joint position sense, ACL anterior cruciate ligament, ROM range of motion, SICK scapula malposition, inferior medial boarder prominence, coracoid pain and malposition, and scapular dyskinesis
motor control tasks (Tables 3, 4). These activities would aim to develop JPS, kinaesthesia and JFS.

For moderate- and high-risk athletes, pre-activation of peroneus longus could be undertaken at the beginning of the warm-up to aid in motor control. Following this, single-leg static balance on a stable surface could follow for all athletes. All athletes who have had a prior ankle sprain should complete an 8-week course of daily single-leg neuromuscular programme following their injury. As capacity improves over the duration of the season, unstable apparatuses can be introduced. Similar activities have resulted in significant improvements in plantar-dorsiflexion JPS [60]. Manual partner perturbations may be added to further challenge the athlete [61].

More dynamic and ballistic activities to further challenge neuromuscular control and JFS could follow for all athletes. This can include single-leg squats on a stable surface in addition to more general dynamic warm-up activities such as basic squat and lunging patterns. Lateral movement tasks are recommended, as interventions involving these movements have resulted in improvements in functional capacity amongst individuals with CAI [62]. Drills with greater sports specificity, in particular plyometric and ballistic exercises, should also be included [63] (Table 3). Moderate- and high-risk athletes could progress to more complex versions of these tasks. In accordance with Bahr et al. [7], technical training to safely reach a ‘tight set’ and land from a two-person block should be conducted during training sessions with moderate- and high-risk players. Such training will require collaboration with sports-specific coaches, and will involve a more vertical trajectory for both techniques.

Use of external ankle supports such as taping or bracing has been reported to reduce the risk of ankle sprains in athletic populations, particularly amongst those athletes with a previous ankle sprain [64]. Mickel et al. [65] reported no difference in the effectiveness between ankle bracing and taping methods in reducing ankle sprains in

Table 3 Injury prevention strategies for all players

<table>
<thead>
<tr>
<th>Type of strategy</th>
<th>Injury</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example neuromuscular tasks</td>
<td>ACL injury</td>
<td>Single-leg squat</td>
</tr>
<tr>
<td></td>
<td>Ankle sprain</td>
<td>Shuffles or Cariocas—progress to change of direction reaction (mirror partner or coaches cue)</td>
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<td></td>
<td></td>
<td>Lateral or 45° bound and balance, landing on opposite leg</td>
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<td></td>
<td></td>
<td>Single-leg hops over line, or ladder drills</td>
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<td></td>
<td></td>
<td>Jump to 45° turn—progress to reaction (‘jump left’, ‘jump right’), further progress to dual task (catch and pass, set, dig)</td>
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<tr>
<td></td>
<td></td>
<td>Submaximal single-leg landing drills, depth jumps and variations</td>
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<td></td>
<td></td>
<td>Progressions to pivoting and cutting activities after capacity is developed</td>
</tr>
<tr>
<td>Motor learning and coaching strategies</td>
<td>ACL injury</td>
<td>Precise movement mechanics to ensure lower-limb joint congruency and encourage active, soft landings whilst maintaining the centre of mass over the base of support</td>
</tr>
<tr>
<td></td>
<td>Patella tendinopathy</td>
<td>Close qualitative analysis to identify these movement dysfunctions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Combined visual and verbal feedback</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use of implicit learning strategies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cognitive teaching describing both the injury prevention and performance benefits of prescribed activities</td>
</tr>
<tr>
<td>Load management</td>
<td>Patella tendinopathy</td>
<td>Cautious introduction of tendon-loading activities during the preseason or following a period of inactivity</td>
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<tr>
<td></td>
<td></td>
<td>Structure high, medium and low tendon-loading days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tracking of ‘ground contacts’ during plyometric and ballistic activities in strength and conditioning sessions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Application of valid periodization strategies to prevent fatigue-related injuries, particularly in preseason and regular season</td>
</tr>
<tr>
<td>Rotator cuff strengthening</td>
<td>Shoulder overuse injury</td>
<td>External rotation and external rotation with scapular plane abduction exercises in functional, athletic positions (Fig. 1)</td>
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<tr>
<td></td>
<td></td>
<td>Such exercises can also be conducted with eccentric emphasis. Here, the athlete externally rotates against light elastic tubing, steps away and along the line of action to create more tension while the free hand supports, then completes, the eccentric action</td>
</tr>
<tr>
<td></td>
<td></td>
<td>These exercises can be performed between sets during resistance training</td>
</tr>
</tbody>
</table>

ACL anterior cruciate ligament
high-school athletes. However, it should be noted that tapping is reported to decrease dynamic balance during jump landings in athletes without a history of ankle injury [66]. For this reason, the use of such strategies is recommended for high-risk athletes only.

6.3 Patella Tendinopathies

It is theorized that excessive tendon loading causes tenocyte apoptosis, resulting in pathology and pain [67]. In accordance with this, close monitoring and manipulation of tendon loading may be an effective strategy for injury prevention (Table 4) [30]. It has been reported that the process of collagen synthesis within a tendon peaked 96 hours after the loading was applied [68]. This suggests that 4 days of recovery from higher tendon-loading stimuli may be required for optimal adaptation. As increases in tendon load can be a cause of tendinopathies, particular caution should be applied following periods of time off, such as at the beginning of the preseason and following injury or illness. To address this, a prevention strategy would prove valuable provided the tendon load is managed appropriately (Table 5). The intensity of each day will differ based on the susceptibility of the athlete, with those at higher risk exposed to lower tendon loads than less susceptible athletes. In addition to load management, the use of eccentric focused activities are recommended for those in the degenerative stage of tendinopathies (Table 4) [69].

Limited ballistic and plyometric activities should be employed during the preseason resistance training sessions. As the tendons adapt, capacity increases and greater intensities and volume of ballistic activities may be employed both in practice and strength and conditioning sessions. Neuromuscular training and motor learning strategies to improve landing biomechanics would also prove valuable provided the tendon load is managed appropriately (Table 3). In particular, eccentric horizontal and vertical landing activities will focus on soft contact with the ground to effectively absorb ground reaction forces. Vertical landing drills will aim for increased knee flexion, while horizontal stop-jump tasks will aim to increase hip flexion and decrease knee flexion in at-risk athletes.

6.4 Shoulder Overuse Injury

Activities that strengthen the rotator cuff are recommended to rectify strength imbalances, and should be included for these athletes (Table 3) [5, 70]. Low to moderate tension elastic tubing can be used to provide resistance through this movement pattern. Movement involving external rotation combined with abduction should be emphasised to provide a stimulus that more closely resembles the overhead actions in volleyball. The eccentric action of many of these exercises will also be emphasised. For example, an athlete could take the shoulder concentrically through external rotation with low tension, then step away from the resistance along the line of action to create more tension before the eccentric action is performed. These exercises could be combined with other aforementioned injury prevention tasks to form a single, athletic movement. For example, an athlete may perform a ‘quick drop squat to external shoulder rotation’ (Fig. 1). Here, the athlete would rapidly drop into a squat and pause while holding the tubing; the external shoulder rotation could then be performed before ascending from the squat. This would challenge neuromuscular control and promote eccentric activity in the lower limb, in addition to strengthening the rotator cuff. This exercise may even be performed on an unstable surface for those athletes also at high risk of ankle injury. Such an activity also creates a more athletic, complex movement which would likely lead to greater compliance from the athlete.
Close tracking of serves and spikes throughout training is required to manage the load on the shoulder and prevent overuse injury. For example, a player who executes a particularly high volume of these actions during a match may need a reduced training load of overhead movements in the following week.

Addressing mobility impairments in the shoulders of at-risk athletes should also form a key component of this injury prevention plan. Stretching to improve posterior capsular tightness is recommended for these athletes [2, 70]. Such interventions conducted over the course of a season have resulted in considerable reductions in shoulder injuries amongst overhead-sport athletes [42].

Training to improve core strength should also be considered for at-risk athletes. Adequate strength in this region allows for effective summation of forces throughout the kinetic chain, from proximal to distal, allowing the shoulder to play a greater role in expressing the force, rather than producing it [71]. Research has indicated that dynamic resistance training activities performed in an upright position elicit an improved activation of the trunk musculature than alternate methods [72, 73]. For this reason, an increased focus on structural resistance training activities should be included for athletes deficient in this region.

Athletes with at-risk serving and spiking techniques would benefit from altering these movements to an action that places less stress about the shoulder [9, 74, 75]. Such technique modifications have improved performance in these actions while reducing the risk of shoulder impingement [75]. Activities to both strengthen the rotator cuff and improve internal rotation ROM should be included alongside load management of overhead volleyball actions. Shoulder overuse prevention methods for all athletes are included in Table 3. Table 4 details specific strategies for moderate- and high-risk athletes.

6.5 ACL Injuries

Athletes susceptible to ACL injury would benefit from strategies that improve landing mechanics. These methods would aim to minimize both knee valgus collapse and excessive internal or external knee rotations, and increase knee flexion. To minimize the risk of these injuries, neuromuscular control tasks such as basic movement patterns progressing to more complex plyometric and deceleration exercises are recommended (Table 3) [19]. Neuromuscular training such as this is reported to increase semitendinosus relative to quadriceps activity during pre-landing and landing phases of cutting manoeuvres [76]. This results in an altered motor control programme which decreases the risk of dynamic valgus collapse.

Optimal absorption of initial ground reaction forces can be achieved by encouraging soft, controlled and ‘quiet’ landings which aid in increasing knee and hip flexion, and ensuring precise lower-limb alignment upon vertical landings [77, 78]. These qualitative analysis and feedback techniques should be applied throughout practice and strength and conditioning sessions. Moderate- and high-risk players may benefit from a greater volume of plyometric activities in strength-power training sessions to provide greater motor learning opportunities. However, this intervention would only be suitable for players at a low risk of patella tendinopathies. Additionally, this increased volume would have to be within the volume-load bandwidth for the particular training block. Table 3 presents injury prevention strategies for all athletes. Interventions for moderate- and high-risk athletes are included in Table 4.

Table 5  Tendon loading schedule for volleyball athletes

<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
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<tbody>
<tr>
<td>M</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>M</td>
<td>H</td>
<td>L</td>
</tr>
</tbody>
</table>

L low tendon load, M medium tendon load, H high tendon load

Fig. 1 Quick drop squat with external shoulder rotation

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7 Conclusions

The minimization of injuries should form the cornerstone of any training plan within a sporting team or organization. Given the impact of injury to both athletes and teams, a targeted injury prevention plan, based upon the interaction of modifiable and non-modifiable risk factors, for volleyball is essential. Presented here is a theoretical strategy for both the identification of at-risk volleyball athletes, and the design and delivery of specific injury prevention activities based upon this categorized risk level to reduce the occurrence of ankle sprains, patella tendinopathies, shoulder overuse injuries and ACL injuries. To minimize extended training time and ensure compliance, the warm-up within training sessions and games is proposed as an opportune time to integrate these exercises. Collectively, this plan provides a practical solution, with minimal cost of time or resources, for the reduction of injuries amongst volleyball athletes.

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