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NARRATIVE REVIEW

Shoulder girdle injuries in volleyball players: structure, symptoms, cause and prevention. A narrative review

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Abstract

Shoulder joint injuries are a major concern in volleyball, particularly among elite athletes who undergo rigorous training sessions and frequently participate in competitions. Given that volleyball is a polystructured sport that requires volleyball players to constantly change the amplitude of movement in the shoulder joint, frequent injuries such as subacromial impact syndrome, compression of the suprascapular nerve, bursitis and tendinitis of the rotator cuff occur. In order to prevent injuries, prevention programs are increasingly introduced today. Consequently, the aim of this research was to describe the structure and prevention of shoulder girdle injuries in volleyball players. Prevention programs developed by researchers have been shown to be effective in reducing the prevalence of shoulder injuries. Prevention programs include adequate warming up, strengthening and stretching of the muscles of the shoulder girdle, as well as correct execution of technical elements. The development and implementation of individualized prevention and rehabilitation programs can significantly contribute to reducing the risk of injuries and prolonging the sports career of volleyball players.

Keywords: *shoulder joint injuries, prevention, rehabilitation, volleyball*

Introduction

William Morgan could not find any sport similar to today's volleyball. By aligning his unique methods of training and recreation, he created a game he called "Mintonette" (Rustamovich, 2024). Mintonette is the original name of today's Olympic team sport – volleyball (G'ayratovich, 2022). Volleyball belongs to semi-structured sports with unpredictable dynamics of both cyclic and acyclic types of movements (Nešić et al., 2020; Yue & Hong, 2023). Like most sports, volleyball physically strains and activates the entire human musculature through various forms of movement (Reitmayer, 2017). This sport is based on natural forms of movement that constantly alternate, such as running, jumping, landing, sprinting, digging, hitting the ball, and blocking (Cosmin et al., 2016; Tsoukos et al., 2019). In addition to natural forms of movement, volleyball requires players to perform short high-intensity actions followed by low-intensity activities (Gabbett et al., 2007; Kilic et al., 2017; Majstorović et al., 2020). Matches generally last between 60 and 100 minutes, during which more than 250 actions are performed with jumps accounting for about 50-60%, defense with landings about 15%, and rapid changes of direction 27-33% (García-de-Alcaraz et al., 2020; Mori et al., 2022). Indeed, players on the court perform a series of different motor activities involving movements with and without the ball to achieve specific goals during the game (Mroczek et al., 2014). While performing basic and specific movements, some muscle groups are more, and some less strained compared to others (Cuñado-González et al., 2019). Numerous studies suggest that the strains create asymmetries in various sports disciplines that negatively affect the human body (Fort-Vanmeerhaeghe et al., 2016; Parpa & Michaelides, 2022). Asymmetry appears in many sports, including volleyball (Hadzic et

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al., 2014; Kozinc & Šarabon, 2020). Cuckova & Suss (2014) in their study found that the dominant side of female volleyball players' bodies is under greater strain, leading to body asymmetry. Such conclusions are explained by the shortening or excessive tension of certain muscle groups during the execution of motor movements and technical elements specific to volleyball. Indeed, due to the tension and overstrain of certain muscle groups, injuries in volleyball often occur (Wang & Cochrane, 2001). Injuries in volleyball occur due to jumping, landing, or grounding but nowadays increasingly from hitting and blocking the ball (Chojęta et al., 2020). Generally, sports injuries are divided into acute and overuse injuries (Višnjevac et al., 2009; Višnjevac et al., 2020). Overuse injuries are somewhat more common than acute injuries in volleyball (Cieśla et al., 2014; de Azevedo Sodré Silva et al., 2023). Various factors contribute to the occurrence of injuries, the most common being improper technique, fatigue, and overtraining (Zetou et al., 2006). Also, professional volleyball players are at greater risk of injuries compared to amateur players due to more intense training, competition schedules, and loads (Azuma et al., 2019; Eerkes, 2012). The most common injuries in volleyball are ankle injuries, followed by knee injuries including anterior cruciate ligament rupture, hand injuries, lumbar spine injuries, and shoulder joint injuries (Eerkes, 2012; Migliorini et al., 2019).

Accordingly, the goal of this research was to summarize the scientific evidence and describe in detail the structure of the most common shoulder girdle injuries in volleyball players, as well as the prevention and prevention program of shoulder girdle injuries, in order to prevent injury and thereby improve the health and prolong the sports career of volleyball players in the future.

Methods

For the collection, classification, and analysis of the targeted research, a descriptive method and theoretical analysis were used, while the material was gathered through internet databases and search engines: Google Scholar, Pub Med, Web of Science, and ResearchGate. The key terms used during the search included: shoulder joint injuries, prevention, rehabilitation, and volleyball. Only the studies relevant to the purpose of this research were considered. The search was limited to studies conducted on volleyball players who sustained shoulder joint injuries. Studies that were excluded from the analysis did not meet the criteria of having an adequate sample size, or the results were not adequately presented for further analysis.

Anatomy of the Shoulder Joint

The shoulder joint, also known as the glenohumeral joint, is an extremely mobile joint in the human body. The shoulder muscles have a wide range of functions, including movements such as lifting, lowering, rotating, and extending the arm (Bakhsh & Nicandri, 2018). The central bony structure of the shoulder is the scapula, which serves as the attachment point for all these muscles. On the surface of the scapula is the glenoid cavity, which along with the glenoid ligaments and muscle tendons, provides stability to the shoulder joint (Cowan et al., 2018). Additionally, there are other muscles that make up the shoulder girdle, such as the pectoralis major, pectoralis minor, deltoideus, trapezius, and serratus anterior. These muscles play an important role in supporting the shoulder joint and enabling various movements of the arms and shoulders. Furthermore, there are several joints that connect the pectoral girdle to the rest of the body, such as the sternoclavicular, coracoclavicular, and acromioclavicular joints (Card & Lowe, 2018). The scapula is a key bone located on the back and has numerous muscle attachments. The glenoid cavity on the scapula allows for smooth articulation with the head of the humerus. This is important for the stability of the shoulder joint and enables us to perform various arm movements. Additionally, the coracoclavicular and acromioclavicular joints contribute to the stability of the shoulder girdle (Holt et al., 1990). Embryologically, the upper extremities develop during fetal development through the process of cell condensation that differentiates into bones and cartilage. Muscle tissue begins to form around the seventh week of development. This process involves the migration of mesenchymal cells to the extremities and their differentiation into muscle fibers (Warmbrunn et al., 2018). In terms of vascularization, the upper extremity receives its blood supply from the subclavian artery, which further branches into the axillary artery. These arteries supply the shoulder muscles and ensure adequate blood circulation in this area (de la Garza et al., 1992). The nervous system plays a crucial role in innervating the shoulder muscles. Various nerves, such as the subscapular nerve, suprascapular nerve, axillary nerve, and others, innervate different muscle groups in the shoulder girdle, enabling them to perform their functions (Okwumabua et al., 2018). The rotator cuff muscles, including the supraspinatus, infraspinatus, teres minor, and subscapularis, are key structures for the stability of the shoulder joint. These muscles enable various arm and shoulder movements, such as lifting, lowering, and rotation. Additionally, muscles such as the trapezius, deltoideus, and others contribute to the mobility of the shoulder joint and allow us to perform everyday activities (Precerutti et al., 2010).

Common Shoulder Joint Injuries in Volleyball

Volleyball is considered a safe sport compared to other contact sports such as handball, football, and basketball (Challoumas et al., 2017; Engebretsen et al., 2013; Vaandering et al., 2023). However, volleyball players can be at risk due to tasks specific to volleyball. Generally speaking, the prevalence of shoulder joint injuries varies depending on the sports discipline (Cibulas et al., 2019; Nadler et al., 2004). Among athletes, shoulder injuries are frequently reported, which can result not only in pain and emotional difficulties but also in temporary or permanent cessation of a sports career (Wilk et al., 2020). The shoulder joint is naturally mobile but less stable, making it vulnerable to injuries under the pressure characteristic of volleyball (Seminati & Minetti, 2013; Tibowe et al., 2004). Volleyball-specific techniques such as spiking, blocking, and serving place significant stress on the shoulder girdle (Hadžić et al., 2022). In recent years, the rate of overuse shoulder injuries among elite volleyball players has increased from 16% to 47% (Eerkes, 2012; Ünver et al., 2020). Numerous studies indicate that outside hitters have a higher prevalence of shoulder injuries (Miranda et al., 2015; Young et al., 2023). These results are expected because they are the main attackers.

Subacromial Impingement Syndrome

The most common shoulder joint injury in volleyball is subacromial impingement syndrome (Erekes, 2012). The factor that contributes to the occurrence of this injury is the compression of one of the rotator cuff tendons (Longo et al., 2020). The rotator cuff consists of four muscles: subscapularis, supraspinatus, infraspinatus, and teres minor (Llopis et al., 2021). These four muscles stabilize the head of the humerus in the concave body of the shoulder joint (Seminati & Minetti, 2013). If one of the structures of the shoulder joint becomes entrapped, normal circulation in that area is impeded, leading to inflammation and swelling (Badıl Güloğlu, 2021). Due to swelling and

inflammation, the rotator cuff thickens, making it difficult for the supraspinatus tendon to pass through the subacromial space (Seminati & Minetti, 2013). The cause of the injury is repetitive overhead arm movements such as spiking and serving (Rohit, 2010). Shoulder pain occurs, especially when raising the arm above shoulder and head level (Shah et al., 2014). Pain increases particularly during internal rotation (Sanati et al., 2022). This injury is often observed in attacking players and servers because they abduct the glenohumeral joint to about 150º during serves and spikes (Shah et al., 2014). Rehabilitation treatments include rest, ice therapy, physical therapy, strengthening the rotator cuff, and possibly corticosteroid injections (Karaca, 2016; Yavuz et al., 2014).

Suprascapular Nerve Compression

Following jumper's knee, one of the most common injuries among volleyball players is suprascapular nerve compression (Kezunović & Laković, 2010). This injury is more dominant among spikers (Mazza et al., 2021). The predominant symptom is pain in the lateral part of the dorsolateral shoulder area, which worsens during arm movements and activities above shoulder and head level (Bozzi et al., 2020). Suprascapular nerve injury occurs in the dominant arm (Kezunović & Laković, 2010). If the injury worsens, pain can manifest along the posterior part of the arm (Dotterweich et al., 2023). Pain can also become constant, accompanied by shoulder muscle weakness and fatigue (Habib et al., 2022). Muscle atrophy can be observed, especially in female volleyball players (Kezunović & Laković, 2010). The cause of this injury can be overuse and repetitive stress on the rotator cuff tendons (Kezunović & Laković, 2010). Suprascapular nerve compression in volleyball players can be treated in several ways (Strauss et al., 2020). One method is non-surgical treatment, which is applied to patients with nerve dysfunction but without muscle atrophy (Leider et al., 2021). The first step in non-surgical treatment is to avoid the activities that caused the injury (John et al., 2020). The second step involves physical therapies focused on strengthening the rotator cuff, deltoid, and spinatus muscles (Strauss et al., 2020). If there is no improvement after three to four months of non-surgical treatment, surgical decompression of the suprascapular nerve is undertaken (Brzoska et al., 2023). Additionally, if muscle atrophy is evident and there is severe pain that cannot be controlled with medication, surgical decompression of the suprascapular nerve is performed (Strauss et al., 2020).

Bursitis Injuries

Bursae synoviales or synovial bursae are smaller or larger structures located around certain joints (Halata, 2001). The function of bursae is to reduce friction between muscles and their tendons and the hard surfaces they rest on (Colas et al., 2004). The shoulder joint has eight bursae, of which the most important is the subacromial bursa (Skazalski et al., 2021). The subacromial bursa is located between the coracoacromial ligament, acromion, and deltoid muscle on one side and the joint capsule with the coracohumeral ligament and rotator cuff tendons on the other side (Colas et al., 2004). Bursitis occurs if the rhomboid and trapezius muscles do not stabilize the scapula during movements, leading to the elevation of the humeral head, which reduces the subacromial space (Skazalski et al., 2021). Clinical signs of bursitis include shoulder pain, reduced range of motion, especially above shoulder level, and weakness of surrounding muscle groups. Local signs of bursitis may include warmth and redness in the shoulder area. Rehabilitation is usually conservative. The primary goal is to relieve the shoulder joint, i.e., rest with the application of NSAID therapy (Khan et al., 2001). This is followed by a focus on physical therapy, which is primarily based on stretching and strengthening the rotator cuff muscles to achieve shoulder joint stabilization (Biundo et al., 2001).

Tendinitis and Rotator Cuff Tear

The most important functional structure of the shoulder joint is the rotator cuff (Ninković, 2020). Rotator cuff injuries are very common, not only among athletes but also among non-athletes (Ninković et al., 2014). During normal daily activities, approximately 140 to 200 N are transmitted through these tendons (Cicak, 2003). For volleyball players, the maximum load that a healthy rotator cuff tendon can transmit ranges from 600 to 800 N (Cicak, 2003). The exact diagnosis of a rotator cuff injury is determined through clinical examination, analysis of radiographic images, and magnetic resonance imaging (Wieser et al., 2019). Rotator cuff tendinitis in volleyball players results from overuse and constant repetitive stress (Čičak et al., 2015). Symptoms of rotator cuff tendinitis include shoulder pain accompanied by weakness in the shoulder joint muscles (Wieser et al., 2019). Rehabilitation treatment consists of rest, i.e., relieving the shoulder joint, and physical therapy (Menshova et al., 2021).

Rotator cuff tear, in most cases, represents a combination of untreated rotator cuff tendinitis and poor tendon nutrition, but it can also result from high-intensity force (Wieser et al., 2019). Treatment of a rotator cuff tear involves arthroscopic surgery followed by a rehabilitation period of three to six months with physical therapy (Menshova et al., 2021; Wieser et al., 2019).

Prevention of Shoulder Girdle Injuries

Since sports injuries can have a negative impact primarily on the continuation of a sports career, they can also result in high costs for society due to interventions based on exercises to prevent or reduce injuries (Cools et al., 2021; Gouttebarge et al., 2017). Maintaining normal kinetic function of the shoulder complex is one of the most challenging tasks in sports medicine (Emery & Pasanen, 2019). Identifying risk factors for shoulder injuries is essential for developing prevention strategies (Abernethy & Bleakley, 2007). The risk factor for musculoskeletal injuries in volleyball is more frequently reported in male volleyball players than female volleyball players (Kilic et al., 2017). The injury prevention model proposed by van Mechelen is the basis for assessing the development of prevention programs (Verhagen & van Mechelen, 2010). The model indicates that sports injury prevention begins with determining the extent of the injury, followed by identifying risk factors for injury in that sports discipline. This is followed by the development and validation of injury prevention strategies (Blauwet et al., 2019; van Mechelen, 1997). This model is still used in designing injury prevention.

The Oslo Sports Trauma Research Center has developed a shoulder injury prevention program. The shoulder injury prevention program increased internal rotation strength of the glenohumeral joint, external rotation strength, and scapular muscle strength (Kilic et al., 2017). The program consisted of warm-up exercises that reduced the prevalence of shoulder problems by 28% (Andersson, 2017). Warm-up before training and matches induces several phenomena related to the muscle-tendon system (Bishop, 2003). In the area of active muscles, muscle contractions increase circulation, leading to an increase in temperature in that area (Fradkin et al., 2010; McCrary et al., 2015). Increasing the temperature promotes the reduction of muscle tension and increases the viscoelastic properties of muscles (Safran et al., 1988). Thus, warming up achieves a range

of physiological processes that increase muscle tolerance to the stresses and forces to which they are exposed (McCrary et al., 2015). In addition to the Oslo Sports Trauma Research Center, Fradkin et al. (2006) conducted a study to examine the extent to which warm-up actually affects injury prevention. The results confirmed that performing proper warm-up before training and matches reduces the risk of injury. Additionally, the combination of active and passive exercises reduces shoulder joint injuries (Huxel Bliven & Anderson, 2013). The first step in injury prevention through exercises begins with static exercises (Yu et al., 2015). They are desirable because in these exercises, the muscle does not perform movement and does not change its length but only changes the muscle tone (Yu et al., 2015). In static exercises, there is no load on the rotator cuff, but the muscles are strengthened. Of course, in addition to static exercises, injury prevention also includes unloading exercises that increase the range of motion while simultaneously strengthening the muscles (Abdulla et al., 2015). In active exercises, results are visible because active movement affects deeper structures (Escamilla et al., 2009). These exercises include muscle strengthening exercises with gravitational force, proprioception exercises, and exercises with elastic bands (Della Tommasina et al., 2023). Stretching exercises are also very important in injury prevention because stretching creates space between joint bodies while stretching muscles and tendons (Weerapong et al., 2004).

Based on existing scientific and practical knowledge, it is stated that systematic strengthening of shoulder muscles is crucial, especially for volleyball players, as a preventive measure against shoulder injuries (Abdulla et al., 2015; Swart & Olivier, 2021). Finally, although strong internal rotators are important for optimal volleyball performance, equally strong external rotators are necessary to maintain shoulder joint health in volleyball.

Shoulder Injury Prevention Program

The issue of shoulder injuries in the sports population emphasizes the need for a prevention strategy and effective rehabilitation programs. Therefore, there is a need for a global approach that includes shoulder injury prevention.

The shoulder injury prevention cycle consists of four steps (Van Mechelen et al., 1992). The first step is identifying the problem, followed by examining the injury mechanism (Van Mechelen et al., 1992). The third and fourth steps, which are also the most significant, involve introducing a prevention program and examining its effectiveness (Van Mechelen et al., 1992). Since the first and second steps have already been described in previous chapters, the focus will now be on the third and fourth steps. In the third step, preventive measures such as exercise or stretching programs are introduced, but preventive measures also include changing volleyball game rules, introducing protective equipment, and adapting the quality of sports equipment (Bahr, 2016). After introducing the prevention program, the effectiveness of the introduced prevention program is examined.

The most frequently asked question is whether preventive programs reduce the rate of shoulder injuries. In the scientific literature, opinions are divided. Andresson et al. (2017) demonstrated through research that preventive programs reduce the rate of shoulder injuries. Sommervold & Østerås (2017) did not find effects of the prevention program on shoulder injuries. They attributed these results to the players not adhering to the preventive program. Today, there is increasing evidence of possible risk factors for shoulder pain in the younger population of athletes. Many studies indicate that injury prevention programs have greater significance for the younger population (Asker et al., 2018; Cools et al., 2021). Of course, there may not be a possibility to predict an injury, but there is a possibility to prevent it. When programming a prevention program, it is necessary to involve multiple experts. Adherence to the exercise program increases by engaging the head coach, assistant coach, strength and conditioning coach, medical team, and parents (Cools et al., 2021).

Conclusion

Volleyball, as a popular sport with a huge number of participants, is unfortunately subject to injuries like many other sports. One of the frequent injuries is the shoulder girdle injury, which can keep the participant off the volleyball court for a short or long period of time. In sports in general, especially where players are exposed to constant repetitive high-intensity movements, this injury is a serious problem. The most common shoulder girdle injuries in volleyball players are subacromial impingement syndrome, compression of the suprascapular nerve, bursitis and rotator cuff tendinitis directly related to the specific biomechanical demands of volleyball. Understanding the anatomical and functional complexity of the shoulder joint is the first step to developing the most effective rehabilitation and prevention programs. There are many risk factors that contribute to the occurrence and worsening of injuries. So far, the most effective prevention programs against shoulder girdle injuries have been programs that include exercises to strengthen and stretch the muscles of the shoulder girdle, as well as proper warm-up before training and matches and proper execution of technical elements.

This scientific paper contributes to the already existing knowledge about the structure, symptoms and rehabilitation of shoulder girdle injuries in volleyball, but also provides guidelines for the practical application of new knowledge regarding injury prevention. The priority of future research should be the development of individual prevention programs for the specificity of sports injuries in order to preserve and improve the health of athletes.

Authors contributions

In this research, Ivana Delibašić conceived and designed the study, as well as wrote the first draft. Slavka Durlevic and Ina Markovic participated in writing the complete scientific paper, while Marija Durlevic contributed to the technical editing of the entire paper. All authors approved the final version submitted for publication.

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