Lower body Movement and Injury Risk During Volleyball Three Step Approach

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Abstract

The growing popularity of volleyball among teens and young adults at highschool and college levels has led to the demand for quick movements, jumping, and leaping. (*2003_Reeser.Pdfpage32*, n.d.). There are many techniques and fundamental skills in volleyball. Specifically, the three step approach plays a critical role in an offensive strategy and provides advantages in the game overall. Jumping is one of the key movements in volleyball, especially in the three step approach. Along with that coordinated movement of the lower extremity joints is important for optimal performance and reducing injury risk. Improper landing techniques can lead to traumatic injuries, such as muscle strains, bone fractures, and ligament tears (sprains) in the lower body joints. These injuries can lead to long term negative effects on your body and can have long recovery times. Understanding which movements lead to these types of injuries helps players and clinicians. This knowledge helps to develop strategies that lead to injury prevention and optimal player performance.

Introduction

Epidemiology research in NCAA women's volleyball players has shown that about 7 injuries occur out of 1000 athlete exposures (Chandran et al., 2021). Of these injuries, the most common are in the knee and ankle, which can be caused by overuse and noncontact (Chandran et al., 2021). Repetitive injuries to a joint can lead to lowered player performance in the short-term, and eventually cause more serious problems like arthritis in the long-term (Brockett & Chapman, 2016). With a possible scholarship loss and lower playing time on court.

In volleyball, injuries are often caused by the three-step approach, a common offensive strategy, because the movement is repetitive and involves jumping. When an athlete shows poor mechanics in the hitting process, there is increased risk of ACL injuries, patellar tendinosis, and ankle sprains (Parsons & Alexander, 2012). Researchers and clinicians developed injury prevention strategies that target poor mechanics during jumping and landings. Common injury preventions include verbal and video feedback, static stretches, plyometrics, and players focusing on landing mechanics and strategy (Gjinovci et al., 2017).

The aim of this paper is to review the relationship between lower body movement and injury risk that is specifically involved in the volleyball three step approach. This paper will do this by discussing the three-step approach, lower body anatomy involved in jumping, common injuries in the lower body, and interventions for injury. The goal of this paper is to educate and serve as a resource for volleyball players.

Three-Step Approach in Volleyball

The three-step approach is a simple way for players to gain momentum, and it is commonly used for a spike and for the defense for a spike. The footwork starts off as left, right foot (acceleration), Left anchor foot building up momentum (right handed hitter). The approach ends with the explosive jump (Figure 1) (Wagner et al., 2009). The goal is to maximize jump height to contact the ball at its highest point so as to have the best offensive shot. The timing is key for a three-step approach, and players aim to sync up their movements with the setter's set. Common kinematics and kinetics that are observed are hip and knee flexion and extension, when preparing for the explosive jump, and quadriceps and hamstrings used in the take off steps (Taylor et al., 2015). While adding on an arm swing to help launch the jump and gain upward momentum (Wagner et al., 2009).

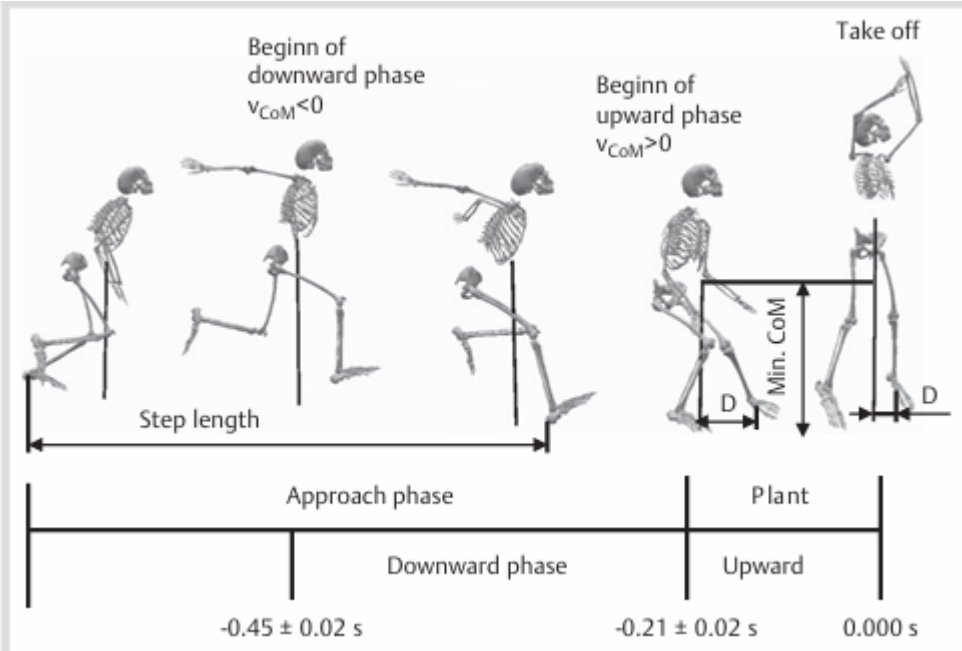

Figure 1. Three-Step Approach. From Wagner et al. 2009

Typically, right-handed players start their approach by a step with the left foot, followed by the right foot, and then planting their left foot with force before jumping. The heel of the foot is the first point of contact, which bends the ankle slightly with minimum knee flexion during take off (Chappell et al., 2007). As the players progress forward, the ankle bends in an upward motion, leading to the toes pushing off the floor, which causes the ankle to move down. (Yu et al., 2006) While the muscles and ligaments in the lower leg stabilize the ankle and prevent injuries. When a player takes off from a three-step approach, common movements consist of knee flexion and hip extension. (Mohammad Amoli et al., 2021). The arms also swing upward and are brought to a bow and arrow (right hand pulls back to ear and left hand guides the right to the ball out in front) in order to further enhance the lift and prepare for the swing.

Lower Body Anatomy

The hip is made up of the pelvis, femur, and muscles. The hip is key for jumping in the three-step approach, particularly for generating power during take-off and preparing for the offensive attack (*Lower Limb Anatomy: Bones, Muscles, Nerves, Vessels | Kenhub*, n.d.). Hip extension and flexion both occur. Extension is a straightening out movement at the joint that leads to an increased angle in between two body parts. While flexion is a bending movement around the joint, a limb such as the knee that decreases the angle in between the bones of the limb from where they join (Taylor et al., 2018). The hip consists of several muscles, including the rectus femoris and hamstrings (biceps femoris, Semimembranosus, Semitendinosus) (*Lower Limb Anatomy: Bones, Muscles, Nerves, Vessels | Kenhub*, n.d.). The rectus femoris (on the front of the leg) is responsible for the extension of the knee, while the hamstrings (on the back of the leg) help bend the knee before taking off (Boden et al., 2013). In a three-step approach, the quadriceps contract as the steps in the approach are taken, and in the jump, they work to straighten out, producing the power. The hamstrings allow the knee to bend during the explosive step, allowing the player to take off, and then work to stabilize the knee during the landing (Mohammad Amoli et al., 2021).

The knee consists of the femur, tibia, patella, and other supporting ligaments. The crucial ligaments that make up the knee are the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and lateral collateral ligament (LCL) (Figure 2). All of these ligaments help support stability of the knee (Flandry, 2011). The ACL prevents the tibia from colliding with the femur, and the PCL holds the tibia from sliding back (Flandry, 2011). These two ligaments help prevent knee injuries by allowing the knee to rotate and move with better stability (Flandry, 2011). The MCL allows the knee to shift inwards, while the LCL prevents outward bending. Both ensure that the knee stays aligned. Three bones are critical to the anatomy of the knee, the femur, the tibia, and the patella. The femur is the largest bone in the body and connects the pelvis and the knee (Flandry, 2011). It allows key support for the muscle and ligaments during the three-step approach. The tibia, on the other hand, supports the weight during landing and maintains stability (*Lower Limb Anatomy: Bones, Muscles, Nerves, Vessels | Kenhub*, n.d.). The patella protects the knee joint and assists with knee extension (*Lower Limb Anatomy: Bones, Muscles, Nerves, Vessels | Kenhub*, n.d.).

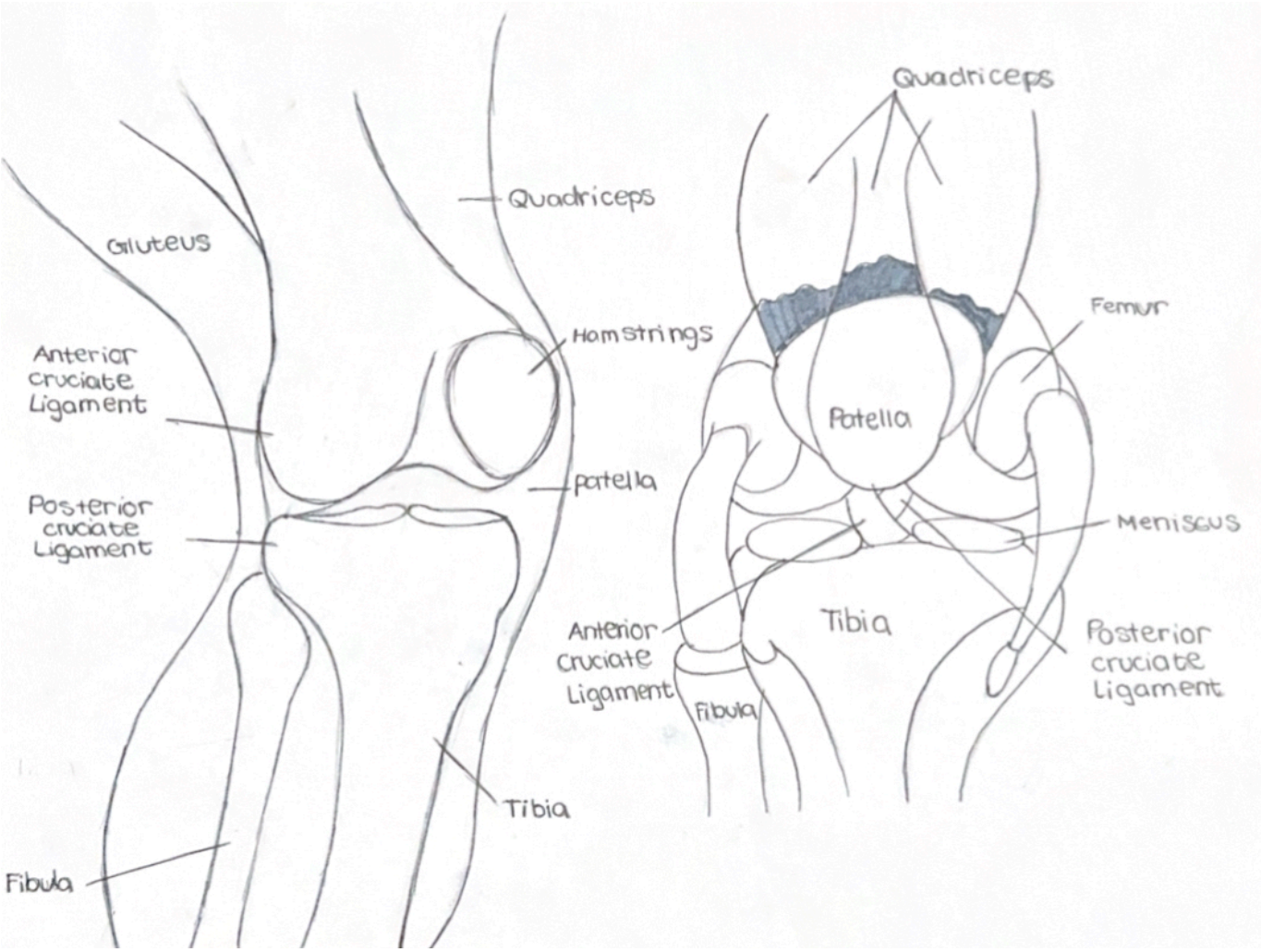

Figure 2. Knee Anatomy.

The ankle consists of the anterior talofibular and posterior talofibular ligaments. The anterior talofibular ligament is located on the outside of the ankle, and it keeps the ankle from inward rolling (Figure 3) (Brockett & Chapman, 2016). The posterior talofibular ligament is located in the outer section of the ankle, and helps stabilize the fibula and rest towards the back of the ankle. The ankle provides key stability to the body. Some bones that contribute to this are the tibia and fibula, which always bear an abundance of body weight, throughout . Performing the three-step approach leads to stretching the Achilles tendon and calf muscles, making them ready for the explosive upward jump (Gjinovci et al., 2017). The Achilles tendons allow a release of the stored energy, leading to an explosive jump. Once a player lands, the shock is absorbed by the ankle's ligaments and muscles.

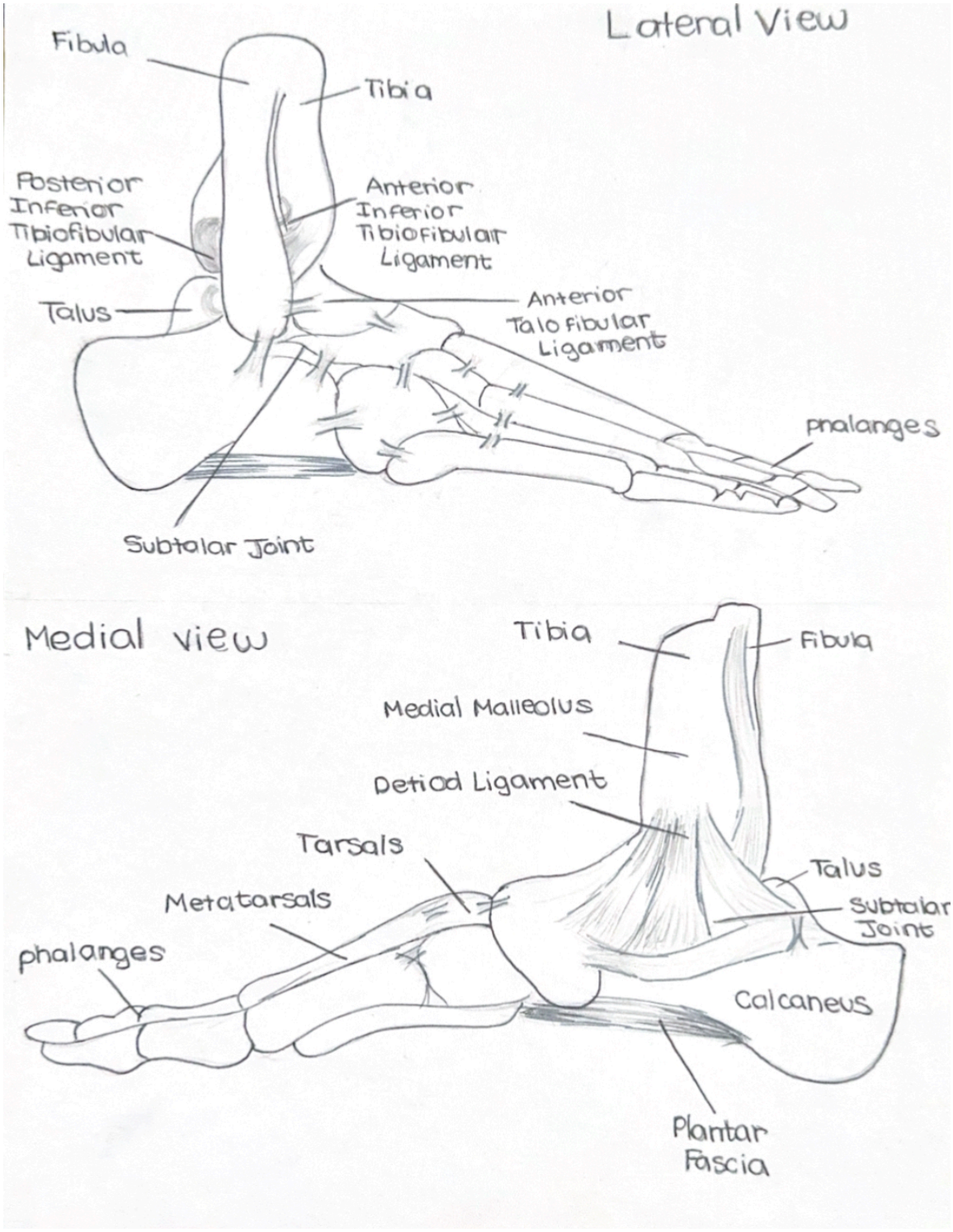

Figure 3. Ankle Anatomy.

Lower Body Injuries

Understanding the lower body anatomy can provide better analysis of injuries. Many injuries can be acquired during the offensive three-step approach. The most common ones are ACL tears, ankle sprains, patellar tendinitis, and hamstring strains (Kristianslund et al., 2011). Specifically, the ankle and knee contribute to about 60% of injuries in volleyball (Wasser et al., 2021). Non Contact injuries can be due to poor landing mechanics, sudden shifts in direction, and poor balance (Boden et al., 2013). Noncontact ACL injuries are likely caused by a combination of knee abduction, axial force, and ankle flexibility, mainly in female athletes (Boden et al., 2013). In addition, injuries are caused by things like knee movement, muscle force, and pressure on the joint, with female athletes being at higher risk due to factors like knee angle and hormones. These constant movements can weaken the knee overall. Non-contact injuries remain the most frequent, with player contact injuries making up only a quarter of competition injuries (Taylor et al., 2015).

Overuse injuries are often caused by repetitive movements. Overuse injuries are common in NCAA women's volleyball, especially in the shoulder, trunk, and lower extremities (Chandran et al., 2021). Changes in game rules that reduce player collisions may have led to more non-contact and overuse injuries (Chandran et al., 2021). A common injury is jumper's knee (patellar tendinitis), caused by repetitive jumping and landing forces. This injury is due to the patellar tendon getting inflamed. Additionally, in NCAA women's volleyball, the overall injury rate was 6.73 injuries per 1,000 athletes-exposed (Chandran et al., 2021). Most injuries were to the knee and ankle, with overuse and non-contact injuries being the most common causes.

There are two key types of movement relevant for leg injuries in volleyball, kinematics and kinetics . Kinematics is the body movement in speed, posture, and joint movement, while kinetics is force, loading, and impact (Kristianslund et al., 2011). A common mistake that leads to more absorption of force in the knees and ankles is lower hip flexion (Boden et al., 2013). Additionally, the landing force is absorbed by bigger muscles that are stronger; it can lead to less injury risk as for smaller weaker muscles that can have a higher injury risk.

Common recovery time for many overuse injuries is one to three weeks in their early stages, though the time can increase as the injury progresses. An inflammation in the patellar tendon also known as jumper's knee taking up to 6-12 weeks for full recovery. Some injuries, like ACL tears, are much more severe and can lead to a long medical process and a six to nine month recovery time.

Interventions for Proper Technique and Performance

For better player performance, injury prevention programs like taping, bracing, and warm-up routines to keep players safe (Chandran et al., 2021). Additionally, it is important to spread awareness and educate players on injury prevention programs. Current exercises, strength training and conditioning for ACL injury prevention do not represent how fast the players actually would need to move in a real-life game setting (Parsons & Alexander, 2012). These exercises could be improved by making them faster and more unpredictable to mimic

real-life. This would help the athletes improve their movement and decision-making skills, leading to them avoiding injuries. Choosing exercises, drills, stretches that can boost skill, challenge, and have a positive impact on players' confidence level, helping them improve skill and decrease injury risk.

Verbal and video feedback helps improve the landing of young highschool and college, female volleyball players (Parsons & Alexander, 2012). Video feedback caused overall better landing form and motions, such as bending the trunk and hips more (Parsons & Alexander, 2012). It Lasted about 4 weeks. The virtual feedback helps improve the prevention of ACL tears and other potential knee injuries. In a study of 19 female volleyball players, 10 received verbal and visual feedback while 9 control players did not. Over two to four weeks, the players that received feedback showed 50% greater hip flexion in the spike jump landing compared to the control group (Parsons & Alexander, 2012). Focusing on those movements can help reduce the possibility of injuries.

Fatigue is another factor that can increase the risk of knee injuries by affecting how the athlete moves. When athletes are tired, their jump-landing techniques might change, which could affect the patellar tendon (Vermeulen et al., 2023). A few studies show that after fatigue, athletes tend to land with less force, leading to protecting the patellar tendon (Vermeulen et al., 2023). Looking deeper, after fatigue, players showed increased flexion in the pelvis and trunk during the landing phase, with a reduction in hip and knee flexion (Vermeulen et al., 2023). The foot also landed in a more plantar-flexed position. The hip worked more when landing and less when pushing off, while the knee showed the opposite (Vermeulen et al., 2023). Patellar tendon forces decreased in the fatigue exercise; the tendon had less stress. Depending on the player, different strategies were used to protect the patellar tendon when fatigued (Vermeulen et al., 2023). Reducing knee movement but working their hip and trunk more to absorb the impact.

Young athletes are more likely to get injured because their bones and muscles are still developing. They may not have enough strength, flexibility, or control over their movements, which makes them more prone to injury.Neuromuscular training, including resistance exercises (lunges, squats, etc.), could help reduce injury rates, especially for players around 15 years old, who were most likely to be injured (Owoeye et al., 2018). Around 6-weeks of neuromuscular training 2-6 times per week, can properly show biomechanical change in players (Taylor et al., 2018).

Conclusion

Injuries that occur in NCAA women's volleyball, that are particularly to the lower body, are most often non-contact and overuse mechanisms, repetitive (Jumper's Knee), from movements like the three-step approach. These movements consisting of jumping, landing, and the sudden shifts on court, put stress on the hips, knees, and ankles. This leads to an increasing risk of ACL tears, ankle sprains, and patellar tendinitis. In these, injuries are most common in young athletes. However, when looking at interventions such as, neuromuscular training, proper warm-ups, and real-time verbal or video feedback. It can significantly reduce injury risk. Training programs that reflect game-like speed and unpredictability. It is key to educate and refine

technique in players. This can play a critical role in the prevention of long-term injury and short term injuries. Overall improving the players performance. Understanding these biomechanical aspects, anatomy, and injury prevention strategies is crucial to ensuring the athletes safety and optimal play on the court. Coaches, trainers and other clinics should take in and implement these training stataries to enhance the players performance and lower injury rates in the lower body.

References

2003_Reeser.pdfpage32. (n.d.).

Boden, B. P., Sheehan, F. T., & Torg, J. S. (2013). *Non-contact ACL Injuries: Mechanisms and Risk Factors*.

Brockett, C. L., & Chapman, G. J. (2016). Biomechanics of the ankle. *Orthopaedics and Trauma*, *30*(3), 232–238. https://doi.org/10.1016/j.mporth.2016.04.015

Chandran, A., Morris, S. N., Lempke, L. B., Boltz, A. J., Robison, H. J., & Collins, C. L. (2021). Epidemiology of Injuries in National Collegiate Athletic Association Women's Volleyball: 2014–2015 Through 2018–2019. *Journal of Athletic Training*, *56*(7), 666–673. https://doi.org/10.4085/1062-6050-679-20

Chappell, J. D., Creighton, R. A., Giuliani, C., Yu, B., & Garrett, W. E. (2007). Kinematics and Electromyography of Landing Preparation in Vertical Stop-Jump: Risks for Noncontact Anterior Cruciate Ligament Injury. *The American Journal of Sports Medicine*, *35*(2), 235–241. https://doi.org/10.1177/0363546506294077

Flandry, F. (2011). *Normal Anatomy and Biomechanics of the Knee*. *19*(2).

Gjinovci, B., Idrizovic, K., Uljevic, O., & Sekulic, D. (2017). Plyometric Training Improves Sprinting, Jumping and Throwing Capacities of High Level Female Volleyball Players Better Than Skill-Based Conditioning. *J Sports Sci Med*, *16*, 527–535.

Kristianslund, E., Bahr, R., & Krosshaug, T. (2011). Kinematics and kinetics of an accidental

lateral ankle sprain. *Journal of Biomechanics*, *44*(14), 2576–2578. https://doi.org/10.1016/j.jbiomech.2011.07.014

Lower limb anatomy: Bones, muscles, nerves, vessels | Kenhub. (n.d.). Retrieved June 1, 2025, from https://www.kenhub.com/en/library/anatomy/lower-extremity-anatomy

Mohammad Amoli, S., Aghaie Ataabadi, P., Letafatkar, A., Wilkerson, G. B., & Mansouri, M. B. (2021). *International Journal of Athletic Therapy and Training*, *26*(3), 161–166. https://doi.org/10.1123/ijatt.2020-0022

Owoeye, O. B. A., Palacios-Derflingher, L. M., & Emery, C. A. (2018). Prevention of Ankle Sprain Injuries in Youth Soccer and Basketball: Effectiveness of a Neuromuscular Training Program and Examining Risk Factors. *Clinical Journal of Sport Medicine*, *28*(4), 325–331. https://doi.org/10.1097/jsm.0000000000000462

Parsons, J. L., & Alexander, M. J. L. (2012). Modifying Spike Jump Landing Biomechanics in Female Adolescent Volleyball Athletes Using Video and Verbal Feedback. *Journal of Strength and Conditioning Research*, *26*(4), 1076–1084. https://doi.org/10.1519/jsc.0b013e31822e5876

Taylor, J. B., Ford, K. R., Schmitz, R. J., Ross, S. E., Ackerman, T. A., & Shultz, S. J. (2018). Sport-specific biomechanical responses to an ACL injury prevention programme: A randomised controlled trial. *Journal of Sports Sciences*, *36*(21), 2492–2501. https://doi.org/10.1080/02640414.2018.1465723

Taylor, J. B., Waxman, J. P., Richter, S. J., & Shultz, S. J. (2015). Evaluation of the effectiveness of anterior cruciate ligament injury prevention programme training components: A systematic review and meta-analysis. *British Journal of Sports Medicine*, *49*(2), 79–87. https://doi.org/10.1136/bjsports-2013-092358

Vermeulen, S., De Bleecker, C., Spanhove, V., Segers, V., Willems, T., Roosen, P., Vanrenterghem, J., & De Ridder, R. (2023). The effect of fatigue on spike jump biomechanics in view of patellar tendon loading in volleyball. *Scandinavian Journal of Medicine & Science in Sports*, *33*(11), 2208–2218. https://doi.org/10.1111/sms.14458

Wagner, H., Tilp, M., Duvillard, S. P. V., & Mueller, E. (2009). Kinematic Analysis of Volleyball Spike Jump. *International Journal of Sports Medicine*, *30*(10), 760–765. https://doi.org/10.1055/s-0029-1224177

Wasser, J. G., Tripp, B., Bruner, M. L., Bailey, D. R., Leitz, R. S., Zaremski, J. L., & Vincent, H. K. (2021). Volleyball-related injuries in adolescent female players: An initial report. *The Physician and Sportsmedicine*, *49*(3), 323–330. https://doi.org/10.1080/00913847.2020.1826284

Yu, B., Lin, C.-F., & Garrett, W. E. (2006). Lower extremity biomechanics during the landing of a stop-jump task. *Clinical Biomechanics*, *21*(3), 297–305. https://doi.org/10.1016/j.clinbiomech.2005.11.003