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A Comparative Analysis of Men's and Women's Sports with Respect to Types of Injury, Anatomy and Physiology, and Care and Prevention

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Abstract

Although studies have been performed to retrieve information about sports-related injury incidence patterns observed in high school and collegiate athletes, little research has been done to investigate the causes of the injuries that occur. This study analyzes five sports (tennis, baseball/softball, soccer, basketball, and football) to explore the connections between the sport-specific motions of each of these sports and the most common injuries that correlate in frequency with the sport. While this research answers the question of why certain athletes are prone to the injuries that correspond with their sport, it also examines care and prevention strategies with the goal of lowering the number of sports-related injuries in the United States. After reviewing numerous studies performed by injury surveillance programs, in addition to different methodologies involving care and prevention techniques, it is clear that not enough focus is being placed on training athletes properly in order to avoid injury. Therefore, this study calls for the necessary implementation of injury prevention programs into an athlete's daily regimen that are uniquely suited for each sport being performed in order to improve strength, flexibility, and balance. Ultimately, this will simultaneously teach and reinforce the proper technique needed to perform for the highest and safest level of play.

Introduction

An alarming trend has been developing throughout the United States’ youth, as the number of sport-related injuries has been on the rise at a disconcerting rate. In the 2005-06 school year, the number of sports related injuries among high school athletes occurred at a rate of about 2.4 injuries per 1,000 student athlete exposures (Comstock, Knox, Yard, & Gilchrest, 2006). While this may seem insignificant, the severity of the issue arises when the findings of this study are compared to a repeated study that recorded the rate of injury to be 6.0 per 1,000 exposures, from 2009-10 to 2013-14 (Kerr et al., 2015). Therefore, in less than ten years, the rate of injury nearly tripled, which shows a desperate need for investigation into the matter. Furthermore, the American Academy of Orthopedic Surgeons (AAOS) reported that out of the thirty million children participating in organized sports, over three million have ended up with sports-related injuries, resulting in about one-third of all adolescent injuries occurring as a result of athletic activity (Chandra, Dunn, & Paul, 2008). Although it is essential, especially at this point in time in American history with obesity rates at an all-time high, to encourage healthy eating and activity habits, which often incorporates participation in organized sports, it is also critical to introduce proper training techniques to help minimize the risk of injury.

While there are many factors that contribute to the increase in the number of sports-related injuries, one of the crucial reasons is due to improper training techniques that begin at a young age. Improper training at a young age can then, consequently, lead to an acute injury, which may progress into a chronic, recurring injury at a later point in development. Add improper technique and mechanics to a practice and game schedule that is greatly too involved for a child who is still developing and, as one can imagine, the result is injury. These early poor training techniques and their resulting injuries can, in turn, help to explain the increase in sports-related injuries that are seen in collegiate athletes, who are supposed to be in the best physical shape in order to perform at the highest level. Regardless of the proper care these athletes receive from athletic trainers and staff, these highly skilled collegiate athletes are still prone to injury if their fundamentals were poor when they first started playing their sport. This is clearly evident in statistics that show during a five-year span, between 2009-2014, 1,053,370 injuries occurred at the collegiate level during an estimated 176.7 million student-athlete exposures, resulting in an average of 210,764 injuries per year, with 134,498 (63.8%) occurring during practices," (Kerr, et al., 2015). Not only do these numbers illustrate the issue at hand, but the study also introduces another alarming fact, that the majority of injuries occur in the practice setting rather than during competitive play. This is problematic because practices are supposed to result in a lower injury rate, as players should be utilizing proper techniques in a controlled, less intense setting compared to that of games. Ultimately, the troubling statistics defined by numerous studies, observing athletes of all different ages, suggest that greater care and prevention techniques need to be introduced to athletes at a young age and then continuously enforced.

Regardless of technique, however, it is a fact that some athletes are more prone to injury because of a unique anatomy that may not be as compatible for the physiological demands required by the sport being played. This is especially true when comparing the anatomy of a female athlete to that of a male athlete playing similar sports. For instance, because of numerous anatomical, hormonal, neuromuscular, and biomechanical differences, women are eight to ten times more likely to suffer knee injuries (Haley, 2001) as compared to a similar male athlete. This increase in probability of injury for a female athlete can be attributed to two main anatomical differences: typically loose ligaments and a natural valgus knee position, in which a female's knees are inherently pointed inward. This distinct anatomical stature often then contributes to improper body mechanics, especially in the landing process of a female athlete, as much less force is absorbed by a woman's knee because it flexes about fifteen degrees less than a man's knee when landing a jump (Haley, 2001). This difference in degree of flexion of the joint creates an immense pounding force on the female joints. Ultimately, because of a natural imbalance in strength between the quadriceps and hamstring muscles, with the quadriceps proving to be dominant, women do not slow down, stop or land as well as men, who are more hamstring dependent, which helps to absorb the force of deceleration better, and therefore aids in the preservation of the ligaments (Osborne, 2012). Furthermore, because of the valgus positioning of the legs, the female knee naturally buckles inward when landing, which only antagonizes the fact that the female trunk tends to be tilted laterally, or to the side, causing the center of the female's body mass to be outside the base of the body's support that stems from the lower extremities. Lastly, because the female body is not able to absorb as much shock of the force of landing, injury usually results when the majority, if not all, of the female's body weight is on only one leg, which often times is hyperextended, or completely straight, at the time of injury (Osborne, 2012). Therefore, because of these innate female tendencies, it is especially important to reinforce appropriate care and prevention techniques that not only help to identify the candidates with a higher risk of injury based on how they move or land, but also that help to teach proper mechanisms to train for laxity and proprioception, as these strategies will help to compensate for the differing female anatomy.

Nevertheless, whether an athlete is male or female, the key to eliminating the risk of injury is to focus on the mechanics of the body's kinetic chain, which is a unifying effect of forces from one part of the body that radiates to neighboring joints and muscles (Dines, et al., 2015). The forces of muscles linked by the kinetic chain start at the feet and travel upwards along the lower extremities, through the knees and hips, into the core, which includes the trunk and back, and finally upwards into the upper extremities, consisting of the shoulder, elbow, and wrist. Therefore, because each part of the body is connected through the kinetic chain, if there is a breakdown that occurs anywhere throughout the chain, injury can result not only at the point of the cessation, but also anywhere in the body where the force is shared. This is especially true of the lower extremities, which serve as the essential foundation of the human body's forces. Although this may seem like a disadvantage, for injury can ultimately affect the entire body's functioning, proper utilization of the kinetic chain can actually enhance an athlete's performance. For instance, if the entire body's kinetic chain is used to generate power, not only will more strength and force be created, but injury will also be less prevalent because not one individual body part will be overly stressed. Therefore, rather than only focusing on the conditioning of certain parts of the body, it is imperative to strengthen the entire body as a whole, in equal proportions, so that the kinetic chain remains balanced and can be applied in the correct fashion.

When accounting for all of these factors, with the number of sports-related injuries on the rise between the youth and collegiate populations, the question remains:

why are athletes prone to the specific injuries that occur at a high frequency in their corresponding sport? By reviewing the importance of balanced anatomical structures, in addition to analyzing the physiological demands of the sport being played, it is possible to explore why certain types of injuries can be significantly attributed to the sport being performed at the time of injury. By understanding the risk factors associated with this phenomenon, the ability to minimize the number of injuries, and therefore time off of the playing field for the athletes affected, will greatly improve, as knowledge of innovative care and prevention techniques will become more commonplace.

Tennis

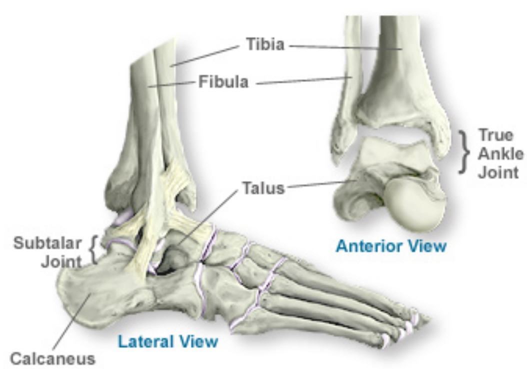
Tennis provides a prime example of how physical demands of a sport can largely contribute to the sport-specific injuries associated with the corresponding biomechanics. With both the upper and lower extremities being affected, tennis puts a high amount of stress on the body that can lead to musculoskeletal adaptions to help handle the demands of the sport. These alterations, however, create great muscular imbalances that can often lead to injury, especially in the four main problem areas of the tennis player's body: the shoulder, elbow, lower back/hip, and ankle. Ultimately, "Although injuries seen in tennis are common to other sports, its year-round nature, combined with the different surfaces on which it is played, equipment used, and biomechanics, leads to a unique spectrum of injuries," (Dines, et al., 2015). Nevertheless, while there are many factors that contribute to the injury rate of tennis, the main aspect that will provide the most insight in terms of researching why such injuries occur is the element of biomechanics, which is the study of the mechanical laws relating to the movement or structure of living organisms.

The Ankle Joint

Tennis is a unique sport in terms of injury, as both the upper and lower extremities are faced with immense loads of stress that are often too heavy for the body to bear. Starting at the base of the kinetic chain, which is an important dynamic to remember when examining the sport-specific injuries associated with tennis, is the ankle. Unbeknownst to many, the ankle is actually comprised of two joints: the subtalar joint, which is essentially located at the back of the foot, and the more recognized, true ankle joint. This joint consists of three bones: the tibia, which is one of the two leg bones that makes up the inside (medial side) of the ankle, the fibula, which is the other leg bone that forms the outside (lateral) part of the ankle, and the talus, which serves as the base of the ankle joint on the bottom of the foot. The last key component of the ankle is the calcaneus bone, which pairs with the talus to form the subtalar joint. While these bones compose the overall structure of the ankle, it is the ligaments that connect these bones that have the important job of holding everything in place. Therefore, when the ankle is injured, the ligaments are usually the physical structures that are damaged. The major ligaments of the ankle include the anterior tibiofibular ligament, which connects the tibia and fibula, the lateral collateral ligaments, which connect the fibula to the calcaneus and provides lateral stability, and the deltoid ligaments, which link the tibia to the talus and calcaneus, providing medial stability. As it is evident that the ankle is a uniquely structured joint, with many components that are all connected to each other, it is no wonder that any little "roll" of the ankle will definitely be a cause for injury.

Figure 1 ("Anatomy of the Ankle," n.d.)

Figure 2 ("Nucleus," n.d.)



Common Tennis Injuries of the Ankle

In terms of tennis, the ankle is the most common joint to get injured, which makes sense as this joint absorbs the most amount of stress if the theory of the kinetic chain, which balances forces, is not utilized correctly. This is common, as these imbalances occur throughout the body, with the ankle paying the price in terms of having to compensate for the strong stressing forces. Because of this, inversion ankle sprains, in which the joint "slips" inwardly, are the most common. With this type of injury, the lateral collateral ligaments are the most affected, as they become over-stretched from the trauma. The unbalanced force that results from bodily adaptations that try to help absorb such strong forces is too much for the lower extremity to bear. When an athlete describes their ankle as rolling or giving out, they are referring to an inversion ankle sprain, during which the foot turns inward quickly, or, in some severe cases, completely rolls under the joint. The latter situation is common in landing injuries, where the athlete jumps up and comes down, but the force that is generated during the jump accelerates downward, greatly stressing the joint. In terms of severity, there are three types of ankle sprains: grade one, grade two, and grade three. A grade-one ankle sprain results in minimal damage done to the ligaments, and is the least problematic. With a grade two-ankle sprain, there is an increased amount of ligament damage and a mild laxity, or looseness, of the joint. Finally, with a grade-three ankle sprain, which is the worst type an athlete can face, there is complete tearing of the ligaments and, consequently, extreme laxity. This is because with the ligaments completely torn, there are no structures to help hold the joint in place. Therefore, with a grade-three ankle sprain, the joint is totally unstable and will need to be surgically repaired.

Care and Prevention of Ankle Injuries

The grade of the ankle sprain, which ultimately represents the severity of the damage, not only describes the pathology of the injury, but also determines how to treat the injury. For grade one and two ankle sprains, surgery is not usually needed because the tendons are not torn. Instead, there is a three-phase recovery program that is the standard protocol for healing of the ankle. The first phase consists of rest, ice, compression, and elevation (RICE), which is the standard procedure for the healing of any acute injury. The ultimate goal of RICE is to eliminate swelling, which will then allow for the introduction of physical therapy practices, including stretching and strengthening. Physical therapy, however, is the third phase of the recovery etiquette. Once the swelling has gone down, phase two is introduced: immobilization. The process of immobilization includes bracing and taping. Therefore, rather than actually completely immobilizing the joint, the braces and taping techniques utilized are primarily stabilization procedures that help the athlete when he/she returns to play or begins physical therapy. Ultimately, bracing and taping are not only "care" procedures, but also "prevention" strategies used to ensure that the joint is properly stabilized and does not become reinjured. While many athletes utilize taping techniques, it has been found that a brace provides better support because it does not lose its rigidity during play. Taping, however, has been found to lose up to 50% of its mechanical strength after 20 minutes of activity (Dines, et al., 2015). Therefore, in addition to proper bracing, an athlete should complete phase three of the recovery program, which can also act as a prevention program for all athletes, whether they have been injured or not, as it enforces proper stretching and proprioceptive training techniques. While proprioceptive training, which teaches how to control the position of the joint, focuses on balance and strength, stretching helps to maintain a proper range of motion for the joint. In terms of recovery, peroneal muscle strengthening should also be put into place to help properly stabilize the joint, as the peroneal muscles are the chief dynamic stabilizing units of the ankle during activity (Dines, et al., 2015). Following all of these care and prevention techniques, which ultimately enforce the stabilization of the ankle, will help to keep athletes on the field and away from injury.

The Lumbar Spine and Hip Joint

When travelling upwards throughout the kinetic chain, the next "problem area" associated with tennis is the hip, which often results in injury in conjunction with the lower back, for the bones of the hip and lumbar spine (lower back) work together to support the body's weight. With the hip being the second largest weight bearing joint and the lumbar vertebrae supporting the most weight out of the entire vertebral column, it is essential to properly maintain the health of these structures. While the lumbar spine consists of five bones, cushioned by cartilaginous discs and held together by ligaments forming facet joints that allow the body to bend, the hip joint is a ball and socket joint between the pelvis and femur (thigh bone) that allows for complete, circular motion of the leg. The head of the femur, which is the largest bone in the body, serves as the ball that fits into the acetabulum, which is the rounded socket of the pelvis. The stability of this joint is not only created by the concrete fit of the ball and socket, but is also provided by the cartilage, ligaments, and muscles of the hip. One of the key components of the hip that helps to provide structural stability is the labrum, which is a circular layer of cartilage that lines the outside of the socket to help provide stability by deepening the cup shape of the acetabulum. In addition to the actual lumbar spine and hip components, the leg muscles also prove to be vital in the proper functioning of these structures. The important muscles include, but are not limited to, the gluteals, located in the buttocks, the quadriceps, which are located on the front of the femur, the hamstrings, which are located at the back of the femur, the iliopsoas, which serves as the primary hip flexor, and the groin muscles, which are located on the inside of the leg and serve in adduction. The injury of any of these anatomical structures proves to be a double-edged sword. Just like tightness in these leg muscles can limit range of motion and cause pain in the hip or lower back, this phenomenon can also occur vice versa; injury to the lower back or hip can cause pain not only in these two areas of the body, but also limit function of the major muscles. Therefore, for the maintenance of health for the entire lower extremity, it is necessary to properly stretch and strengthen the features of the lumbar spine and hip.

Figure 3 ("Leg Muscle Anatomy," n.d.)

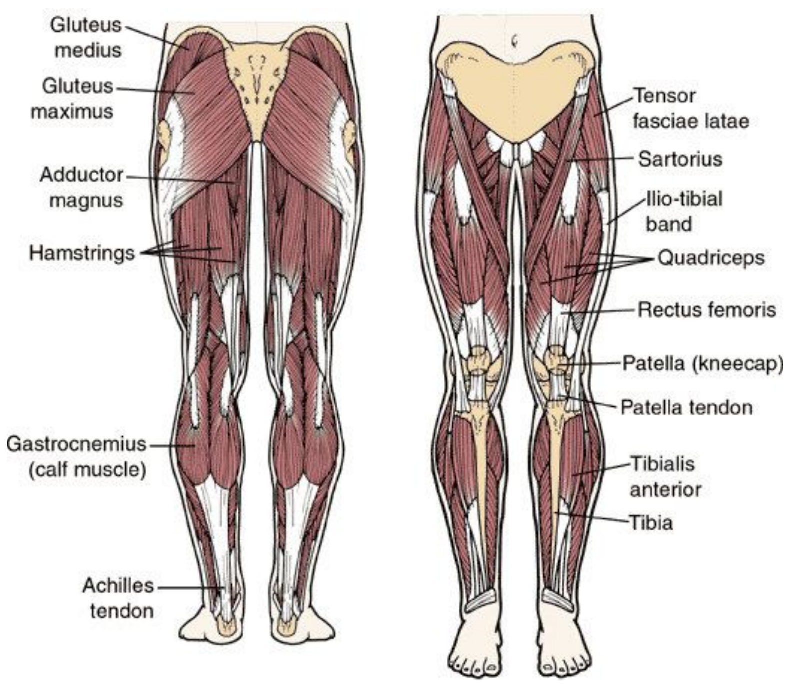


Figure 5 (Eidelson, 2012)

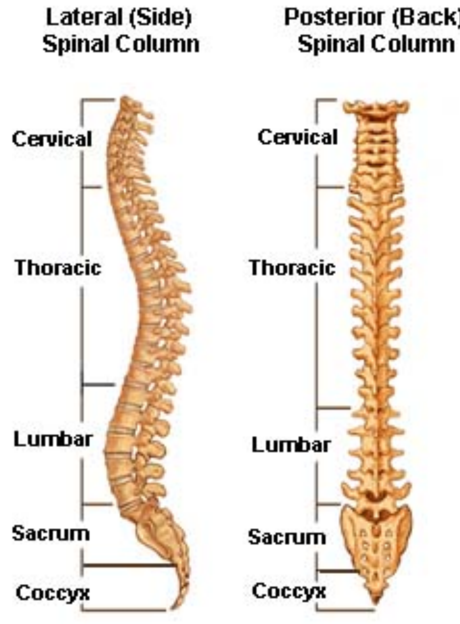


Figure 4 (Eidelson, 2012)

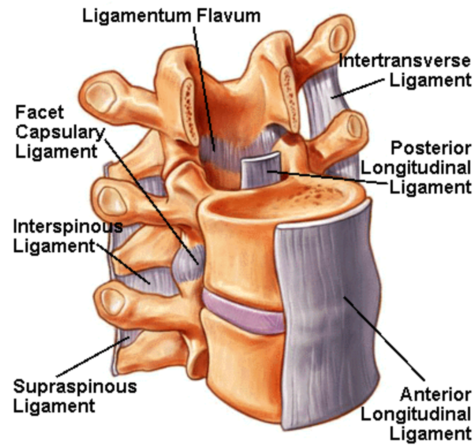


Figure 6 (Eidelson, 2012)

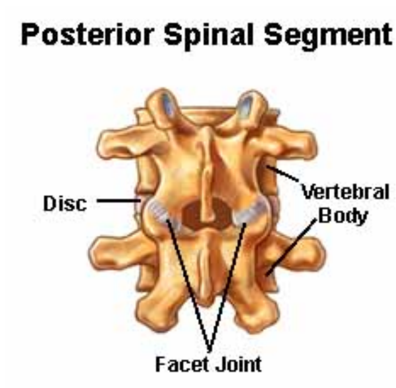
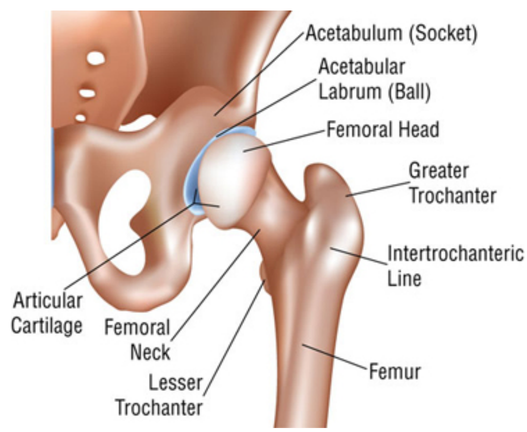


Figure 7 ("Hip Anatomy," n.d.)



Tennis-Related Injury of the Lumbar Spine

Nevertheless, one of the most common tennis-related injuries is acute lumbar strain. Dr. Joshua Dines and associates from the prestigious Hospital for Special Surgery in New York City report that 38% of 143 tennis players had missed tournaments because of severe lower back pain, with 43 players reporting chronic back pain and 11 of 38 players (29% of the study's population) battling acute injury to the lumbosacral spine (Dines et al., 2015). The lower back is such a prone area to injury because of the constant axial rotation of the spine, in addition to the flexion and extension movements that are required in the sport of tennis, involved in the process of striking the ball. A large amount of stress is put on the lower back, especially during the loading phase of the serve, where the player's back sharply arches and cocks backwards to create a large amount of torque that is necessary to generate power in the serve. Consequently, an immense amount of strain is placed on the lumbar spine, which is the lowest section of the back. In some cases, the pressure can be so extreme, that spondylolysis and spondylolisthesis, which are two types of fractures of vertebrae (segmented bones of the spine), can result. Furthermore, "The repetitive rotational forces applied to the lumbar spine, especially when coupled with hyperextension, place the lumbar disk at an increased risk for annular tears, (Dines et al., 2015). If these "annular tears," do in fact, keep reoccurring, extreme degeneration of the spine can result, in which the vertebrae are continuously pounded by the immense loads of stress, so much so that eventually, the disks in between the vertebrae, which serve as shock absorbers, completely diminish and become nonexistent. When this happens, there is nothing between the vertebrae to keep the bones from hitting against one another, which results in extreme pain and instability. Therefore, surgery is needed to introduce a technical mechanism that mimics the effects of a disk. Ultimately, the stresses placed on the lumbar section of the back that are in existence because of the nature of the sport are extremely detrimental to the wellbeing of an athlete.

Common Tennis-Related Injury of the Hip

In addition to possibly needing repair, there are other consequences of lower back injury in tennis that affect another key problem area of the tennis player's body: the hip. While lumbar strain limits the degree of flexion of the spine because of inflammation and paraspinal muscle tightness, the hamstring muscles also become tight, which greatly limits the range of motion of the hip joint. During a tennis match, which includes an athlete running, jumping, and twisting, the hip joint may experience forces up to five times the body weight of the athlete, which puts the joint at a dangerous risk of injury (Dines et al., 2015). Such injury usually results from loading (during the serve), multidirectional movements throughout the tennis court, and abrupt stopping, cutting, and twisting (Ellenbecker, Pluim, Vivier, & Sniteman, 2009). These movements not only place stress on the joint directly, but also stress the muscles around the hip joint (i.e. the tensor fascia latae, sartorius, gluteus muscles, and the quadriceps and hamstring muscles), resulting in muscle strain that not only negatively affects the hip, but also the knee. Furthermore, the tendons and ligaments around the joint become inflamed, which can result in tendonitis, or, if severe, a labral tear. The labrum is the ring of cartilage on the socket of the hip joint that helps to stabilize the joint. Because tennis consists of constant twisting motions to hit the ball, athletes are at a great risk of labral tears, which often need to be surgically repaired through the sewing of the tear.

Care and Prevention of Lower Back and Hip Injuries

In order to avoid surgery, however, proper care and prevention techniques for the hip and back, which often include similar exercises, should be introduced into the athlete's daily regimen. Because both of these anatomical structures are utilized for rotation, which is a constant motion in the sport of tennis, the primary focus of training is core stability. As Ellenbecker and associates describe in their tennis-specific strength and conditioning program, "Emphasis on both the flexors and extensors must be given to ensure that balanced extensor and flexor muscular development occurs as well as an emphasis on rotational exercise due to the predominance of trunk rotation inherent in all tennis strokes," (Ellenbecker, Pluim, Vivier, & Sniteman, 2009). While there are many exercises that can reinforce the strengthening of these muscles groups, the "lunge with rotation" exercise seems to be the most beneficial because of its specificity to the sport of tennis. In addition to introducing proper balance and posture, the lunge with rotation also imitates the common angles and movements displayed during tennis strokes (Ellenbecker, Pluim, Vivier, & Sniteman, 2009). While this movement incorporates the strengthening of the back and hip simultaneously, more hip specific exercises used in both, care and prevention regimens, include exercises, like leg lifts, that reinforce hip abduction strength, and exercises that help to improve the internal and external rotation strength of the hip joint. These hip exercises, in addition to the core stability training and lumbar flexion/extension isometrics, will all help to improve the overall health of the tennis player, as the hip and back are the primary structures used in the sport of tennis because of the constant rotational movements used to hit the ball.

The Shoulder Joint

Not only do the biomechanics of a tennis player inflict injury on the lower extremities, but the upper extremities are also often impaired. However, unlike the lower extremity injuries, which are usually acute in nature, injuries involving the upper extremities are typically classified as overuse injuries, which are sport-specific injuries that result from constant, repetitive motions. The two joints that are mostly afflicted by the overhead motion of the serve and repetitive hitting motions of the forehand and backhand strokes are the shoulder and elbow. Like the hip, the shoulder is also a ball and socket joint that is composed of three bones: the humerus, which is the large upper arm bone whose head serves as the ball, the scapula (shoulder blade), and the clavicle (collar bone). The head of the humerus sits in the socket located on the end of the scapula to form the glenohumeral joint, which like the hip, is deepened by the labrum. Unlike the rigidity of the hip joint, however, the glenohumeral joint is the most mobile joint in the body. The movement of the shoulder is a combination of the mechanics of this main joint, in addition to two other joints: the sternoclavicular and acromioclavicular joint, which incorporates the clavicle and scapula. Each of these joints is stabilized by ligaments and tendons, in addition to the four main muscles that surround the joint: the supraspinatus, infraspinatus, subscapularis, and teres minor, which make up the rotator cuff. Other muscles, like the rhomboids, deltoids, and trapezius muscles, are also important components that contribute to stabilization (of the scapula) and movement functionality. Because the shoulder is comprised of delicately intricate pieces, it is important to maintain a balanced strengthening of each of the muscles around the joint.

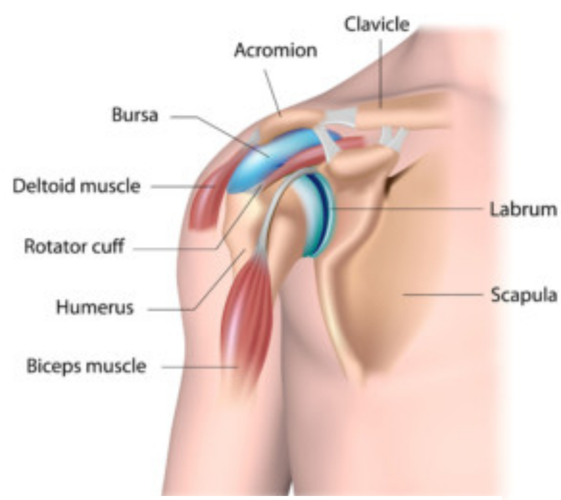


Figure 8 (Verma, n.d.)

Tennis-Related Injury of the Shoulder

In terms of the shoulder anatomy, the rotator cuff, labrum, and biceps tendon are the three structures that face the most deficit from the physical demands of the game. Because over 75% of the modern game of tennis consists of forehand hits and serves, which require strong concentric internal shoulder rotation for the generation of power, it is not shocking that there is often great muscular imbalance between the external rotators, which make up the posterior (backside) rotator cuff, and the internal rotators, which are collectively known as the anterior (front side) rotator cuff (Ellenbecker, Pluim, Vivier, & Sniteman, 2009). Not only is this imbalance detrimental to the health of the rotator cuff, which stabilizes the glenohumeral joint, but it is also harmful in the fact that an imbalance between the internal and external rotator muscles of the shoulder can lead to internal impingement, which is "the mechanical abutment of the articular side of the posterior supraspinatus and anterior infraspinatus tendon against the posterosuperior aspect of the glenoid rim and labrum," (Dines et al., 2015). In other words, the structures of the glenohumeral (ball-and-socket shoulder) joint rub against the cup of the socket, which is lined by the labrum (cartilage), and essentially get caught in an uncomfortable "pinching" position. This is problematic not only because of the pain it causes, but also because the constant rubbing of the tendons against the labrum can cause a labrum tear, or in some cases, complete degeneration of the cartilage.

Care for and Prevention of Shoulder Injuries

Ultimately, concentric muscle contractions, which shorten the fibers of the muscles, are important in the overhead serve of tennis, as the internal rotators accelerate the upper arm from an externally positioned arm to ball impact. Similarly, eccentric (lengthening) contractions are just as important, as the external rotators decelerate the arm in the follow-through phase of the serve and therefore stabilize the shoulder joint (Saccol et al., 2010). Therefore, it is clear that both the internal and external rotators should be equally strong because they are, as previously described, equally important in the serving demands of tennis. Nonetheless, it has been found in numerous studies that tennis players, like overhead throwing athletes including baseball and softball players, display much greater internal rotation strength compared to external, which creates hypermobility (movement beyond the normal range of motion) and laxity, or looseness, of the joint. This occurrence is usually because of the internal impingement syndrome, described in the previous paragraph, where abduction (movement of the arm away from the body) and external (lateral) rotation of the joint are painful motions. Therefore, the main goal of care and prevention protocol for the shoulder is to help stabilize the glenohumeral joint through rotator cuff strengthening and scapula stabilization, which ultimately helps to set the joint in place without any hypermobility. However, even though strengthening is priority, exercises must be performed at moderate intensity, with neutral arm positioning that does not reinforce the impingement of the joint or firing of the major back muscles, like the deltoids, that alter the functioning of the smaller, joint-specific (rotator cuff) shoulder muscles (Ellenbecker, Pluim, Vivier, & Sniteman, 2009). Therefore, the ultimate goal for the training of the shoulder joint is to decrease laxity by strengthening the rotator cuff muscles and further stabilizing the scapula muscles, without further strengthening the larger deltoid muscles, which often actually pull down on the scapula.

The Elbow Joint

The last body part that is most affected by the sport-specific demands of tennis is the elbow, which is a complex hinge joint formed by the distal (lower) end of the humerus, which is separated into a medial and lateral epicondyle (protuberance), and the proximal (upper) ends of the two forearm bones, the ulna and radius. Because the elbow is a hinge joint, that means the only motions allowed are flexion and extension of the joint. In addition, there is rotation of the radius just below the distal humerus. Therefore, the ligaments around the joint play a major role in strictly stabilizing the joint and forearm, protecting these bones from dislocating at their insertion points. Nevertheless, despite the forces that these ligaments can withstand, because so many muscles attach at the elbow, it proves to be a common site of injury.

Figure 9

(Klein, 2008)

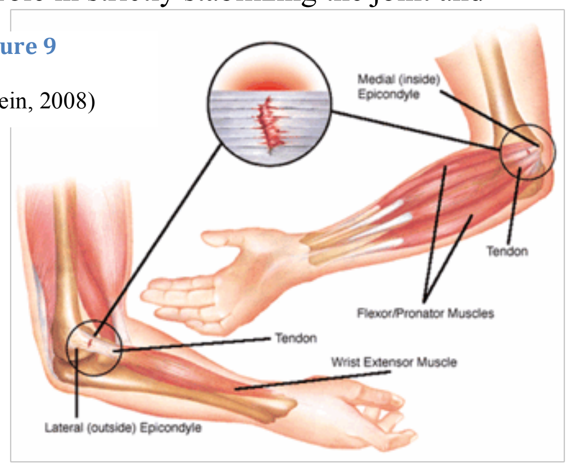


Figure 10 ("Medial Epicondylitis," 2011)

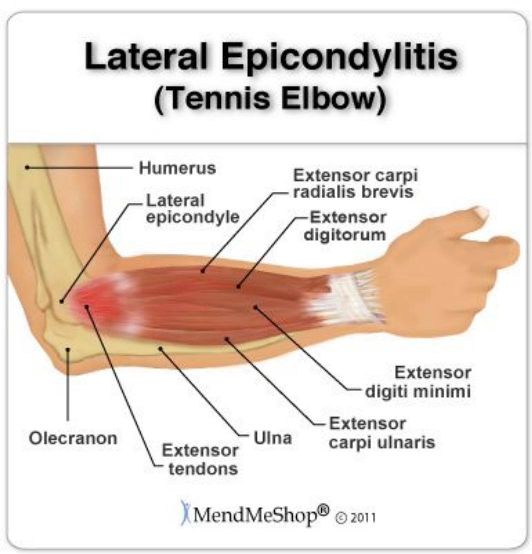


Figure 11 ("Lateral Epicondylitis," 2011)

Tennis-Related Injury of the Elbow

One of the most common tennis-related injuries, which, as its name suggests, is "tennis elbow." While tennis elbow is the term that is universally accepted, the real title of this injury is lateral epicondylitis. Lateral epicondylitis is inflammation of the tendons attached to the epicondyle, which is the round protuberance of the of the joint that serves as a place of attachment for tendons, ligaments, and muscles. Therefore, because the elbow has two protuberances, there are two types of epicondylitis: medial and lateral. Medial epicondylitis, otherwise known as "golfer's elbow," which creates pain on the inside of the elbow, results from stress on the flexor tendons (specifically the pronator teres, flexor carpi radialis, flexor carpi ulnaris, flexor digitorum superficialis, and palmaris longus tendons) that insert at the medial humeral (upper-arm) epicondyle. Similarly, lateral epicondylitis creates discomfort on the outside of the elbow, and is a result of stress on the extensor tendons of the forearm (specifically the extensor carpi radialis brevis) that attach to the lateral humeral epicondyle. Ultimately, the stresses that are put on these two structures are caused by improper biomechanics that only utilize the forearm and wrist to generate power when striking the ball, rather than using the entire body, and therefore kinetic chain, to create a total force that is much greater than one simply generated by the arm (Ellenbecker, Pluim, Vivier, & Sniteman, 2009). Interestingly, however, regardless of the same origin of stress, there is a discrepancy in ability between athletes who experience medial and lateral epicondylitis, with the latter being the most common. Based on a study performed by Ellenbecker and associates, it was found that more elite tennis players experienced medial epicondylitis because of their overload of stress during the serve and forehand stroke, which is congruent to the internal shoulder strength being more dominant, and recreational players experiencing more cases of lateral epicondylitis because of the overload of stress they endure during backhand strokes. One hypothesis for this phenomenon is that the elite players do not utilize backhand strokes as often as recreational players because of their advanced speed and agility that allows them to travel to the spot of the ball in time to perform a forehand stroke, rather than having to reach and resort to a backhand stroke. Nonetheless, regardless of the athletic level of the tennis player, "tennis elbow" proves to be a common injury that athletes face, with up to 57% of the tennis population reporting this elbow injury.

Care for and Prevention of Elbow Injuries

Because of the high frequency, it is clear that a proper care and prevention program needs to be implemented into a tennis player's training routine. In order to prevent cases of tennis elbow, it is important to increase the strength and muscular endurance of the wrist and forearm muscles through the following exercises: flexor and extensor wrist curls, that help to promote a balanced strengthening of the tiny wrist muscles, and ulnar and radial curls, during which the arm pronates (palm faces down) and supinates (palm faces up). These last two movements will help to strengthen the forearm muscles, which will ultimately eliminate the injury of tennis elbow by alleviating the burden of stress placed on the joint. Therefore, strengthening of the entire upper-extremity kinetic chain is necessary for the care and prevention of tennis elbow, as this will help to absorb the loads of force endured during the sport of tennis (Dines, et al., 2015). This will not only help to prevent injury, but if injury has already occurred, these exercises, in addition to icing and stretching, will help to alleviate the pain and ultimately diminish the severity of the condition.

Conclusion

Because of the high amounts of stress that the sport-specific movements of tennis put on the body, it is clear that proper care and prevention techniques need to be utilized throughout the entire body, for not just one major area is affected by these forces. As stated before, the best way to be efficient, especially to generate power in the sport of tennis, is to make use of the kinetic chain to the athlete's advantage, making sure to use all parts of the body instead of straining one major muscle group. While the base of the kinetic chain is fundamentally the ankle, each type of movement that utilizes any body part located higher on the kinetic chain must also use the remaining parts of the body to help balance the immense forces faced when playing tennis. Therefore, it is essential to locate strength imbalances found throughout the tennis player's body in order to improve the overall output of the athlete. Once these problem areas are located, a proper tennis-specific care and prevention protocol can be put into place, that focuses on improving the absorbance of forces, balance, and agility training to help prepare the athlete for the exhaustion he/she will face during a match. Ultimately, not only will implementing a strengthening program help to improve the athlete's play, but it will also help to limit the probability of injury.

Baseball and Softball

While baseball and softball share many similarities, there are significant differences that result in differences of common injuries. While baseball is most commonly played by males and softball most commonly played by females, each sport has its own specific techniques. Therefore, it is necessary to consider, both, the differences in technique and anatomy when discussing the most common injuries. Similar to the stress that tennis players face during a serve, in which the arm is in an overhead, unnatural position, baseball and softball players also have to endure the immense forces that travel through the arm. These stresses through the arm often result in injury to the shoulder or elbow. Ultimately, baseball and softball players greatly utilize their upper extremities in sport-specific ways and put a large amount of force through their glenohumeral (shoulder) joint when their arm is in an overhead position. This overhead position of the glenohumeral joint is unnatural and unstable, which leads to injury. Furthermore, most of these upper extremity injuries are classified as "gradually progressive overuse injuries," and result from the repetitive motion of the overhand throw that every position in baseball and softball utilizes. With this being said, however, it is clear that baseball pitchers are at the highest risk for injury, since they use this shoulder position the most often and with the hardest intensity, compared to other positions. In fact, out of a total of 1,623 NCAA baseball injuries over a sixteen-year span, 972 injuries (59.5%) were attributed to throwing, with 709 (73%) of those throwing injuries occurring during pitching (Dick, Sauers, Agel, & Keuter, 2007). This phenomenon is not only observed in baseball pitchers, however, for the windmill style pitch of a softball player also greatly stresses the shoulder. A study performed during the 1996 Olympics found that the degree of shoulder distraction stress of elite softball pitchers (50% to 149%) was comparable to that observed in baseball pitchers (83% to 139%), which indicates that both pitching positions incur a similar amount of shoulder stress (Marshall, Hamstra-Wright, Dick, Grove, & Agel, 2007). Therefore, while it is commonly thought that the windmill pitching motion puts less stress on the shoulder than the overhead throw of a baseball pitcher, it is clear that that is not the case. In actuality, softball players seem to be at an even greater risk of overall injury than baseball players, for not only are upper-extremity injuries predominant in softball players, but a lower extremity injury is also common: anterior cruciate ligament (ACL) tears. This is not surprising, for the reasons female athletes are more prone to ACL injuries than their male counterparts has been described in the introduction. As will be discussed, when dealing with a male baseball player or female softball player, it is crucial for proper care and prevention techniques to be implemented into these athletes' daily regimen in order to limit the risk of injury they face, whether it be to the most common problem areas of the shoulder and elbow, or to the knee of the lower extremity.

Common Baseball-Related Upper Extremity Injuries

Baseball players are at a great risk for, both shoulder and elbow injury. Because the shoulder is in an unnatural, and therefore unstable position, when the arm is overhead, it is not surprising that about 45% of all game and practice injuries are to the upper extremity, with shoulder injuries accounting for the bulk of the severe injuries (Dick, Sauers, Agel, & Keuter, 2007). Furthermore, in the same sixteen-year study of collegiate baseball players that attributed throwing as the major cause of injury, it was found that a player was twice as likely to sustain a shoulder strain and three times as likely to endure an acute elbow injury in a game than in practice (Dick, Sauers, Agel, & Keuter, 2007). The specific injuries of the shoulder include muscle or tendon strains, usually resulting in tendinitis, which is inflammation caused by irritation of the tendon, labral tears, and ligament sprains, which can create an array of lesser rotator cuff issues that, if not treated, can worsen and result in a rotator cuff tear. Acute injuries of the elbow also include muscle, tendon, and ligament sprains or tears, in addition to contusions, which are bone bruises that occur when the tissue around the joint has become inflamed from overuse or trauma. It was also observed that these types of injuries were more prevalent during games than during practices (Dick, Sauers, Agel, & Keuter, 2007). This increased rate of these specific injuries during games makes sense, as pitchers, who are at the highest risk for upper extremity injury, tend to throw harder in a game and use adrenaline to fight through any pain they may face in order to finish their contest. While this can be dangerous because the adrenaline masks the onset of pain from injury and can lead to a worse injury, the more troubling phenomenon is that the practice injury rate is highest during the preseason. This observation suggests that proper throwing progression programs, in which the distance and velocity of throws are gradually increased through incremental intervals, are not being implemented. While the rate of injury was three times higher in games (5.78 per 1,000) than in practices (1.78 per 1,000), it was found that the preseason injury rate was double that of in-season practices, which implies a need for proper conditioning and training progressions (Dick, Sauers, Agel, & Keuter, 2007). This is especially true for throwing because pitchers often rush into trying to build up their endurance and power during the preseason without taking the necessary precautions, which usually results in an acute or overuse injury from an overload of stress on the shoulder and elbow joints by the time the season begins. Ultimately, with baseball being a predominantly upper-extremity sport, it is essential for players, especially pitchers, to preserve their arms as much as possible through the proper use of care and prevention techniques to help avoid injury.

Common Softball-Related Injuries

Interestingly, while softball players also face the risk of injuring their shoulder, the threat of elbow injury is not as imminent as in baseball players. Instead, softball players have a greater potential of injuring their knee, in addition to their shoulder. In fact, the risk of injury to the lower extremity (42%) is higher than that of the upper extremity (33%), which is opposite that of baseball, where the risk of injury to the upper extremity is greater than to the lower extremity. Furthermore, while knee internal derangement, which is a collective term used to describe any disturbance to the knee joint including a torn meniscus, loose bodies in the knee, and damaged ligaments, was the most frequent injury during games (22.6%) and practices (15%), shoulder tendinitis only accounted for 5.5% of severe injuries during practice (Marshall, Hamstra-Wright, Dick, Grove, & Agel, 2007). Ultimately, softball players are at the greatest risk of enduring acute injury to their knee, with the second most problematic area being the shoulder, which is at risk of an overuse injury rather than an acute injury.

The Knee Joint

Before analyzing the biomechanics of a softball player's knee, it is necessary to examine the anatomy of the joint in order to understand the sport-specific factors that antagonize the components of the knee. The knee is the largest joint in the body that bears the most weight, which also makes it one of the easiest joints to injure. Like the elbow, the knee is a hinge joint that is comprised of bones, cartilage, ligaments, and tendons. The four bones that are connected by four ligaments are the femur, tibia, fibula, and patella, which is the kneecap. The four ligaments include two major types of ligaments: collateral ligaments, which are found on the sides of the knee, and the cruciate ligaments, which cross each other inside the joint to form an "X." While the collateral ligaments, which include the lateral collateral ligament (LCL) and medial collateral ligament (MCL), stabilize the knee and control the sideways motion of the joint, the cruciate ligaments, which include the anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL), control the back and forth, hinge motion of the knee. In addition to ligaments, there are also tendons and cartilage that help to hold the components of the joint together. The tendons, which connect the bones to the major muscles of the knee, include the quadriceps tendon that connects the quadriceps (muscles at the front of the thigh) to the patella and the patellar tendon that connects the patella to the tibia. While these tendons and ligaments play a major role in coordinating the function of the bones and muscles of the knee, the cartilage is also important, as it serves as the shock absorber of the knee. The most important piece of cartilage in the knee is the meniscus, which is composed of two pieces of meniscal cartilage that is wedged in the

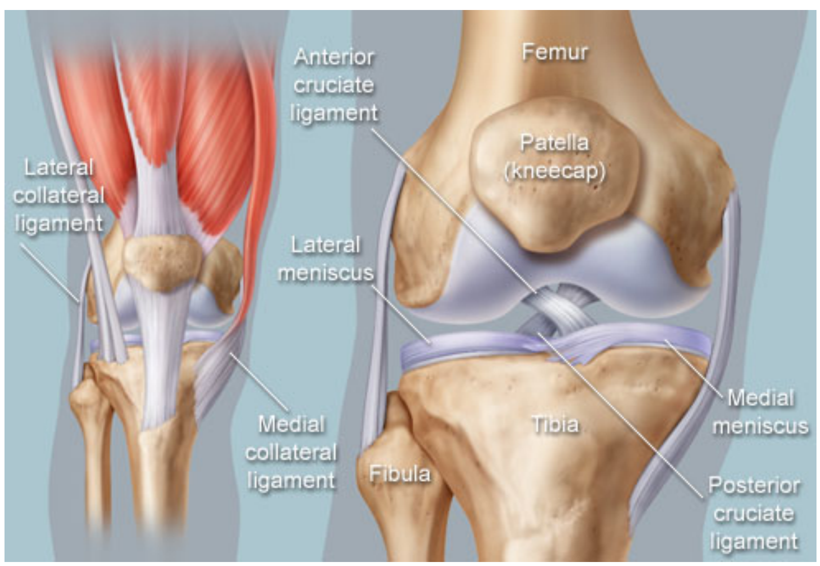


Figure 12 ("Picture of the Knee," 2014)

middle of the joint between the femur and tibia. Because this important structure of the knee absorbs the large forces that the knee joint endures, it often diminishes through wear and tear. Furthermore, acute injuries to other pieces of the knee can also result in damage to the meniscus, as each component of the knee is connected and held together. Ultimately, injury to any part of the knee often involves more than one structure, making an injury to the knee one of the most detrimental.

Common Softball-Related Injury of the Knee

As previously stated, the most imminent threat to a softball player is knee internal derangement, which is a collective term for damage to the structures of the knee with primary focus on the meniscus and ligaments. With this being said, one of the most common injuries in softball is an ACL tear, which is consistent with the observation that women are more prone to this injury than men, due to the anatomical differences previously described. Furthermore, many of the movements in softball fit into the type of motion that highly correlates with ACL damage, for "noncontact ACL injury often is associated with a planted foot and deceleration, resulting in a valgus (displacement away from the midline) knee position due to a combination of motions and rotations at the hip, knee, and ankle that potentially include hip adduction and internal rotation, knee abduction, tibial external rotation and anterior translation, and ankle eversion," (Marshall, Hamstra-Wright, Dick, Grove, & Agel, 2007). This type of rotational motion of the knee is common in both the fielding and hitting aspects of softball. When a player throws, their front leg strides forward, plants, and then the entire body rotates about the axis of this planted leg, which puts immense loads of stress on the knee. During hitting, the front leg also strides and plants, while the back leg quickly rotates as the hips open up towards the ball during the contact phase of the swing where the bat meets the ball. Furthermore, base running can also prove to be harmful, for the base runner abruptly decelerates after running through a base. The predominance of ACL injury in softball was examined in a sixteen-year study of NCAA athletes, which found that out of the 8.7% of game injuries to the knee, 34% of these injuries were ACL tears (Marshall, Hamstra-Wright, Dick, Grove, & Agel, 2007). Therefore, in addition to a proper throwing progression program to help alleviate the stress on the shoulder of baseball and softball players, an ACL prevention program should also be introduced to softball players, for the unique female anatomy and sport-specific motions of softball are risk factors for injury to the knee.

Care for and Prevention of Injuries to the Upper Extremities

Nevertheless, for both, baseball and softball, it is especially crucial to take the necessary precautions to preserve the body's health because of the frequency of overuse injuries associated with each sport's specific motions. This means that it is essential to reinforce proper throwing mechanics through the implementation of a gradually increasing throwing progression as a warm-up before activity. Because "research suggests that sport-specific preseason conditioning is important in reducing the incidence of injury during the regular season," it is necessary to train the body progressively, rather than sharply (Marshall, Hamstra-Wright, Dick, Grove, & Agel, 2007). This progression should include position-specific interval training, which is a specialized workout that incorporates functional drills to enhance the necessary skills related to each individual position on the field. This type of workout is especially important for pitchers where the focus is shoulder preservation. Therefore, proper strengthening of the shoulder is necessary to improve the joint's range of motion and flexibility, which will help to compensate for the stress placed on the joint during the overhead throw. A beneficial way of performing this type of training is through the use of therapy resistance bands because they mimic the opposing force that the body endures during the throwing motion. The four motions that should be practiced using the therapy bands include abduction, adduction, and internal and external rotation, for these are the typical motions of the shoulder performed during an overhand throw. Regardless of the type of upper extremity training, however, the most important piece to the regimen is rest. Without proper rest, the constant, repetitive overhead motion of the shoulder during throwing will inevitably result in an overuse injury.

Care for and Prevention of Injuries to the Knee

In addition to a care and prevention protocol for the shoulder, softball players also need to be introduced to ACL prevention training to lower the risk of injury to the knee. Specifically, neuromuscular training needs to be performed to help correct the innate valgus knee position of the female, where the knees are naturally turned inward, which places an unbalanced force on the knee that not only causes stress, but can greatly damage the internal structure of the joint. Ultimately, neuromuscular training that applies plyometrics, balance, and strengthening exercises will help to stabilize the knee and overcome these negative anatomical positions that the female naturally endures. Because foot planting and decelerating are the two movements associated with ACL injury, it is important to introduce exercises that will help to alleviate the stresses these motions place on the anterior ligament of the knee. Plyometrics, which is a form of "jump training," successfully does this by reinforcing proper planting techniques mimicked in the landing of the jump. Plyometric exercises are those in which muscles exert maximum force in short intervals of time, with the goal of increasing power. In doing so, the muscles that are strengthened through exertion of maximum force during short intervals of time, including the quadriceps and hamstrings, are better trained to handle the forces faced during deceleration, which alleviates the burden of the ACL absorbing these forces.

Conclusion

Regardless of the anatomical gender of the athlete, it is necessary for baseball and softball players to follow the above-mentioned protocols in order to avoid injury, due to the stresses during the unnatural, overhead motion of the overhand throw. Because this unique throwing motion exhibits horizontal abduction and external rotation of the shoulder, which greatly stretches the ligaments that stabilize the joint, it is important to strengthen the rotator cuff components of the shoulder through the previously described band work. Furthermore, because of the rotational movements performed in every aspect of baseball and softball, it would also be beneficial to implement a neuromuscular training program that focuses on balancing and plyometric strength. This additional regimen is especially important for female softball players, as they are at a greater risk of lower extremity injury, in addition to upper extremity damage. It is without question that these two types of care and prevention protocols are needed in the baseball and softball player’s routine because of the statistical data that correlates the sport-specific motions of the sport with injury rates.

Soccer

Although women are, in general, eight to ten times more likely to suffer knee injuries than men because of the anatomical, hormonal, neuromuscular, and biomechanical differences described in the introduction, the gender of the athlete is not as significant when studying soccer-related injuries, for both males and females face issues involving the knee. The female soccer player, however, is still at a greater risk of knee injury. Because of the constant stop and go nature of the sport, both men and women are at an elevated risk of injury to the knee, with anterior cruciate ligament (ACL) tears proving to be the prominent injury. While there are between 100,000 and 200,000 ACL ruptures, which are acute explosive disturbances (tears), per year in the United States, these detrimental injuries can often be prevented through appropriate training techniques that emphasize the importance of proper biomechanical technique when running and landing (Osborne, 2012). Balance training that reinforces the absorption of forces through the entire body’s kinetic chain is also crucial for endurance athletes. Endurance athletes are those that utilize the aerobic system of the body, which requires oxygen, to withstand the hardship that longevity of a sporting event employs. A prime example of an endurance athlete is a soccer player because these athletes run above average, cumulative distances during game-play and practices. A consequence of this high intensity participation is that soccer players tend to suffer from anterior and lateral knee pain. This type of pain is usually associated with the cruciate ligaments of the knee and can often be attributed to a tight patellar tendon of the knee or iliotibial (IT) band, which runs from the hip to the knee, that tugs on the knee cap, applying a strong opposing force on the joint. This phenomenon can often be due to a biomechanical technique flaw, in addition to muscle imbalance, that stems from other parts of the body like the foot/ankle or the hip/lumbar-pelvic region ("Prevention and Treatment," 2014). Therefore, the proper utilization of the kinetic chain once again proves to be important in the avoidance of injury. Especially in a high demand sport like soccer, where planting, cutting, and stopping suddenly and quickly changing directions are motions characteristic of the sport, it is necessary to implement an agility program that reinforces proper landing techniques through plyometric exercise and improves core strength, which will help to maximize use of the body's kinetic chain. This will ultimately lower the injury rate that is predominated by ACL tears.

The ACL in the Knee

To review, the knee is composed of bones, ligaments, tendons, and cartilage, which are all structurally significant to the proper functional movement allowed by the joint. While cartilage cushions the bones of the knee, including the femur, tibia, and fibula, the ligaments connect each of the bones and provide support for the joint so that the components stay intact and function properly, without too much laxity (looseness). The four ligaments of the knee are categorized into two types: the collateral ligaments, which are located on the sides of the knee to stabilize the joint medially and laterally, and the cruciate ligaments, which are located in the middle and back of the actual joint to provide stability and limit the amount of movement of the joint forwards and backwards. In other words, the cruciate ligaments, which include the posterior cruciate ligament (PCL) and anterior cruciate ligament (ACL) prevent hyperextension and forward slipping of the knee, respectively. The ACL, which runs diagonally in the middle of the knee, proves to be the ligament most prone to damage in the sport of soccer because of the constant cutting, pivoting, and stop-and-go nature of the sport, which greatly stresses the ACL. Because the ACL “provides stability for the knee by limiting the amount of forward translation of the tibia (lower leg bone) on the femur (upper leg bone)”, it is highly strained when an athlete decelerates from running full speed, as this motion inherently causes the knee joint to pull back while the leg stays forward (Osborne, 2012). The purpose of the ACL is to limit this slipping motion, but after repeated stresses, which accumulate throughout a soccer player’s career, the ligament can become so stressed, resulting in micro tears, that it ultimately gives out and completely tears/ruptures.

Men vs. Women

Even though the sport-specific motions of soccer greatly stress the ACL in both men and women, it has been confirmed that ACL injuries occur with a four to six-fold greater incidence rate in females than in males (Osborne, 2012). While many of the anatomical and physiological differences between the male’s and female’s body were discussed in the introduction, it is important to reiterate some of the main contributing factors that predispose the female body to knee injury, compared to the male’s body. Some of the main causes include anatomy, hormones, landing technique, proprioception ability, which is the sense of the body and limbs, and muscle strength. First and foremost, the natural valgus position of the knee in the female’s body, in which the knee buckles inward, is a major anatomical flaw in terms of being predisposed to knee injury because of the stress the anatomical position imposes on the knee joint. Not only this, but the valgus knee position also causes the center of body mass to be outside the base of the body’s foot support, which therefore throws off the entire linkage of the kinetic chain. Secondly, it is thought by some doctors that women are more prone to ACL injury than men because of the higher amount of estrogen and relaxin hormones circulating throughout the body, which increases the flexibility (laxity) of the ligaments, causing the joint to become unstable (Osborne, 2012). Furthermore, in terms of landing technique, which is greatly related to the female's proprioceptive consciousness, the female knee does not absorb the shock force as well as the male joint because it does not flex as much to absorb these powerful forces. As stated in the introduction, while males flex their knees to about 30 degrees when they land, and then bounce back up with ease, females only flex their knees to about 15 degrees and abruptly come back up (Haley, 2001). This phenomenon greatly corresponds with the female muscle strength imbalance between the quadriceps and hamstring muscles. While female athletes tend to use their quadriceps muscle to slow down from sprinting, which causes knee instability, a male athlete usually decelerates using the hamstring muscle, which better absorbs the force from the change in speed (Osborne, 2012). This seemingly trivial difference proves to be quite significant, for the dependence on the hamstrings rather than quadriceps helps to protect the ligaments of the knee, and therefore minimizes the risk of an ACL tear. Ultimately, because of the female athlete's innate anatomical and physiological discrepancies, they face a much more imminent danger of injuring their knee, especially the ACL, than their male counterpart athletes.

Care and Prevention

Because of this inherent risk of knee injury for females, the prevention aspect of training is especially important. Nevertheless, care for and prevention of knee injuries for both male and female soccer players are vital for the preservation of the ligaments in the knee, which face immense stress forces from the constant agility-type nature of the sport of soccer. In terms of prevention, "running gait analysis is a key ingredient to identify biomechanics of the athlete," in addition to an evaluation of their body position when they land (Adams, 2014). If the knee drastically buckles inward at any point during these two observations, showing looseness in the joint and wobbling of the leg because of an instability, the athlete is at a very high risk of damaging their knee, with the ACL being the primary focus point. Therefore, in order to reduce the risk of injury, it is important to implement training drills, which improve balance, power, and agility, to the soccer player's practice regimen. These drills should include plyometric exercises, like jumping, to teach and re-enforce proper landing techniques in which the knee stays parallel with the foot and does not slide forward past the toe, and balance drills to help improve the strength and stability of the joint (Osborne, 2012). These two types of activities will greatly help to lessen the risk of ACL injury. Ultimately, there needs to be more of a focus on functional strength training. However, the implemented training needs to be manageable, for often times athletes who are already suffering from overuse due to the repetitive nature of their sport usually attain an injury when they add an overload of strength training to their regimen. If injury does occur, the focus of rehabilitation should be improvement in range of motion/flexibility, through a structured stretching routine, and strengthening of the quadriceps and hamstrings, for these are the muscles that influence the forces that the knee endures. Once the athlete has rehabilitated their knee to the point of return to functional exercise, education of proper running and jumping techniques should be taught based on the knowledge of correct biomechanics so that re-injury does not occur.

Conclusion

Regardless of the gender of the athlete, the constant, stop-and-go nature of the sport of soccer proves to highly contribute to knee injury, especially in terms of ACL tears. Because many players, especially female athletes, are at a higher risk of ACL injury because of their anatomical and physiological alterations that disrupt the performance of proper biomechanics, it is important to screen for the previously mentioned "red flags" that predispose an athlete to potential injury. If caught early enough, these improper habits can be eliminated and replaced by techniques that re-enforce the correct body position and absorbance of forces when performing at a high level. Therefore, because soccer is such a high-intensity agility sport, in which athletes are constantly accelerating, decelerating, and cutting/changing directions, it is necessary to implement training regimens that focus on the preservation of the knee through strengthening of the hip and leg muscles, in addition to plyometric exercise that re-enforces the proper positioning of the knee when running and jumping. If done properly, the risk of injury of the ACL for soccer players can greatly decrease, which is the ultimate goal of prevention techniques.

Basketball

Similar to the phenomenon observed in soccer, in which female athletes are more prone to knee injury than their male counterparts, female basketball players are also more prone to injury because of the altered anatomical and physiological mechanisms previously described in the introduction and soccer chapters. In basketball, however, the focal point of injury is the ankle, which is crucial to the functioning of the body in athletic participation because of its location at the base of the kinetic chain. To review, the kinetic chain is a unifying effect of forces from one part of the body that radiates to neighboring joints and muscles (Dines, et al., 2015). The forces of muscles linked by the kinetic chain start at the feet and travel upwards. Therefore, because the ankle is the first joint along the forces created by the kinetic chain, injury to this crucial part of the body can create disturbances throughout the body. In particular, the joints of the lower body, including the knee and hip joints, are most vulnerable to injury due to problems in the ankle. Injuries to the lower extremities comprise about 60% of all basketball-related injuries, with ankle sprains being the most predominant, followed by knee internal derangement (Dick, Hertel, Agel, Grossman, & Marshall, 2007). Thus, it is imperative to implement proper care and prevention techniques that help to mitigate the effect of the basketball-specific, physiological stresses on the ankle. This type of intervention, that strengthens the base of the kinetic chain through proper training, will not only help to reduce the number of ankle sprains that basketball players endure but will also help to lower the overall injury rate. The net consequence will be that the other joints and muscles of the body, especially in the lower extremity, will be stronger and at less of a risk of injury, for they will not have to compensate for the breakdown of the kinetic chain occurring at the ankle. Ultimately, because of the key role that the ankle serves in the kinetic chain, it is necessary to reinforce proper care and prevention techniques into the basketball player's daily training regimen to lower the incidence of injury to this joint, which will also help to decrease overall injury rate.

The Anatomy of an Ankle Sprain

As stated, ankle sprains are the leading injury of the 60% of basketball-related injuries to the lower extremity. Most ankle injuries result from player to player contact, with the majority of ankle sprains being a consequence of a player landing from a jump on another player's foot, causing the ankle to roll (Dick, Hertel, Agel, Grossman, & Marshall, 2007). To review, this rolling of the ankle, in which the joint is said to "slip," is really a result of trauma to the ligaments of the ankle. The major ligaments of the ankle include the tibiofibular ligament, which connects the tibia to the fibula (the lower leg bones), the lateral collateral ligaments, which connect the fibula to the calcaneus to provide lateral stability, and the deltoid ligaments, which link the tibia to the talus and calcaneus, providing medial stability. When a basketball player lands on another player's foot and the landing player's foot rolls underneath the ankle or leg, this is classified as an inversion ankle sprain. In this type of sprain, the lateral collateral ligaments are the most affected, as they abruptly stretch, or in severe cases tear. The three ligaments that comprise the lateral collateral ligament complex include the anterior talofibular ligament, which connects the fibula to the lateral talus, the calcaneofibular ligament, which connects the fibula to the talus, and the posterior talofibular ligament, which links the fibula to the posterior talus. While these ligaments are more commonly injured than the medial (deltoid) ligaments of the ankle, the ligament that proves to be the most affected by inversion ankle sprains is the anterior talofibular ligament, located on the front, top of the foot. Because of its location, it is logical that this ligament would be the most stressed as a result of the foot rolling underneath the ankle, as it is the only lateral collateral ligament that is linked to the foot.

Men’s Basketball

In a 16-year study conducted by the National Collegiate Athletic Association (NCAA) Injury Surveillance System (ISS), injury reports were analyzed to study trends in frequency and type of injury to help better identify methods of injury prevention. The overall results showed that 4,211 injuries occurred in over 45,000 games, while 7,833 injuries occurred during 140,000 reported practices. The NCAA ISS reported that the majority of the injuries sustained were classified as soft tissue injuries to the lower extremity, specifically the ankle, which makes sense because of the sport-specific motions of basketball, including sprinting, changing direction, lateral movement, jumping, and most importantly, landing (Dick, Hertel, Agel, Grossman, & Marshall, 2007). While the injury data gathered could be attributed to the characteristics of the sport of basketball, there was a discovered trend that did not present itself with a positive correlation. Alarmingly, preseason practice injury rates were about three times higher than in-season practice injury rates (Dick, Hertel, Agel, Grossman, & Marshall, 2007). This statistic presents a major issue in regards to care and prevention, for the increased rate of injury in the preseason can be attributed to improper maintenance of health resulting from inadequate preventative and preparation techniques. In other words, because of the lack of a preseason-training program that consists of specific exercises to help prevent injury, most injuries occur in the preseason, as the body is faced with immense stress that it has not been trained to withstand. Furthermore, over 90% of basketball players studied reported at least one ankle sprain endured, which is problematic as even one ankle sprain predisposes athletes to more frequent ankle sprains. Each time a sprain occurs, the ligaments of the ankle loosen. Therefore, if a number of ankle sprains are sustained, which results in severe laxity of the ligaments, a tear or rupture (complete detachment) of the ankle is probable. In fact, recurrent ankle sprains occur at a 75% incidence rate for all basketball players of different levels (Dick, Hertel, Agel, & Marshall, 2007). This rate communicates the great need for improved care and prevention techniques in the sport of basketball in order to prevent this specific type of injury. Because of such a high number of recurrent ankle injuries, it is critical to improve the care of the injury in order to fully heal the ligaments damaged. Furthermore, it is necessary to implement a prevention program that helps to strengthen the ankle joint through the stabilization of the ligaments.

Women's Basketball

In an identical 16-year study conducted by the NCAA ISS, injury occurrences among women's basketball players were similar to those observed among men's basketball players. While 3,556 injuries to female basketball players occurred in over 45,000 games and 6,665 injuries occurred during 134,000 reported practices in total, about sixty percent of all injuries were to the lower extremity, with ankle ligament sprains being the most prevalent (Agel, et al., 2007). Furthermore, as observed in men's basketball, most of these ankle sprains resulted from player-to-player contact. Specifically, most ankle injuries occurred when landing on another player, causing the ankle to roll. Furthermore, 30% of all ankle sprains were recurrent problems. The risk of re-injury displayed almost a 70% increase, which suggests there is a need for improved care and prevention measures to reduce the risk of recurrent ankle injuries. Also, it was found that women had a 25% greater risk of an ankle ligament sprain than men in the NCAA, which can be attributed to the differing anatomy and physiological processes previously described. For example, women absorb jumps less efficiently than men, and, coincidentally, about 45% of women's ankle injuries occurred during landing (Agel, et al., 2007). Therefore, women need to be introduced to proper preventative and rehabilitation training techniques that suit the specific vulnerabilities of their anatomy and help to correct the innate differences that alter the functioning of the body during participation in athletics.

Care and Prevention

Because it was discovered that preseason injury rates for both men's and women's basketball were the highest out of all observed time frames, there is a major need for improved care and prevention techniques. Clearly, the proper measures are not being taken to condition the players so that they will not only be prepared for games, but also so that injury is avoided. While other factors come into play, like deconditioning from the off-season, an increased intensity in the practice setting, and early season fatigue from lack of recovery due to year-round training, it is still important to try to compensate for these elements through a sport-specific training regimen that eases the athlete back into the full intensity of game play. Coaches need to be more aware of the dangers that these risks impose on their players in terms of injury and better prepare their athletes through proper stretching and warm-up regimens, in addition to strength, agility, and flexibility training. Additional preventative measures, like taping, bracing, and balance/neuromuscular training are also needed because of the increased physical demands of the sport as a result of a more contact-prone style of play that has evolved (Dick, Hertel, Agel, Grossman, & Marshall, 2007). Taping and bracing help to stabilize the ankle joint, while balance training enhances the neuromuscular efficiency and biomechanics of the athlete, which, in turn, reduces the rate of ankle sprains and other lower extremity injuries. This type of training is especially important for females, as their anatomic variations (e.g. below normal hamstrings-to-quadriceps strength ratio) and differing lower extremity biomechanical alignment (i.e. inversion/valgus position) predisposes female athletes to an increased risk for injury (Agel, et al., 2007). If a balance-training program is implemented to counteract these physiological discrepancies, functioning and utilization of the kinetic chain will improve. As a result, the rate of injury will decrease. Therefore, in order to lower the number of injuries observed in both men's and women's basketball, it is necessary to improve care and prevention measures through proper techniques that help to stabilize the ankle joint, which include taping/bracing and balance training that focuses on strength and proprioception.

Conclusion

Because of the increased intensity and amount of player-to-player contact that has become apparent throughout the evolution of the sport of basketball, injury has become a major concern for both male and female basketball players. Specifically, the ankle joint has been proven to be the most at risk for injury because of the predominance of agility in the sport-specific nature of basketball, in which jumping is a major aspect of the sport that leads to ankle injury. Because most of the ankle injuries observed in basketball occur during landing, which reveals a weakness in the athlete's ankle joint, it is crucial to implement care and prevention techniques that help to better stabilize the joint. In order to do so, balance training needs to be utilized to improve the overall function of the body through proper maintenance of the kinetic chain. If this type of training is paired with efficient taping and bracing techniques to further stabilize the ankle, the risk of injury will not be as imminent and overall injury will decrease. Ultimately, it is necessary to implement these preventative measures into the basketball player's training regimen in order to decrease the risk of injury to the ankle.

Football

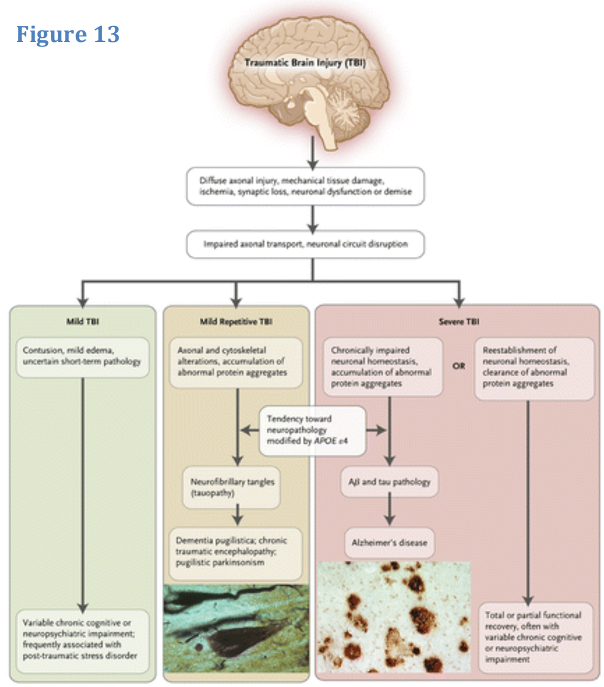
Compared to the other sports examined, football is unique in terms of the diversity of the sport-specific injuries related to the high intensity and violent nature of play. Football players do suffer from many of the common injuries of the upper and lower extremities that are observed in other sports; however, the predominant injury to football players that requires significant attention in terms of care and prevention is concussions. One of the main reasons that football has the highest concussion incidence rate each year is because of the large number of adolescent, high school, and college players that participate in the sport (McCrea et al., 2003). Furthermore, the Centers for Disease Control (CDC) has confirmed that the number of sports-related injuries occurring in adolescents is on the rise (Health & Medicine, 2015). This positively correlates with the increase in the amount of children participating in sports at young ages. With regard to football, children are at extreme risk for danger if a concussion is received because of the important stage of growth and development that the brain undergoes during this age. In fact, “between the ages of eight and 12, the brain undergoes a period of intense axonal growth and myelination,” (Schaffer, 2016). If this period of development is disrupted, the brain may never fully mature, which will lead to long-term impairment (Schaffer, 2016). The imminent risk of long-term consequences resulting from concussions has prompted more research to study the effects of taking repetitive hits to the head, which has greatly increased public awareness of the effects of traumatic brain injury.

The general awareness of the public to the issue of concussions also increased following the release of the movie, *Concussion,* which tells the story of how neuropathologist Bennet Omalu diagnosed a well-known professional football player with chronic traumatic encephalopathy (CTE), which is a severe degenerative disease of the brain. As a result, public pressure demanded that more action be taken in terms of rule changes and regulations to minimize the chances of repeated concussions. Football officials have already implemented rules to help limit hits to the head so that the number of concussions and other fatal, long-term illnesses that result from concussions decreases. For instance, players are no longer allowed to engage in helmet-to-helmet contact and the number of hours of full contact practice has been reduced. However, more preventative measures need to be taken because concussions still remain the predominant injury related to football (McCrea et al., 2003). Therefore, it is crucial for improved care and prevention techniques to be implemented into players' practice and recovery regimens in order to help mitigate the harmful effects concussions imprint on the brain and body's functioning.

Concussions and their Implications

The Centers for Disease Control and Prevention (CDC) defines a concussion as "a type of traumatic brain injury—or TBI—caused by a bump, blow, or jolt to the head or by a hit to the body that causes the head and brain to move rapidly back and forth," (CDC, 2015). Ultimately, a concussion is an injury to the brain that results from the brain banging against the thick, bony encasement of the skull. Precisely, when the brain is rattled in the skull, the long axons, which are pathways for neurons to fire that control our body's reactions and movements, are damaged. Because of this, the brain does not function properly, as these neurons, which are connections between each of the brain's regions, become impaired. With proper rest and decreased sensory stimulation during the recovery period, players can heal their damaged axons, but these pathways will never be completely as strong as they once were (DeKosky, Ikonomovic, & Gandy, 2010). Therefore, after each concussion suffered, players are more predisposed to recurrent brain injuries because of the permanent weakening of the axons. This harm to the brain’s axons results in many complications that are usually evident immediately or soon after injury. Some of these symptoms include chronic headaches, dizziness and vertigo, difficulty concentrating, word-finding problems, depression, irritability, and impulsiveness,” (DeKosky, Ikonomovic, & Gandy, 2010). This long list of implications only includes the short-term effects related specifically to the trauma of the brain from the concussion. In actuality, traumatic brain injury, especially if severe or suffered repeatedly, can lead to permanent, irreversible brain damage resulting in sensory, motor, and cognitive deficiencies (DeKosky, Ikonomovic, & Gandy, 2010). Furthermore, if the axons that connect the frontal and thalamic cortices, which are involved in temperament and emotion, are damaged, concussion sufferers can be left in a state of dementia (DeKosky, Ikonomovic, & Gandy, 2010). This symptom of dementia is exactly what initiated the study of professional football players who began to act irrationally after years of taking repetitive hits to the head. In his autopsy of a retired NFL player who displayed signs of cognitive impairment, a mood disorder, and symptoms related to Parkinson’s Disease, which is a motor disorder, Bennet Omalu discovered CTE was evident in the brain of this player who retired 12 years ago and died at the young age of 50 (Omalu et al., 2005). CTE is a degenerative disease of the brain that is identified by an abundance of tangles of neuronal fibers and an abnormal metabolism, or breakdown, of tau proteins in the brain. It has been discovered through numerous studies that this disease results from repetitive trauma to the head. Ultimately, as the number of concussions an athlete receives increases, the chance of acquiring this detrimental disease also increases. Therefore, it is crucial to implement protocols that test for, identify, and properly care for the presence of concussions. Historically speaking, football players and coaches have typically ignored the symptoms of concussions in order to keep athletes in the game, but this is no longer the case because of the widespread awareness of the implications that concussions have on football players engaged in full contact play.

Figure 13



Statistics

In order to analyze the concussion incidence rate and average recovery time after concussion in collegiate football players, the NCAA conducted a study in which 2,905 football players from 25 different U.S. colleges were given preseason baseline tests to assess each player's normal brain functioning. These players were then observed throughout the season to review concussion occurrences. Players with concussions were examined immediately after injury and followed up with until all symptoms resolved. They were then further monitored, checking for repeated concussions, up until the completion of their collegiate football career, with the goal of reviewing the cumulative, long-term effects associated with concussions and recurrent concussions.

After reviewing 4,251 player-seasons, the study showed that 184 players had a concussion, with 12 of these athletes suffering from a repeated concussion during the same season. Interestingly, there was a connection between previous concussions and likelihood of incidence of concussion. In fact, players with 3 or more previous concussions were three times more likely to become concussed than those who have never suffered from concussion before (Guskiewicz et al., 2003). Therefore, players with a history of previous concussions are more likely to face future concussions than those without a history. Furthermore, athletes with previous concussions displayed a slower recovery time of neurological function after their reported incident concussion. With headache being the most prevalent symptom at the time of concussion, overall symptoms seemed to last for an average of 82 hours. However, this number increased for players who had previous concussions (Guskiewicz et al., 2003). In addition, players who returned to play the same day after a head trauma experienced a delayed onset of symptoms that lasted longer than those of players who came out of their practice/game at the time of injury. Lastly, with the overall rate of incident concussion being 0.81 per 1000 athletes, most of the concussions were classified as grade 2 (moderate), with offensive lineman, linebackers, and defensive backs experiencing the most concussions (Guskiewicz et al., 2003). This makes sense, as these positions are the most physical, and the majority of concussions that occurred resulted from collision with an opponent, tackling an opponent, being tackled by an opponent, and blocking an opponent (Guskiewicz, et al., 2003). Even though guidelines for return to play after a concussion have become stricter, these numbers suggest a need for more improvement.

Concussion Symptoms

The most important aspect of concussion protocol is early diagnosis. In order for this to be possible, it is imperative to be able to identify the symptoms of concussion, which act as warning signs. Any time an athlete receives a blow to the head or a football player engages in a hard tackle, it is crucial to check and monitor the athlete for symptoms that may be hidden. This is important because about 90% of concussions do not result in loss of consciousness, which most people equate with the injury (Schaffer, 2016). Therefore, it is important to look for other symptoms including headache or pressure in the head, confusion, blurred vision, dizziness, malaise, difficulty balancing and concentrating, nausea/vomiting, and sensitivity to noise and light. However, most of the younger children, who are now participating in full contact, tackle football, do not always know how to express these symptoms, as they may just think that they are sick. Therefore, it is important to look for other concussion symptoms, including behavioral changes, which may be presented in the forms of temper tantrums or irritability long after the hit to the head (Schaffer, 2016). Nevertheless, if any concussion symptoms are present, it is imperative to seek medical attention. This is especially important for children, as their brains are still developing. Because of this, children are more susceptible to long-term consequences of concussions, especially in terms of cognitive ability and functioning (Schaffer, 2016). Ultimately, because of the harm that can occur later in life, it is important to diagnose concussions as soon as the trauma to the head occurs so that proper treatment can be issued to help eliminate lingering effects that can be detrimental to the athlete.

Care and Prevention

In a study performed by the NCAA to evaluate the natural recovery time needed to resolve concussion symptoms and improve cognitive functioning and postural stability following a concussion, it was found that football players need several days to weeks to heal after a concussion. After monitoring 1,631 football players from 15 U.S. colleges immediately, 3 hours, and 1, 2, 3, 5, 7, and 90 days after injury, it was found that on average, symptoms gradually resolved by day 7 (McCrea et al., 2003). While cognitive impairment was most severe immediately after the head trauma and continued through day 2 of recovery, balance deficits developed during the first 24 hours after concussion and did not resolve until day 5, on average (McCrea et al., 2003). Furthermore, players who were concussed showed signs of mild cognitive impairment in terms of processing speed and verbal fluency 2 days and 7 days after concussion, in addition to a gradual decline in verbal memory and mental flexibility (McCrea et al., 2003). The most alarming piece of information that the study unveiled was that on day 90, players who endured a concussion tested lower in verbal fluency than the control group who did not receive a traumatic brain injury. This suggests that even after complete recovery from concussion, the cognitive deficits endured do not completely return to normal.

Ultimately, football players who suffer from concussions face long-term consequences that cannot be eliminated. However, these consequences can be minimalized if the adequate time for recovery, which the study suggested to be a full 7 days, is granted to the athlete. Therefore, coaches should not urge football players to return to play as soon as possible after a concussion. Instead, symptoms should be constantly monitored and the player should not be able to return to play until all symptoms have resolved and testing results return to baseline levels. While this usually requires a complete week of inactivity, every player is unique; some may require more time to fully recover. In the study, 10% of players required more than a week for symptoms to dissipate (McCrea et al., 2003). Furthermore, return to play should be gradual. Before a player returns to engaging in full contact play, and once they have passed their test without any symptoms, it is imperative for the athlete to participate in increasingly intensive cardio before getting back on the field. If the exercise can be tolerated without symptoms returning, it can then be assumed safe for the athlete to practice and participate in games. Ultimately, adequate recovery time with proper care and gradual return to play protocols are crucial in the maintenance of an athlete with a concussion in order to help prevent future deterioration of the brain and its related consequences, in addition to recurrent concussions.

Conclusion

Even though sport-related concussion has become recognized as a major public health concern in the United States, more research still needs to be done in terms of care and prevention techniques that can help to limit the negative effects of concussion and ultimately help to preserve the brain. Especially because of the trend that displays an increase in the rate of concussions in collegiate football over the last 7 years, it is imperative for football officials and medical experts to work together to strategize methods to help halt this alarming increase (McCrea et al., 2003). On a positive note, recent studies have brought more attention to the severity of traumatic brain injuries, but the fact of the matter is that football remains one of the leading causes of concussions. Furthermore, participation in football has increased, with youth football numbers skyrocketing. Therefore, it is even more essential to prevent concussions from happening, as a brain injury to a child whose brain is still developing can be detrimental to their health for the rest of their life. In order to help lessen the risk of concussion, it is important to immediately teach proper tackling techniques as soon as a child begins playing football, with the emphasis being on keeping one's head held high and avoiding helmet-to-helmet contact (otherwise known as spearing). Furthermore, while limitation should be required for all age groups, it is especially important to constrain the number of hours that children are allowed to engage in full contact settings. Even though these measures will help to lower the concussion rate observed in youth and collegiate football, the issue of football-related concussions will always remain because of the highly physical nature of the sport. Therefore, the best way to tackle the problem is the allowance of necessary recovery time. Proper care for concussions will help to lower the threat of recurrent concussion by allowing the damaged axons of the brain to re-strengthen as much as possible. Not only will adequate recovery allow for healing from the trauma, but it will also help to lessen the severity of long-term consequences that the athlete may face later in life.

Conclusion

After analyzing five sports, it is clear as to why athletes are prone to the specific injuries that occur most frequently in their corresponding sport. There are two major factors: anatomical differences and improper body mechanics that disrupt proper functioning of the kinetic chain. Although each sport is unique in terms of the physiological motions that are required to perform, anatomical issues prove to be the underlying factor that is detrimental to the execution of these movements in each sport. Furthermore, women are the most at risk for injury because of their distinct anatomy, which includes an innate valgus knee position and abnormally loose ligaments, when compared to their male counterparts. The valgus knee position, which causes women's legs to be naturally turned inwards, completely alters the female body's center of balance, which is a major cause of injury. When force is absorbed outside of the center of body, an imbalance of strength is created, which causes injury because of the immense amount of stress put on the body's joints as a result. This is especially problematic because of the lack of stability in a female joint, which results from naturally loose ligaments that are not tight or strong enough to hold the joint in place when it is trying to compensate for the extreme amount of force it faces during practice and competition. When the sport-specific motion is repeated over and over throughout an athlete's career, the amount of stress put on the joints and muscles associated with the movement is too much for the body to bear. Consequently, injury occurs, which is often attributed to overuse and faulty body mechanics that disrupt the body's absorption of forces maintained by the kinetic chain. Nevertheless, if the kinetic chain, which is the unifying effect of forces that radiates from one part of the body to surrounding joints and muscles, is utilized correctly, not only will injury be less of a threat but athletic performance will also improve because of an increase in power generation. However, if a breakdown occurs at any point along the kinetic chain, which starts at the feet and travels upward through the lower extremities, into the torso, and out to the upper extremities, the entire body will be altered because of the chain's unifying effect. Therefore, it is important to implement proper training techniques early in an athlete's career that help to compensate for anatomical predispositions through the reinforcement of correct performance of the sport-specific movements required by each sport.

In order to help lower the rate of sports-related injuries in athletes of all ages, it is essential to introduce prevention programs that focus on three key aspects of training: core strength, balance, and agility. The core is a critical part of the body because of its placement in the kinetic chain. Ultimately, it is the most significant unifying feature of the chain because it connects the upper and lower half of the body. Therefore, emphasizing improvements in an athlete's core strength will help to ensure the proper functioning of the entire body. Balance training, otherwise known as proprioception, engages the core and other major muscles groups, typically found in the lower extremities, which control the body's positioning. This helps to reaffirm the body's center of gravity, which helps to mitigate the improper distribution and absorption of forces. Agility training, which is especially important for sports with lower-extremity activity predominance, also reinforces the proper absorbance of forces through plyometric exercise, during which muscles exert maximum force in a short period of time. This type of exercise often involves jumping, which requires adequate core strength and balance to be executed correctly. Furthermore, the jumping in agility training helps to improve the strength balance between the quadriceps and hamstring muscles. This, in turn, improves the absorbance of forces when landing, which limits the amount of stress put on the body's joints. Therefore, the goal of prevention programs is to improve the body's functionality through correct performance of the motions required by each sport. This requires the elimination of any unnatural body positions that may place extra stress on the body's joints, which increases the risk for injury. Especially in overhead sports, where the arm is in an unstable, overhead position, it is important to compensate for this stress through strengthening of the shoulder muscles, to help stabilize the joint, and execution of proper throwing mechanics. Nevertheless, regardless of the sport, athletes need to be conditioned and trained in accordance with the motions performed during their sport's play.

If prevention is not successful and an athlete does face injury, it is crucial to allow for adequate recovery time of the injured body part. Although recovery is often a long process, it cannot afford to be rushed. If not enough time is allowed for recovery, the risk for recurrent injury increases, as the body part will not be properly healed. Therefore, after a stage of complete rest to recuperate from the injury, it is imperative to complete a physical therapy program that gradually prepares the athlete to return to play. Once this process has been completed, it can then be deemed safe for the athlete to participate in their sport. However, exercises should always be continued to further strengthen and maintain the health of the previously injured body part. In addition, a proper prevention program should also be utilized to help decrease the risk of re-injury. Therefore, care and prevention cannot be viewed as separate entities, as both protocols rely on the completion of one another. Furthermore, both care, in which rest is significant, and prevention, in which proper technique is emphasized, are necessary protocols for a competitive athlete who continuously exhausts the body's muscles and joints. Ultimately, care and prevention practices will help to limit the number of sports-related injuries attributed to each sport through the minimization and correction of an athlete's anatomical and physiological flaws.

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