Proceedings of ICBioMed 2025 Symposium: AI for Healthcare: Advanced Medical Data Analytics and Smart Rehabilitation
DOI: 10.54254/2753-8818/2025.AU27099

Position-specific Injury Mechanisms and Related Rehabilitation Methods in American Football

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Abstract. As a high-intensity and tactically complex sport, American football has a high injury rate, and the specific movement patterns in certain positions lead to different injury situations, posing significant challenges to the health and sustainability of athletes, highlighting the importance of targeted research. This study focuses on key positions in American football, and develops comprehensive targeted training and rehabilitation plans by analyzing the injury mechanisms, differential factors, and rehabilitation strategies in specific positions. Research has found that injury patterns vary in different positions: quarterbacks have multiple upper limb injuries, running backs and wide receivers have lower limb injuries, forwards are prone to spinal injuries, and defensive guards have the highest incidence of concussion. The differences in injuries are related to biomechanical load, movement mechanisms, and training mismatches, and training plans corresponding to each position have been designed accordingly. This study emphasizes the crucial role of location specificity in injury management, providing personalized guidance for coaches and physical therapists to help reduce injuries and restore athletes' optimal performance.

Keywords: American football, position-specific injury, rehabilitation protocols, epidemiology.

1. Introduction

American football is a high-intensity competitive sport characterized by a complex tactical system and extreme specialization of positional roles, making it one of the most physically demanding sports. American football is not only known for its high competitiveness, but also for its high injury rate. Lawrence et al.'s study documented injuries that occurred during matches between 2012 and 2014. The results showed that in competitive American football, injury rates were very high, with injuries occurring in almost all matches. Concussions accounted for a large proportion of the total injury burden, while injury free matches only accounted for a small proportion [1]. The movement pattern at specific locations is also directly related to different injury situations. For example, defensive guards and perimeter receivers mainly engage in high-capacity, high-speed running activities, while offensive and defensive line guards have relatively less running, but exhibit more collision and contact oriented non-running movements [2]. With the increasing intensity of competitive sports, athlete injuries have become a key issue affecting sports performance, career, and public health. Especially in highly competitive sports like American football, the prevention of

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injuries and analysis of injury mechanisms have always been a research hotspot in the fields of sports medicine and sports science. The results of these studies directly affect the health protection of athletes and the sustainable development of sports events.

The existing literature records the epidemiology of injuries commonly found in American football. For example, previous studies have shown that supporters (including linebacks, running backs, and tight ends) exhibit unique characteristics in terms of head impact patterns compared to other position groups (linebacks and technical players), with a significantly higher frequency of head impacts per contact in both competition and practice environments, and a significantly higher burden borne than other position groups [3]. However, there is currently almost no information regarding the responsibility of players in specific positions, injury mechanisms, and the integration between related treatments and interventions.

The core objective of this study is to develop and provide a comprehensive targeted training and rehabilitation program system for key positions in American football. The study explores the unique sports needs and injury risks of various positions in American football, analyzes the factors that lead to differences in injuries between positions, dissects the reasons why athletes find it difficult to recover to their pre injury state, and proposes rehabilitation strategies to optimize the recovery of specific position injuries. By systematically organizing these contents, provide rehabilitation paths that are adapted to the sports characteristics of athletes in different positions, and help improve the effectiveness of injury recovery.

2. Position specific injury in American football

American football is one of the most physically demanding and tactically complex sports in the world, with its complexity reflected in the specific movement patterns and physiological needs of each position. For example, in various positions on the court, the quarterback is the offensive commander responsible for protecting the ball by dodging footsteps, while completing quick decisions and precise passes. Due to repeated over throwing movements, the quarterback position requires extremely high demands on the upper limbs (especially the shoulder complex), making it particularly prone to overuse injuries. Rehabilitation and training after injury are also crucial for athletes' performance. Although targeted treatment helped this quarterback return to the field, many athletes did not receive such personalized care.

2.1. Positional injury epidemiology

In the context of high competition in American football, different positions assign players with differentiated competitive tasks, and the nature of these tasks directly determines the functional requirements and usage intensity for specific body parts of players. To achieve the core competitive goals of each position, players need to frequently utilize the corresponding body parts in daily training and official competitions, and optimize their specialized performance by repeatedly strengthening specific movement patterns. However, such targeted high-intensity usage is prone to cause cumulative load overload in local tissues, leading to long-term excessive stress on structures such as muscles, joints, and ligaments. From the perspective of sports injury mechanisms, repeated mechanical stimulation of specific body parts will disrupt the dynamic balance between tissue repair and injury, thereby increasing the risk of specific injury in those parts. It can be seen that the differences in players' on-field positions, by affecting the frequency and intensity of the use of body parts, ultimately form a unique spectrum of high-incidence injuries for each position.

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Epidemiological data shows that there are significant differences in injuries at different locations, which are directly related to their unique exercise needs.

2.1.1. Upper limb injury

In the dynamic positioning of American football, quarterbacks are usually smaller in size than players in other positions. Meanwhile, their core responsibilities revolve around passing execution and attacking organization, which exposes them to higher frequency interception attacks. As a key player involved in ball control throughout the game, coupled with their unique vulnerability to attacks on the court, quarterbacks are more susceptible to upper limb injuries. Taking NCAA players as an example, shoulder injuries in quarterbacks are not only caused by interception and impact with the field, but also related to the throwing action itself [4].

2.1.2. Lower limb injuries

Running backs and wide receivers have the highest incidence of lower limb injuries because they have a great need for running. In the pre match preparation stage, the total running distance of the external receiver significantly exceeds that of other positions; Running guards also have longer high-speed running distances during training [2]. These data indicate that running backs and wide receivers engage in high-frequency running activities during training. This repetitive high-intensity exercise (including sprinting, acceleration, and changing direction) can impose a huge load on the lower limbs. Over time, these demands may increase the risk of overuse injuries, such as hamstring strains caused by high-speed running, as well as acute injuries such as ankle sprains - especially when recovery is insufficient or there is a lack of targeted preventive training, unexpected situations during the game (such as stepping on the opposing hand or foot and landing off balance, or hitting the opponent's supporting leg inside during interception) are more likely to cause such injuries [5,6].

2.1.3. Spinal and axial injuries

American football players need to have extremely strong core strength to withstand the extreme mechanical loads generated by high-intensity physical contact during the game. This physiological demand, combined with the repeated force borne by the spine in contact scenarios, significantly increases the incidence of spinal injuries in this sport. The data shows that the proportion of affected cervical and lumbar vertebrae is similar, with cervical vertebrae mainly experiencing "stinging sensation", while lumbar vertebrae are most commonly affected by back spasms; Frontlines are particularly affected by spinal injuries, which not only prevent them from entering the starting lineup, but also greatly limit their ability to participate in interception [7].

2.1.4. Concussion

Concussion is also one of the most common injuries in American football, with varying rates in different locations. Taking defensive guards as an example, they block the attack by rushing towards the ball holding opponent. The task of a defensive defender is to quickly intercept and frequently collide at high speeds, which puts them at a higher risk of concussion than players in other positions, resulting in the highest incidence of concussion in all defensive positions. On the other hand, players with offensive skills have a higher incidence of concussion than forwards, and their rapid running movements result in greater head impacts [8].

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2.2. Factors contributing to differences in positional injuries

The differences in the location of injury characteristics confirmed by the above epidemiological data highlight the unique injury situations in different positions of American football. These specific injury patterns not only pose significant challenges to the sustainability of players' careers, but also directly affect the stability of team performance. For sports organizations and coaching teams, prioritizing the development of strategies to reduce injury rates, optimize post injury rehabilitation outcomes, and maintain peak athletic performance is a critical operational priority.

It is also necessary to clarify the differences in recovery trajectories of athletes after injury. Some players have successfully returned to the field and regained their athletic abilities, such as a 26 year old National Football League (NFL) quarterback who suffered from subluxation of the shoulder, accompanied by a 330° joint capsule labrum injury and partial rotator cuff tear. Through arthroscopic repair surgery and a 28-week targeted rehabilitation program, he fully returned to the professional field and maintained elite performance 8 months after surgery [9]. However, many other athletes experience long-term functional impairments or repeated injuries, and their career length and performance significantly decrease after standard recovery. Thus, standard recovery does not always mean the best recovery to individual players.

This difference may stem from the complex interplay of multiple factors. The first factor is the difference in biomechanical load. Previous studies have shown that there are differences in player load (PL) among players in different positions, with PL values ranging from moderate to extremely high for defensive guards and wide receivers, reflecting their high running needs; The PL values of offensive and defensive forwards are relatively low - although they perform a large number of specific sports movements, the PL value of defensive forwards is the lowest among all positions [2]. The second factor is the specificity of different action patterns. For example, a running back's turning motion can generate a knee joint outward torque, causing tension on the anterior cruciate ligament (ACL). The throwing motion of the quarterback involves a chain process of "arm pull release swing", causing the rotator cuff to repeatedly bear tension - their shoulder abduction and outward rotation reach their peak in the early acceleration phase, and elbow flexion reaches its maximum amplitude at maximum outward rotation; The rotation of the torso towards the throwing side is reversed during the acceleration phase, and the hip shoulder separation is minimized when the ball is released. Repeated running and throwing movements will gradually increase the pressure on relevant body parts. These unique patterns lead to overuse injuries and acute injury risks in specific locations. In addition, training mismatch can also affect injury differences. Athletes in different positions in American football require targeted training interventions that match their unique functional needs and performance goals. For example, positional training should be tailored to the physiological needs of different positions: the attacking forward strengthens the explosive initial movement of the opening line through "standing posture and starting" training, while the receiver combines route running and receiving tasks for training to improve lower limb strength and receiving response [10]. Due to the lack of preparation tailored to the unique needs of each location, this mismatch between training plans and physiological requirements may increase the risk of injury. Therefore, addressing these issues is crucial for developing a targeted injury management framework that meets location requirements and individual athlete characteristics.

3. Position-specific training and rehabilitation protocols

It is necessary to provide targeted rehabilitation and training recommendations for the main rugby positions after identifying the key reasons for the differences in injury mechanisms at different

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positions and athlete recovery outcomes, such as differences in position load patterns, specific movement requirements, and mismatches between training programs and on field requirements. The rehabilitation of quarterbacks focuses on strengthening upper limb and core functions. This position requires significant pressure on the shoulders and elbows due to repeated over throwing, rapid upper body rotation, and evasive movements under pressure. The rehabilitation goal is to reduce upper limb strain and improve throwing efficiency. Specifically, priority should be given to restoring shoulder mobility, ensuring a complete range of head movements without pain and balanced muscle activation, which is crucial for throwing mechanics and impact prevention. Studies have shown that stretching combined with instrument manipulation is more effective than stretching alone [11]. At the same time, it is necessary to conduct advanced training on throwing at specific positions, incorporating different tactical feints to simulate the variability in the game, such as retreating, dodging, and passing.

The focus of rehabilitation for running backs is to enhance their explosive power and deceleration control ability. Due to frequent rapid acceleration, deceleration, and directional changes, the knee joint (especially the anterior cruciate ligament) is often subjected to high valgus stress and rotational stress, leading to a high incidence of anterior cruciate ligament injury and ankle sprain, with a long recovery time and a high risk of re injury. Therefore, rehabilitation should emphasize proprioceptive training, restoring functional stability through balance, agility, and joint position perception training [12]. This method is also applicable to positions such as quarterback and defensive guard. During the rehabilitation of injured patients, attention should be paid to the symmetry of lower limb strength, and bilateral symmetry and motor control should be enhanced through neuromuscular control exercises such as squats, stair climbing, and landing [13]. Furthermore, it is imperative to incorporate advanced and plyometric training methodologies to enhance key physical performance metrics, such as sprint velocity and turning agility, which hold significant applicability for defensive guards in particular. After recovering strength, gradually incorporate progressive agility and sprint training, and improve running speed through various methods such as free sprints and assisted sprints [14].

The rehabilitation of offensive line guards focuses on static strength enhancement and spinal protection. Due to frequent strong and repetitive blocking movements, the lower back (especially the lumbar spine) is subjected to extremely high loads, which can easily cause spinal fatigue and chronic lower back pain, prolong recovery time, and increase the risk of re injury. Rehabilitation needs to be specifically designed to reduce spinal pressure while rebuilding functional strength that matches the location requirements. Starting from activating deep core muscles, improving lumbar stability through dynamic trunk stability training, prioritizing strength endurance training such as rhythm-controlled weightlifting and plank support to meet the need for long-term force application in that position. Re-introduce resistance mechanics through lighter sled training, resistance band pushing and resistance, and perform specific position load training. It should be noted that although offensive and defensive linebacks often face similar collision injuries, there are differences in rehabilitation methods - the former requires more static strength and core stability training, while the latter focuses on explosive power regeneration and multi-directional movement recovery.

The rehabilitation of defensive guards needs to take into account the improvement of various abilities. This position (including corner guards and safety guards) is prone to lower limb injuries due to high-speed directional changes, sudden retreats, explosive lateral movements, and vertical jumps (while maintaining visual contact with the ball and receiver), mainly caused by deceleration and directional changes, and has a higher risk of concussion due to capturing the role of the receiver. In rehabilitation, hamstring eccentric training is indispensable, and high-capacity Nordic leg bending

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exercises can reduce the risk of re injury and improve deceleration ability, which is crucial for transitioning from a retreat to a sprint [15]. Deceleration and retreat control training is necessary, simulating competition scenarios such as sudden emergency stops, transitions from lateral slides to sprints, and emphasizing knee alignment and foot placement to reduce anterior cruciate ligament load. Simultaneously integrating visual motor and cognitive training, incorporating reactive cues in agility training to simulate complex decision-making environments in competitions.

4. Conclusion

This study constructs a training and rehabilitation framework for specific positions by elucidating the correlation between the positional characteristics, injury mechanisms, and targeted intervention strategies in American football. Epidemiological analysis shows that the characteristics of injuries in various positions are closely related to functional requirements. Quarterbacks face the risk of upper limb (especially shoulder) injuries due to repeated throwing and interception, while running backs and wide receivers are prone to lower limb injuries such as hamstring muscle strains due to high-intensity running. Frontlines bear more spinal injuries due to contact loads, and defensive guards have the highest incidence of concussion due to rapid interception. The key factors contributing to differences in injury and recovery performance include differences in biomechanical load, specific movement mechanisms (such as running back knee joint eversion torque, quarterback rotator cuff pressure), and training mismatch. The designed plan is targeted to meet different physiological needs. The quarterback enhances shoulder flexibility and throwing efficiency, the running back focuses on proprioception and agility, the forward prioritizes spinal protection and static strength, and the defensive guard integrates hamstring muscle training and cognitive visual exercises. The effectiveness of the plan has been verified through case studies. The study emphasizes the crucial role of location specificity in injury prevention and rehabilitation, providing guidance for personalized management, helping to reduce injuries and restore athletic performance, and offering more comprehensive multidimensional solutions for coaches and physical therapists to address specific injuries caused by location requirements, promoting efficient recovery of athletes to their optimal state. The limitation lies in the reliance on existing data, limited universality, and the need for more comprehensive and repeated research to meet actual needs. In the future, longitudinal research across age and skill levels should be conducted, combined with advanced movement analysis to optimize solutions and promote the health and performance improvement of American football players.

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