

REVIEW PAPER

Injuries in High-Performance Football: A Systematic Review

Alberto Sanmiguel-Rodríguez^{1,2}

¹University Camilo José Cela, Faculty of Language and Education, Madrid, Spain, ²Nebrija University, Faculty of Language and Education, Madrid, Spain

Abstract

The large number of sports injuries, especially in football, is becoming a major problem for professionals who work with athletes, making it one of the team sports with the highest injury incidence rates. The objective of this review is to offer an overview of the most recent scientific publications in relation to injuries in high-performance football. For this, a systematic review was carried out from 2015 to 2020, searching with the terms of the UNESCO Thesaurus: “injuries”, “football”, “elite”, “professional football” and “high performance” in the international databases Scopus and Web of Science and the Spanish database Dialnet, allowing the selection of original articles (experimental, descriptive, quasi-experimental studies and/or case studies), which included information on this line of research. A total of 833 articles were found, although this was reduced to 67 articles after applying the review’s inclusion criteria. These publications were divided into three main categories: A) Research related to characteristics and types of injuries, B) Research related to game conditions and training loads and C) Other topics studied. In conclusion, this systematic review allows us to quickly and easily analyse information about injuries in high-performance football in recent years. These results are interesting for the researchers and different professionals who comprise coaching staff in football clubs.

Keywords: *injuries, football, soccer, elite, high performance*

Introduction

Football is the most popular team sport in the world; it is estimated that around 4% of the world’s population plays it; three activity involves running, kicking, jumping, stopping, and changing direction at high and medium speeds (Echavarría-Calderon & Galvis-Rincon, 2020; Fernández et al., 2020). The dynamic character is a determining factor in the face of injuries that occur. Although most injuries are caused by contacts or impacts, many are caused by catches after jumping and by the sudden changes of direction characteristic of this sport (Fernández et al., 2020).

Thus, due to the specific characteristics of football, according to which high high-intensity action such as jumps and changes of direction can become determining factors in achieving sporting success, including strength training in football training plans is essential. Depending on the variables to be influenced and the time of the season, a specific strength training method should

be chosen, so that knowledge of the effects of each one of them seems essential for the success of the training, not only concerning physical-sports performance but also injury prevention (Raya González & Sánchez, 2018). At a professional level, the combination of these high physical demands coupled with the stress and anxiety generated by the intense competitive calendar can place players at a high risk of injury (Carling, McCall, Le Gall, & Dupont, 2016; López Valenciano, 2018; Wollin, Pizzari, Spagnolo, Welvaert, & Thorborg, 2018).

The internal workload of training and games is considered one of the most important risk factors for injury in elite football; however, there is little published evidence to support this belief (McCall, Dupont, & Ekstrand, 2018). Injuries have a great impact on high-performance football during practice in training and especially in competition, due to their significant influence on team performance and the considerable rehabilitation costs for players (Carlos-Vivas, Martín-Martínez, Chavarrias, &



Correspondence:

A. Sanmiguel-Rodríguez
University Camilo José Cela, Faculty of Language and Education, Urb. Villafranca del Castillo, 28692 Madrid, Spain
E-mail: asrgz2014@gmail.com

Pérez-Gómez, 2017; Chena, Rodríguez, & Bores, 2017; Mears, Osei-Owusu, Harland, Owen, & Roberts, 2018; Raya González, 2017a; Rossi et al., 2018; Windt, Ekstrand, Khan, McCall, & Zumbo, 2018); therefore, many efforts are made to reduce the incidence of injuries in football, and preventive programmes based on strength training appear to show positive results (Chena et al., 2017; Martín-Moya & Ruiz-Montero, 2017; Raya González, 2017a). Existing studies in the literature provide only a preliminary understanding of which factors primarily affect injury risk (Coppalle et al., 2019; Rossi et al., 2018).

The large number of sports injuries, especially in football, is becoming a major problem for professionals who work with athletes and make it one of the team sports with the highest incidence rates of injuries (Eckerman, Svensson, Edman, & Alricsson, 2019; López Valenciano, 2018; Martín-Moya & Ruiz-Montero, 2017; Palmi, Planas, & Sole, 2018). The study of the epidemiology of sports injuries and the complexity of the variables present in the athlete's recovery process prompt the incorporation of new intervention techniques (Palmi et al., 2018). Injuries to the knee joint have a high incidence among football players. One of the most frequent traumas is an injury to the anterior cruciate ligament, which involves a high social, psychological and economic cost for footballers and their teams (Bertomeu et al., 2019; Gómez-Piqueras et al., 2017). Unfortunately, many players do not regain the level they maintained before the injury due to the loss of functional aspects such as knee stability in rotational movements (Bertomeu et al., 2019). Different studies have shown that a poor psychological and kinematic predisposition of the injured athlete could make it difficult for them to return to training and competition (Gómez-Piqueras et al., 2020; Oriol, Leyton, Pascual, & Batista, 2018). However, the COVID-19 pandemic has changed the conditions for competing in football around the world. Thus, several competitions and leagues have been cancelled or postponed, and players have been forced to train alone and in small groups with strict contact restrictions, and return to competitive play may occur after only a few weeks of normal group training preparation; these special circumstances are likely to affect return to competition performance and injuries (Mohr et al., 2020).

For all the aforementioned, the objective of this work is to review the scientific literature from 2015 to 2020 that addresses

the field of high-performance football, selecting only articles related to injuries for content analysis.

Methods

The bibliographic review is a type of scientific article that, while not original, collects the most relevant information on a specific topic. Thus, for this review, a bibliographic search was carried out in the two most relevant international databases in this line of study. The first one, the Scopus database (Elsevier), selected as it is a review in social sciences (texts in different languages); the second database was Web of Science (WoS). In addition, the Spanish Dialnet database was used as a complement. As keywords, the following terms taken from the UNESCO Thesaurus (injuries, football, elite, high performance) were chosen. The inclusion criteria used in the review were the following:

- 1) Articles published from January 1, 2015 to August 1, 2020;
- 2) Articles that address any type of research related to football in the international context, incorporating experimental, descriptive, quasi-experimental studies and/or case studies;
- 3) Articles that are published in English or Spanish;
- 4) That the study be carried out with a sample of high-performance players, or else, analyse some variable related to this area.

Results

A total of 833 articles were found, but after removing the duplicates, the search brought together a total of 798 documents for analysis. After the initial review of these 798 documents, those articles that did not directly address or were not related to high-performance sports and injuries were discarded. After applying the selection and categorization criteria, a total of 67 articles that provided a scientific method and fulfilled the inclusion criteria mentioned above were compiled. Likewise, the work schedule for the search for information had four different phases, as can be seen below and in the flow diagram represented graphically in Figure 1: 1st Phase: Search and selection of descriptors through the UNESCO Thesaurus; 2nd Phase: Detailed search in the scientific databases Scopus, Web of Science (WoS) and Dialnet, using the inclusion criteria described above; 3rd Phase: Analysis of the content of the articles and classification by subject; 4th Phase: Categorization of articles and preparation of the manuscript (i.e., a systematic review).

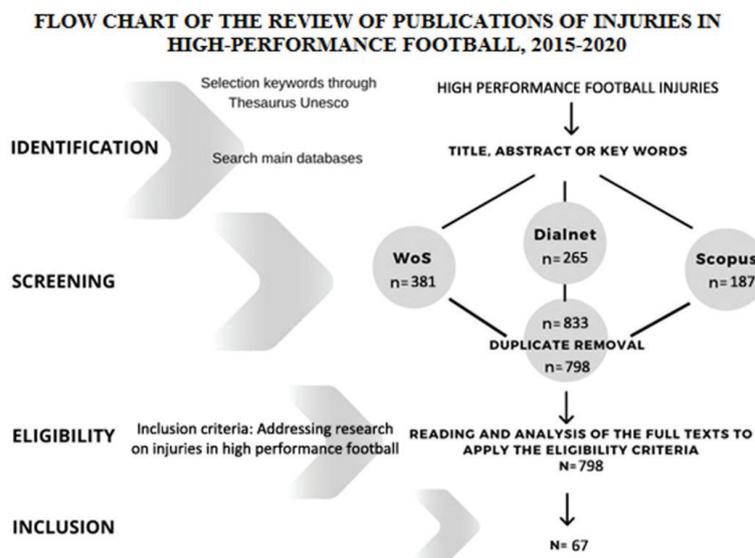


FIGURE 1. Flow diagram of the systematic search process

Once the 67 definitive articles had been selected, a detailed reading of all the articles was carried out individually, and a first categorization was made. The second phase was the analysis of the different articles and the specification of the three definitive categories. As a result of this deductive procedure and triangulating the information, the final classification of

the articles was carried out in the three mentioned categories.

Once the process described in the flowchart of the systematic review of publications on injuries in high-performance football was made, the result was 67 publications. All of them were included in a categorization process by subject, finally finding three categories of analysis of the scientific literature (Table 1).

Table 1. Synthesis of the studies found on injuries in high-performance football

Categories (number of articles)	Authors and year
Research related to characteristics and types of injuries (27)	Ayala et al. (2019); Bernal et al. (2019); Bourne et al. (2020); Carlos-Vivas et al. (2017); Cruz-Ferreira et al. (2015); Esteve et al. (2018); Fransz et al. (2018); Gómez-Piqueras et al. (2017); Konopinski et al. (2016); Kudaş et al. (2016); Langhout et al. (2018); Larsson et al. (2016); López Valenciano (2018); Lundblad et al. (2019); Molano & Molano (2015); Moreno-Pérez et al. (2019); Oriol et al. (2018); Raya-González et al. (2018); Raya-González et al. (2018); Ribeiro et al. (2020); Rhodes et al. (2019); Sintés & Caparrós (2019); Stubbe et al. (2015); Svensson et al. (2018); van Dyk et al. (2018); Wong-On et al. (2017); Yanguas et al. (2017)
Research related to game conditions and training loads (17)	Abade et al. (2017); Abade et al. (2018); Coppalle et al. (2019); Ekstrand et al. (2020); García-Concepción et al. (2015); Jadcak et al. (2019); Krutsch et al. (2020); Lubberts et al. (2019); Martín-Moya & Ruiz-Montero (2017); Núñez et al. (2016); Pffirrmann et al. (2016); Raya González (2017b); Raya González et al. (2020); Raya-González et al. (2018); Suarez-Arrones et al. (2019); Torrontegui-Duarte et al. (2020); Zouita et al. (2016)
Other topics investigated (injuries and gender, types of surfaces and recovery times; 23)	Calloway et al. (2019); Castro et al. (2016); Ekstrand et al. (2019); Gómez-Espejo et al. (2017); Lai et al. (2018); Lai et al. (2019); Lanzetti et al. (2017); Larruskain et al. (2018); Leventer et al. (2016); Lundblad et al. (2020); Malone et al. (2018); Mears et al. (2018); Pellicer-Chenoll et al. (2017); Royán-González et al. (2017); Prieto (2015); Prieto (2016); Roberts et al. (2020); Shalaj et al. (2016); Smpokos et al. (2018); Stares et al. (2019); Valle et al. (2018); Waldén et al. (2018); Zurita et al. (2017)

As shown in Table 1, from 2015 to 2020, the category of research related to characteristics and types of injuries has brought together a total of 27 studies. The category of research related to game conditioning factors and training loads has had a total of 17 studies, and the category of other topics has brought together a total of 23 studies on different topics on injuries in high-performance football.

Discussion

Research related to characteristics and types of injuries

Carlos-Vivas et al. (2017) state that injuries are a major problem in high-performance football; 83.4% of them appeared in the lower extremities and specifically were the thigh (35.7%), ankle (23.8%), adductors (14.3%), knee (4.8%) and calves (48%). The number of lower extremity injuries was higher in the group that did not perform preventive work than in the group that did. Along these lines, another investigation (Stubbe et al., 2015) pointed out that the injuries were more likely to be located in the lower extremities (82.9%), as the most common injury in the muscles and tendons with a recovery time between 1 and 752 days. Gómez-Piqueras et al. (2017) indicated that the incidence of injuries during competition was higher than that obtained during training; specifically, the back of the thigh (19.6%), the knee (18.3%) and the groin (17.4%) were the most frequently injured areas. It was found that 14.4% of the injuries were relapses of injuries suffered previously. According to Larsson, Ekstrand, and Karlsson (2016), 45% of traumatic fractures and 86% of stress fractures affected the lower extremities. For van Dyk et al. (2018), the hamstring has been repeatedly identified as the most common non-contact injury in high-performance football at 12%. Likewise, the results of other authors (Molano & Molano, 2015) allowed identifying that the highest rate of injury occurred in the lower limbs, especially the ankle (56%), with the most frequent

injury of a first-degree sprain (43.4%), and muscle tear (38%). Fransz et al. (2018) showed that after a landing with a jump and a fall with one leg, the probability of an ankle sprain increases. In contrast, Lundblad et al. (2019) indicated that knee injury is the most common in high-performance football, 75% of which occurred with a contact mechanism. These same authors (Lundblad et al. 2019) pointed out that devices such as knee braces should not be necessary in milder cases.

For Carlos-Vivas et al. (2017), including a preventive programme after warming up helps reduce the risk of lower limb injuries in football players. Following these contributions, López Valenciano (2018) indicated that the lower extremities have more injuries, with the thigh being the anatomical region where more injuries occur. The results of this study (López Valenciano, 2018) show the need to prescribe exercises aimed at improving the range of motion of hip flexion with extended knee and dorsiflexion of the ankle with knee flexed during training sessions. Additionally, and since bilateral range-of-motion imbalances are common, unilateral training should be implemented if necessary. However, Bourne et al. (2020) indicated that hip abduction imbalance was associated with a reduced likelihood of future injuries to the hip and groin.

Moreno-Pérez et al. (2019) pointed out that the majority of groin injuries occurred during competitive matches, in which lower adductor maximal isometric force values increase the probability of injury by 72%. According to Langhout et al. (2018), the point prevalence of serious groin injuries was 24%, and the incidence of injury within the season was 11%. For their part, Wong-On et al. (2017) collected injury data from four teams in the Spanish League in a total of four seasons, and the results indicated that a total of 16 players suffered injuries to the external and internal shutter during matches or training sessions. According to Raya-González, Gómez Piqueras, and Sánchez-Sánchez (2018), the application of an eccentric

resistance training programme during the functional recovery process increases the power of the lower body and reduces the asymmetry caused by an injury, which is reflected in the decrease in the payback period. Esteve et al. (2018) indicated that hip adductor muscle weakness and a history of groin injuries have been identified as important risk factors for re-injury. Thus, male footballers with groin pain during the previous season are likely to start the next season with a high risk of groin injury. The results of Raya-González, Suárez-Arrones, Ríquez, and Sáez (2018) suggest that the inclusion of an eccentric resistance training programme in the periodization of football training allows the optimization of the specific physical condition of football players.

Strain in the hamstring muscles, mainly in the biceps femoris, is the most common injury in football. Despite all the studies carried out on its prevention, the incidence is not reduced. Possible causes are the incorrect choice of exercises for strength development and the failure to consider the interrelationships between risk factors (Sintes & Caparrós, 2019). Similarly, other authors (Ribeiro, Oliveira, De Lima, & Baroni, 2020) demonstrated that players with a history of hamstring strain in the previous season present a reduction in the eccentric strength of the knee flexors in the injured limb. Following these contributions, Rhodes, McNaughton, and Greig (2019) indicated that eccentric strength of the hamstrings is a risk factor for injury, and these strength parameters would not be fully recovered until 96 hours after football-specific fatigue. Hamstring injuries are the most common in football, and they can present residual effects that change the pattern of a technical gesture (Oriol et al., 2018). Other studies (Ayala et al., 2019; Cruz-Ferreira, Marujo, Folgado, Gutierrez, & Fernandes, 2015; Yanguas, Pruna, Puigdellívol, & Mechó, 2017) indicated that hamstring injuries are the most frequent in high football performance, and the long head of the biceps is the most affected muscle, with the proximal locations being the most common with important clinical characteristics, such as time off and the risk of re-injury (Yanguas et al., 2017). According to Svensson, Eckerman, Alricsson, Magounakis, and Werner (2018), in 53% of cases, there were more hamstring injuries in the dominant leg compared to the non-dominant leg.

Bernal, Morcillo, Santafé, and Santafé (2019) highlight the importance and added value provided by the podiatrist within the medical services of a high-performance football team in bone consolidation or cases of refracture in the fifth metatarsal, as well as the validity of conservative treatment for this type of injury based on medical considerations and the characteristics and location of the injury. For their part, Konopinski, Graham, Johnson, and Jones (2016) indicated that hypermobility showed a trend towards a higher risk of injury. According to Kudaş et al. (2016), non-surgical treatment modalities were effective in two thirds of the cases in posterior ankle impingement, with posterior ankle arthroscopy being a safe and effective treatment option if conservative treatment fails.

Research related to game conditions and training loads

Warm-up routines are normally used to optimize football performance and prevent injuries. Furthermore, official pre-match protocols may require players to rest passively for approximately 10 to 15 minutes between warm-up and the start of the match (Abade et al., 2017, 2018). The absence of re-warm up activities can be detrimental to the physical performance of the players. However, including a pre-game

warm-up is a complex issue, as manipulating volume, intensity, and recovery can affect performance positively or negatively. Abade et al. (2018) demonstrated that eccentric exercise can be harmful to physical performance when performed before a football game; however, plyometrics and repeated directional exercises appear to be simple, fast, and effective activities for attenuating losses in vertical jump and sprinting ability after a warm-up. For Martín-Moya and Ruiz-Montero (2017), the key elements of an effective strengthening and injury prevention programme for football players must include cardiovascular exercises, functional strength (which includes eccentric work of the biceps femoris), stability of the trunk, neuromuscular balance, plyometrics and static or dynamic stretching depending on the time of the session.

The preseason training develops the physical capabilities of the players and prepares them for the demands of the competitive season. Teams that did the most preseason workouts had “healthier” season spells. Preseason training and football team planning and preparation could help reduce and prevent injuries during the season (Ekstrand et al., 2020). In contrast, Coppalle et al. (2019) showed that the training load during the preseason is not associated with the general performance of the team and that this is due to a multifactorial association, since other factors, such as the technical and tactical level of the team, the opponents, and the environment can play an important role for the collective performance of the team. For Suarez-Arrones et al. (2019), a combined football and eccentric resistance training programme promoted positive changes in body composition and physical factors relevant to both on-field performance and injury prevention in elite football players. According to Raya-González et al. (2018), the effect of a strength training programme with eccentric load based on the squat exercise and the application of a strength programme executed in a rotational inertia device during the process of functional recovery produces an increase in the muscular power of the lower body and decreases the asymmetry caused by the sports injury, which is reflected in the reduction of the recovery period.

The results obtained in other investigations (Raya González, 2017b; Raya González et al., 2020) show that football is an injury-prone sport that varies according to the category in the same club, that there are more incidences of injuries in matches than in training (López Valenciano, 2018; Lubberts et al., 2019; Pfirrmann et al., 2016; Raya González, 2017b; Raya González et al., 2020), that a preventive force programme is effective in reducing of the number of muscle injuries in a season, and that training with an inertial device with eccentric overload improves vertical jump and leg power (Raya González, 2017b). For other authors (Zouita et al., 2016), precisely and efficiently programmed strength training-induced performance improvements and reduced the injury rate in young football players. According to Krutsch et al. (2020), the key to the sustainability of prevention measures are programmes specifically adapted to the demands of the level of play and the preferences of the coaches. Following these contributions, Torrontegui-Duarte et al. (2020) pointed out that exposure to training was inversely related to the total number of injuries, which means that the higher the exposure to training, the lower the number of injuries.

The results indicate the importance of evaluating and monitoring the dynamic and static balance in both legs, which allows a complete comparison of the control of the body balance and

the balance recovery strategy based on the sport level represented. The study indicates that the higher the sporting level of the players, the better their balance, which can indirectly contribute to the prevention of injuries and the more effective execution of actions directly related to the game (Jadczak et al., 2019). Núñez, Lancho, and Ramírez (2016) pointed out that, during the first stages of functional recovery, general exercises provoke adaptations between extremities and reduce the asymmetry caused by sports injury. In the physical recovery process, the excessive load caused by separately working the limb decreases and, consequently, so does the recovery period. Thus, according to García-Concepción, Peinado, Paredes, and Alvero-Cruz (2015), the performance of combined recovery protocols carried out after the training session tend to be more effective compared to the protocol that only included stretching.

Other topics studied (injuries and gender, types of surfaces and recovery times)

Fatigue is an element that brings with it a series of physiological changes and renders the motor response ineffective in the face of the diversity of stimuli and actions offered by a sport, such as football, which can lead to injury (Royán-González et al., 2017). Thus, for other authors (Malone et al., 2018), players with poor aerobic fitness had a higher risk of injury than players with better developed aerobic fitness, and exposing players to large and rapid increases in distances in high-speed running increased the odds of any type of injury. Larruskain et al. (2018) demonstrate that prevention strategies must be adapted to the needs of both male and female football players, with men more predisposed to hamstring strains and hip/groin injuries and women to quadriceps strains and severe knee and ankle ligament injuries. For Pellicer-Chenoll et al. (2017), both men and women showed lower rates of injury in the non-dominant leg compared to the dominant leg.

According to Shalaj et al. (2016), sprains, thigh muscle tears, knee ligament injuries, as well as meniscus or other cartilage tears, represented the most frequent differential diagnoses, although no significant differences were found between players of different positions. In contrast, another study (Leventer et al., 2016) indicated that midfielders had the highest incidence and injury rate during matches, while central defenders maintained the highest injury incidence rate during training. However, Torrontegui-Duarte et al. (2020) indicated that the forwards presented the highest rates in both the incidence and severity of the injury.

Shalaj et al. (2016) found that the injury rate in competitions in Kosovo had been slightly lower than the international average, surely related to less exposure to matches, but in contrast, the incidence of injury was 10-13%, higher in younger players, which may indicate a more aggressive and risky playing style in this age group. Following these lines, Pfirmann, Herbst, Ingelfinger, Simon, and Tug (2016) pointed out that injury rates were higher during matches than in training sessions for both young and adult players, whereas younger players had a higher incidence of injuries during training sessions. Other research results (Prieto, 2015, 2016) indicated that a higher number of total injuries and a higher injury rate were associated with a lower age. According to Lai, Feller, and Webster (2019), players under the age of 25 were more likely to return to their pre-injury performance levels after ACL reconstruction. Following these contributions, another study (Lai, Feller, & Webster, 2018) indicated that the injury rate to the

anterior cruciate ligament in any knee was 30% and was especially high among players under 21 years of age. Larsson et al. (2016) indicated that stress fractures produce longer absences than traumatic fractures and younger players have more stress fractures than older players do. In contrast, Valle et al. (2018) demonstrated that hamstring injuries among younger football players are less frequent than among older ones.

In contrast, the results of another study (Gómez-Espejo, Álvarez, Abenza, & Olmedilla, 2017) show that the group of uninjured football players had higher levels of social support compared to the group of injured players. According to the results of other authors (Zurita et al., 2017), the higher the level of professionalism, the greater the resilience capacity since the competitive level directly affects the ability to face injuries regardless of the levels of anxiety that football players have. Castro, Chacón, Zurita, and Espejo (2016) demonstrated that the competitive level directly affects the ability to face injuries, and footballers who have suffered more injuries are used to facing them. However, due to the few differences found, it is clear that the resilience capacity depends on individual factors.

According to Mears et al. (2018), 91% of players perceive that the type or condition of a surface such as artificial turf could increase the risk of injury. Following these contributions, Roberts, Osei-Owusu, Mears, and Harland (2020) indicated a greater preference of players for natural grass because they perceive a greater risk of injury on artificial grass. Calloway et al. (2019) found that ankle fracture had a statistically higher incidence in artificial grass, although the general injury rate in artificial grass was not lower than that of natural grass; artificial grass is licensed from FIFA as a viable alternative to natural grass. Following these contributions, Lanzetti et al. (2017) showed equivalence in the risk of injuries on natural grass and artificial grass in high-performance football during official matches.

For Ekstrand et al. (2020), most injuries are mild (42%), and these resulted in an average absence of 7 days or less; moderate injuries have a mean absence of 7 to 28 days in 56% of cases, while only 2% were severe with a mean absence of more than 28 days. Other authors (Lundblad et al., 2020), in contrast, indicated that the lateral collateral ligament and posterior cruciate ligament injuries lasted two and four weeks, respectively, and are associated with a contact injury mechanism. In contrast, Waldén et al. (2018) indicate that the injury rate is higher when players have a recovery time of five days or less between two games. In another study (Stares et al., 2019), the risk of injury was highest in the week of return to play and decreased with each week, indicating the need for injury prevention strategies. According to other authors (Ekstrand et al., 2019), teams without winter holidays (English clubs) had a higher incidence of injuries than other European clubs that did have their scheduled break. For Smpokos, Mourikis, and Linardakis (2018), the highest total distance travelled was registered in January and the lowest during the preparation phase, while in the February matches, higher average levels were found in high-speed running in relation to the ones of November.

Conclusions

After the analysis of the 67 articles used for this review on injuries in high-performance football that have been published during the years 2015 to 2020, the researchers have concluded that the analysis of physical loads in football can be very useful

to identify the characteristics and types of injuries and power, in this way, to carry out more individualized and specific training. Therefore, this review provides summary information on injuries in high-performance football and could be effective in managing the loads of players to avoid the risk of injuries since

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Conflict of Interest

The author declare that there are no conflicts of interest.

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