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Incidence of Injuries in Elite Spanish Male Youth Football Players: A Season-Long Study with Under-10 to Under-18 Athletes

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Featured Application: Football coaching staff should pay special attention to the regular monitoring of young players' development to balance and adapt training loads, carrying out specific programs to reduce the number of injuries in youth football based on long-term development.

Abstract: The aim of this study was to analyse the injuries sustained by youth football players from a professional team of the Spanish League integrated into an elite academy, considering the sporting context, the month, and the category of the player throughout the 2017–2018 football season. A total of 227 players in under (U) age categories from U-10 to U-18, with two age-groups in each category (A and B), except U-18, with three groups (A, B and, C), were evaluated. Of the 242 cases, 196 injuries were observed. Injury recurrence or different injuries were observed in the same football player during the season, specifically in the older age categories. With regard to the location of injuries, sixteen different parts of the body were associated with injuries, with five of those totalizing the majority of incidence (162 injuries): the ankle (19), the foot (10), the hip (22), the knee (27), and the thigh (74). A negative relationship was observed between the sporting context and the number of injuries sustained ($Rho = -0.203$; $p = 0.002$), and a positive relationship between the category and the number of injuries was identified ($Rho = 0.488$; $p < 0.001$). Of the total, 118 injuries were sustained during training (62.8%), 70 were sustained in competitive moments (37.2%), and the remaining cases were associated with accidents outside football. The majority of injuries were muscular (101), followed by articular injuries (49), with both combined accounting for 150 of the total injuries. Though no relationship was observed between month and number of injuries ($Rho = -0.024$; $p = 0.707$), the months associated with the restart of training routines after interruptions (August, September, and January) were the highest, other than May, in which the highest number of injuries was observed. The findings in this study suggested that it is advisable to carry out a greater number of hours of injury prevention training in U-16 and U-18. Coaches should routinely monitor young players' development in order to adapt and balance training interventions to individual needs, and they should consider implementing specific injury risk mitigation strategies in youth football based on the long-term development of the football players. Additionally, it is our understanding that it is essential to program, perform, and monitor specific training sessions or even specific training tasks considering the player's category and long-term sporting development.

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1. Introduction

Sports practice is a trend in modern society. Nowadays, the introduction of children and youth into organized and regular practice begins much earlier when compared to the past, with parents searching for a safe and healthy environment on the pathway between different age categories, aiming for long-term development towards the senior category. This development is directly associated with the key role of coaches, specifically in designing training sessions [1]. Football is characterized by technical–tactical complexity and is a team sport associated with moments with high running and execution speed; these factors often decide the result of the game [2]. The game has become popular worldwide, and consequently the training methods have improved, the number of competitive moments in a season has increased, and the involvement of highly prepared and specialized players has been observed [3].

The "Federation International de Football Association" (FIFA) represents more than 270 million licensed players, with reports indicating that a similar number of players practice the sport without being registered with any football federation [4]. In the 2020/2021 season, more than one million players participated in registered football activities in Spain [5], with the number of youth football participants systematically increasing during the last decade [6].

There are cardiovascular and several metabolic and musculoskeletal health benefits associated with playing football, and these benefits have persuaded youth players and parents to engage in the sport [7]. Nevertheless, the requirements of football play during youth are associated with a high risk of injury when compared to other sports [8], leading to potential short- and long-term health consequences [9]. Although there is no complete agreement in the literature [10], running activities and high-intensity kicking in football may be the main triggers for thigh and groin injuries, while duels can commonly trigger ankle injuries. Moreover, head injuries and their long-term health implications have caused concern among parents, coaches, and football players [11,12].

The characteristics required to obtain a high level of performance in football have challenged coaches and researchers when it comes to talent identification [13], with football academies systematically considering talent development models at early ages in order to identify the most talented youth [14,15]. The detailed comprehension of injury occurrence is vital when it comes to implementing preventive strategies [16]. At least every third high-level player will be injured once or more during a season [17]. Consequently, it is of great interest to limit the severity and frequency of injuries, since previous reports indicated that EUR 500,000/month is the mean cost of an injured player in a professional team [18]. Hence, football injuries constitute a high economic burden on society [19], with an estimate of 8.1 injuries/1.000 h in professional male football players [20], with injured players still participating in some team football activities [21].

At youth levels, the athletes who exhibit the most advantageous physical characteristics are normally selected to play by football coaches [22]. The best results in physical fitness tests have been observed when comparing age categories [23]. The number of football-related injuries among youth has been associated with a higher participation rate during recent years, with negative consequences for public healthcare systems and an increase in economic costs [24].

Future performance in sports is negatively influenced by injury occurrence, largely because of the restriction in competition and training availability [25,26], as well as a plausible influence in an active lifestyle once the player's sports career has ended [27]. As such, it is our understanding that it is very important to mitigate the impact of injuries in youth football, with the creation of a robust research base regarding the epidemiology of injuries, constituting an important basis for analysis.

Despite the large number of registered male football players in Spain, very few epidemiological studies have focused on this specific population [28,29]. Recently, Robles-Palazón et al. [8] highlighted a significantly higher injury risk during competitive moments compared to training sessions, and a tendency to muscle/tendon injuries sustainability affecting the thigh in male youth football players. Moreover, the study showed an increase in the incidence rate with advances in chronological age (from U-12 to U-19).

Understanding the evolution of injuries in youth football over the course of a sporting season is essential to deepen knowledge, improve training planning and seek to ensure long-term development, particularly in elite academies, where players are exposed to intense training loads and competitive density. Hence, this study aimed to analyse the injuries in youth football players of a professional team of the Spanish League integrated into an elite academy, considering the sporting context, the month, and the category of the player.

2. Materials and Methods

2.1. Study Design

This study uses an ex post facto quasi-experimental methodology [30], because the groups were previously established and were not randomly selected, nor has any intervention been carried out or modification of the variables involved in the context. Furthermore, it is a longitudinal study, performed during the entire 2017/2018 football season, through an associative and comparative strategy [31].

2.2. Sample

A total of 227 male players in under (U) age categories between U-10 and U-18 (all involved in official championships during the football season), with two age groups in each category (A and B), except U-18, with three groups (A, B, and C), were evaluated. Only U-18 included three groups because this age category was over the years involved in the "Union of European Football Associations" (UEFA) Youth Champions League. For this study, the total sustained number of injuries during the 2017–2018 season was compiled and characterized. The U-18 players performed 4–5 group training sessions a week with regular individual training sessions apart, U-16 had the same methodology but four group training sessions a week, U-14 and U-12 were involved in three group training sessions a week, and U-10 only two group training sessions a week. From U-10 to U-14 players participated in one match per week and from U-16 to U-18 plus one match per week, regular games of the Cup or Youth Champions League occurred in the middle of the week.

The football season in the elite academy took place between the beginning of August and the end of June, the latter month constituting a transitional period with lower training loads and no official competitions, with the specific purpose of preparing teams and players for the following sporting season, prior to the vacation period, in July. This study considered the Helsinki Declaration's ethical standards for research in sports and exercise sciences [32]. Written informed consents associated with the football players aged 18 or over who participated in the study were obtained, as well as from the parents and guardians of underage players. This study was submitted to the University of Extremadura Ethical Committee (approved number 67/2017). Table 1 describes the age categories and respective number of players in the sample.

Table 1. Age categories and the respective number of football players.

Age Categories	Number of Players
U-10 A	14
U-10 B	15
U-12 A	25
U-12 B	14
U-14 A	24
U-14 B	24
U-16 A	25
U-16 B	24
U-18 A	20
U-18 B	22
U-18 C	20

2.3. Study Variables

The selected variables for the study were:

- Dependent variable: the number of injuries sustained per player.
- Independent variables: the sporting context in which the injury occurred (training or competition), the month in which the injury was officially diagnosed, and the category and team in which the injured player was integrated.

2.4. Statistical Analysis

First, a descriptive analysis was performed for the quantitative variables (mean and standard deviation, M ± SD). Subsequently, a test was performed to analyse the normality of the sample [33]. For this purpose, the Kolmogorov–Smirnov test was used through the Lilliefors correction, because the sample consisted of more than 50 cases. The results obtained showed that the sample had a non-normal distribution. Therefore, non-parametric tests were used to analyse the relationships between variables (Spearman correlation) and the differences between variables (Mann–Whitney U test and Kruskall–Wallis H test).

Spearman's correlation provided insight into the relationship between two variables, with values ranging from −1 to 1, indicating a positive or negative association. A positive association indicates that as the value of one variable increases, so does the value of the related variable [33]. In the same way, it allows us to understand the strength of the association through different intervals: null (0.00–0.25), low (0.26–0.50), medium (0.51–0.75), and strong or perfect (0.76–1.00). These intervals are identical for negative relationships [34].

The Statistical Package for the Social Sciences software (v27, 2021; IBM Corp., IBM SPSS Statistics, Armonk, NY, USA) was used to carry out the statistical procedures.

3. Results

A total of 196 injuries were observed from 242 cases because of injury recidivism or different injuries observed in the same football player during the season. Figure 1 depicts the mean number of injuries per football player and repetition rate in different age categories.

It can be observed that the average number of injuries in each age category increased with age, as well as the number of injuries per player, with greater emphasis from U-14 A upward. With regard to the location of injuries, sixteen different parts of the body were associated with injuries, although five of which accounted for the highest majority of incidence (162 injuries), namely the ankle (19), foot (10), hip (22), knee (27) and thigh (74). All the other locations of injuries were associated with less than 10 incidences during the football season, specifically abdominal, arm, back, face, head, leg, shoulder, thorax, wrist, and "others".

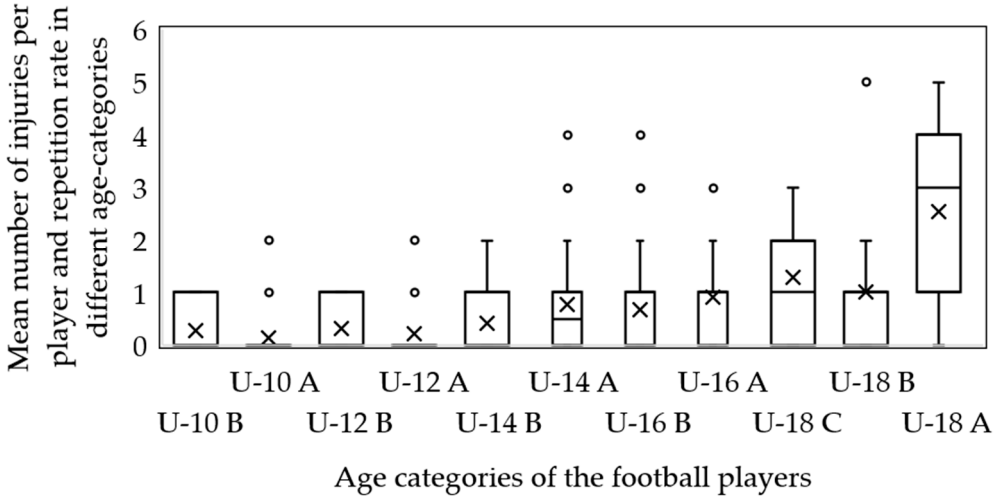

Figure 1. Mean number of injuries per player and repetition rate in different age categories. The bars and x represent the average number of injuries per player in the respective football age category and the dots are the repetition rate of injuries per athlete in the age category.

Considering the correlational analysis of the selected variables, a negative relationship was observed between the sporting context and the number of injuries sustained ($Rho = -0.203$; $p = 0.002$), and a positive relationship between the category and the number of injuries was identified ($Rho = 0.488$; $p < 0.001$). In contrast, no relationship was observed between the month and the number of injuries ($Rho = -0.024$; $p = 0.707$). Figure 2 shows the trend of injuries in all age categories throughout the entire football season.

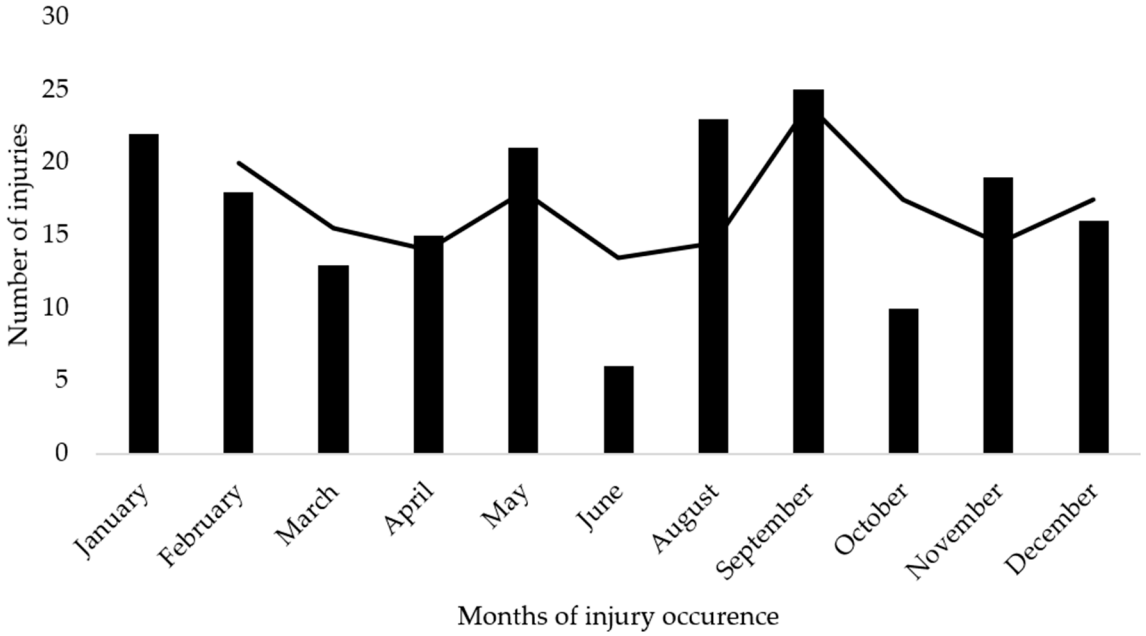

Figure 2. Trend of injury occurrence throughout the football season in all age categories.

Regarding the context, 118 injuries were sustained during training (62.8%) while 70 occurred in competitive moments (37.2%), the remaining cases were associated with accidents outside football. Table 2 shows the descriptive and comparative values related to the analysed sport context (training or competition). Significant differences were obtained depending on the sporting context, with a greater number of injuries associated with training.

Table 2. Descriptive results and differences regarding the context.

Variable	Training		Competition		*U*	*p*
	$\overline{X}$	SD	$\overline{X}$	SD		
Number of injuries	0.98	±1.207	0.58	±0.998	5773.000	0.002

U: Mann–Whitney U test; *p*: significant differences.

Table 3 shows the descriptive results and the differences according to the analysed category. Significant differences were observed between different categories.

Table 3. Descriptive results and differences regarding the category.

Categories	Number of Injuries		H	df	*p*	Post Hoc
	$\overline{X}$	SD				
U-10 A	0.14	0.47	72.96	10	0.000	U-14 A; U-14 B; U-14 B; U-16 A; U-16 B; U-18 A; U-18 B
U-10 B	0.27	0.46				U-16 A; U-18 A; U-18 B; U-18 C
U-12 A	0.23	0.53				U-14 A; U-14 B; U-16 A; U-18 C; U-18 A
U-12 B	0.32	0.48				U-16 A; U-18 A; U-18 B; U-18 C
U-14 A	0.77	1.07				U-10 A; U-12 A; U-18 A
U-14 B	0.41	0.73				U-10 A; U-12 A; U-16 A; U-18 A; U-18 B; U-18 C
U-16 A	0.91	0.81				U-10 A; U-10 B; U-12 A; U-12 B; U-14 B; U-18 A
U-16 B	0.68	1.09				U-10 A; U-18 A; U-18 C
U-18 C	1.32	1.09				U-10 B; U-12 A; U-12 B; U-14 B; U-16 B
U-18 B	0.95	1.09				U-10 A; U-10 B; U-12 B; U-14 B; U-18 A
U-18 A	2.55	1.63				U-10 A; U-10 B; U-12 A; U-12 B; U-14 A; U-14 B; U-16 A; U-16 B; U-18 B; U-18 C

H: Kruskal–Wallis H test; df: Degree of freedom; *p*: significance difference.

Concerning the type and number of injuries sustained by the youth football players during the season, it was observed that most injuries were muscular (101), followed by articular injuries (49), both combining 150 injuries in a total of 196.

4. Discussion

This research analysed the injuries in youth football players integrated into an elite academy of a professional team of the Spanish League. The main findings highlight: (1) The month does not influence the sustainability of injuries. (2) The majority of injuries occur in the lower limbs and are either muscular or articular. (3) The number of injuries and repetition rate per football player increases in line with the age of players. (4) The sports context (training or competition) influences the sustained number of injuries.

4.1. Location and Types of Injury

Quadriceps, especially hamstring muscle injuries, were indicated as being the most frequently diagnosed in previous studies associated with youth football players [35]; therefore, training, fitness, and medical staff should be persuaded to pay special attention to these particularities and implement routines and measures directed to the reduction in the number and severity of muscle injuries at these specific locations [36], including ankle sprains [37], ensuring a safer football practice.

A recent study indicated the knee and ankle as the body parts with the highest injury incidence, severity, and burden across all age categories [38]. Additionally, the authors found that for all age categories combined, the highest incidence was observed for muscle injuries, stressing that the highest incidence of muscle injuries was found in the U-15 age category, associating the evidence with the growth spurt during these specific ages.

Another recent study highlighted that knee injuries accounted for 53% of all injury costs, nearly EUR 9.000 per injury, leading the authors to suggest special attention and priority to this location regarding injury prevention [19]. Moreover, Pritchett [39] and Cumps

et al. [40] also highlighted that knee injuries are associated with serious health-related consequences for individuals, beyond being cost relevant, such as prolonged absence from physical activity [41,42].

Our results support previous findings since the thigh was associated with more injuries in all age categories (total of 74 in 196) followed by the ankle (19), foot (10), hip (22), and knee (27). Furthermore, the highest prevalence of muscular injuries was also a reality in our study; however, contrary to Ruf et al. [38], the increase in the number of injuries across all age categories, specifically each player, was observed in the U-14. Our research took place in an elite European football club with a vast tradition in the Champions League competition, where some of the best football players were formed over time, and players from the A team were considered Ballon d'Or by the France Football magazine. Ruf et al. [38] based their study in a German football youth academy from the age category U-14 to U-19 (a total of 166 players) between seasons 2016/2017 and 2018/2019. This difference in the sports status of the academy and football players may explain our observation regarding the increase in the occurrence of injuries before the U-15 age category.

4.2. Seasonal Variation of Injuries

The higher number of tackling, cutting, and sprinting in training and competitive moments may lead to injuries in football players [43], and seasonal variation of the injury incidence showed a peak in February in a recent study [8], which may be related to an inadequate workload after a rest period that might have led to a decline in physical fitness [44] or the return to competition after the winter break (extended until the second week of January in Spain). To prevent these undesirable situations, we agree with previous suggestion of more regular short breaks throughout the season [44,45], which allow players to recover from match and training loads, while avoiding the decline in their fitness levels.

It was also previously suggested that football club structures should consider regularly monitoring the training process, assuming this as fundamental to improve the detection and prevention of injuries and, simultaneously, enhance sports performance [46], considering that when football players are engaged in the specialization of certain mission-tactical game functions, the body composition, anthropometric, and physical fitness characteristics become relevant, and possibly affect game performance [47].

The results from our study revealed that the month does not influence the sustainability of injuries in youth football players from an elite academy. It is our understanding that due to the higher regular training stimulus associated with weekly championship matches, Spanish Cup, tournaments, and specifically in U-18 playing in the Youth Champions League, the players are more adapted to regular stimulus. Another factor that may have influenced our results (particularly the downtrend in injuries from January to May) is the cultural context, namely in Spain, King's Day is a more important date compared to Christmas, which influences the training routines close to New Year's date, and also the environmental conditions, namely the weather is different compared to Germany, the context in Ruf et al. [38].

4.3. Match and Training Injury Incidences

The topic of low training volumes to provide the required physical readiness for match intensity in youth football players was previously addressed with an indication of a possible higher match exposure relative to training [48]. It was also previously indicated that matches present the highest data on injury incidence and injury burden, representing the most worrying events [8,25,49]. In these competitive moments, collision and an elevated number of high-intensity situations are associated with players' actions [50], which may induce neuromuscular fatigue and motor control damage that may trigger injury occurrence. Previous research described similar tendencies for training incidences; nevertheless, match injury rates were greater than the data provided by youth football players in Italy [51], Portugal [52], Brazil [53], and Spain [28,29].

It was previously stated by Read et al. [44] that strength and conditioning programs and injury prevention tasks have not been prioritized due to the lack of time to train in football, and consequently the focus of coaches directed to other components of football training associated with the more competitive aspect (i.e., technical, and tactical skills). Consequently, daily high-quality training routines associated with the match demands are very important to prepare youth football players for competitive moments [54]. Nonetheless, a study developed with football coaches from three European countries (with Spain included), underlined a deficit in knowledge, confidence, and attitude towards the implementation of injury prevention programs in youth players [55], leading the authors to suggest the improvement of the education of coaches regarding injury risk management [55].

The results of our study revealed a negative relationship between the sporting context and the number of injuries sustained. Close to 65% of injuries were sustained during the football training process and as previously pointed out, we found that most injuries were muscular (101) followed by articular (49), both contributing to the large majority of total injuries. If we focus on the months of injury occurrence, it was observed that the months associated with the restart of training routines after interruptions (August, September, and January) along with May (end of championships, fatigue accumulation), were those in which the highest number of injuries occurred, which suggests the need for the planning and implementation of an injury program throughout the season, with particular emphasis during these season moments.

4.4. Comparisons by the Age Category

It was previously indicated that in youth football players, the highest injury rate arises in U-15-16 and U-17-19 players, with notorious advances in chronological age [8], a trend previously associated with greater training loads [35], namely related to the ability to perform at higher intensities as players progress to later adolescence stages [56]. In addition, the U-15 and U-16 age categories have been associated with the highest burden and number of severe incidents [29,35,57,58]; however, this is not consistently reported across studies [52,59]. These age categories match with the periods of peak height velocity [60] and peak weight velocity [61], in which fast changes in the body of football players may temporarily compromise the structural capacity of body tissues to tolerate the mechanical demand derived from playing football [62].

In our study, we found age category differences in injury incidence with the older football players, starting in U-14, evidencing a higher total number of injuries within the age category compared to the younger ones and, additionally, a higher individual number of injuries, clearly observed in the U-18 age category. We consider that these results reflect the demand of the training process in elite youth football academies in all age categories and increasing daily demand with the progression of age and competitive commitments, that have greater emphasis and regularity in U-16 and U-18. We should also note that the competitive density should be carefully monitored since most injuries found were most probably associated with fatigue, which may be associated with weeks in which, namely, the U-18 football players in elite youth football academies sometimes play three times in seven days (two times for the Championship on the weekends and in the middle of the week for the Cup or Youth Champions League).

Some limitations in this study should be addressed. First, the training load outside the academy was not considered and the number of players in each age category was not the same. Secondly, information regarding the biological maturity of the players was not assessed, neither physical fitness nor anthropometric and morphological data, these might provide additional information about the injury risk. Thirdly, we did not compare the results from an elite youth football academy with other lower-level academies or players not engaged in football academy programs, so the results should not be generalized and considered for other level football players. Lastly, we did not consider the playing position and individual competitive involvement throughout the season, which could provide more

information about fatigue mechanics, as well as the separation of thigh muscles in the analysis, namely quadriceps and hamstrings.

Future research should consider the abovementioned limitations. In addition, combining data with match and training load data from a global navigation satellite system could provide very helpful information relating specific training and recovery tasks to fatigue mechanisms in the future, which could support football coaches regarding the possibility of preventing the risk of injury at an early stage. We also suggest, if possible, the severity and burden of injuries to be determined, and perform this evaluation considering more narrow age categories and both sexes regarding the relationship between intervention programs and injury occurrence, with an adequate pre-determined sample power.

5. Conclusions

We found a total of 196 injuries from 242 cases, which indicates injury recidivism or different injury sustainability in the same football player during the season, mainly from the U-14 upwards, but with greater emphasis on U-16 and U-18. Sixteen different parts of the body were associated with injuries, with five of those totalling the majority of incidences (162 injuries), namely the ankle (19), foot (10), hip (22), knee (27), and thigh (74).

Most injuries were sustained during training (62.8%) and were muscular (a total of 101), followed by articular injuries (49), both contributing 150 of the total injuries. Despite this, no relationship was observed between the month and the number of injuries, the months associated with the restart of training routines after interruptions (August, September, and January), except for May, were those in which the highest number of injuries were observed, which suggests the need for the planning and implementation of an injury program throughout the football season, with special attention given to these football season months.

In this particular, the findings in this study suggested that it is advisable to carry out a greater number of hours of injury prevention training in U-16 and U-18, and football coaching staff should pay special attention to the regular monitoring of young players' development to balance and adapt training interventions to individual needs, considering the implementation of specific injury risk mitigation strategies in youth football based on long-term development.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the University of Extremadura (approved number 67/2017) for studies involving humans.

Informed Consent Statement: Informed consent was obtained from all subjects, or their parents/guardians (when appropriate) involved in the study.

Data Availability Statement: The data that support the findings of this study are available from the last author (martingamonales@unex.es), upon reasonable request.

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Conflicts of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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