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THE IMPACT OF PHYSICAL TRAINING ON REDUCING THE INCIDENCE OF INJURIES IN HIGH-PERFORMANCE FOOTBALL

THESIS SUMMARY

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INTRODUCTION

Being a coach is a beautiful profession, but complex, which requires combining qualities and psychological knowledge, for example to lead a group, knowledge of physiology, to understand the responses of the athletes' body, knowledge of training methodology, to prepare a strategic training plan and choose the most correct working methods.

Coaches assist football players in developing their full potential. They are responsible for their training, analyze their performance, provide technical support and instill encouragement, as well as assume an important role of reference, often on the youngest even of driving also, in the life of the athlete.

The importance of the role of coaches has also been declared at European level. For example, in November 2017, under the presidency of Estonia, the European Council produced a political declaration by all European Union ministers responsible for sport on the role of coaches in society.

Being a successful coach, which does not mean winning the most prestigious sports competitions, but being able to get the most out of the training and competition process, requires not only helping athletes to master sports techniques and tactics, but also transmitting skills to them, also representing reference development models for the person. A coach is in fact also a leader, and as such exercises a certain power over the athletes, which must be understood and managed to help the athlete.

Being a coach is therefore a profession that requires you to make continuous choices, sometimes even difficult and/or not without an ethical dilemma. In fact, the process of coaching itself is based on interpersonal dimensions that are varied and complex and is characterized by objectives that can be multiple (Jones & Wallace, 2005).

The first study of the research analyzes the opinions of fitness specialists in two different periods: 2014 and 2024. The results indicate a complex perspective on the phenomenon and reflect modern training concepts.

The second study examined the relationship between physical fitness and injury prevention in football, involving 118 professional and amateur football players monitored throughout an entire sports season.

The main study investigated the effectiveness of structured injury-prevention programs, systematic training-load monitoring, and periodized performance conditioning in professional football, aiming to enhance athlete availability, reduce injury incidence, and support sustainable performance across competitive seasons.

PART I. THE THEORETICAL FOUNDATION OF THE RESEARCH TOPIC

CHAPTER 1. Football and its effects on human behavior: fundamental notions

1.1. Fundamentals of the impact of football to human being

1.1.1. Psychological effects

Carrying out sports activities, in particular within an open skills and acyclic sport such as football, allows you to develop a series of fundamental mental skills even outside the sports context. Scientific literature suggests that sports that allow you to develop a wide variety of mental processes and abilities have two main characteristics: they are characterized by a dynamic and constantly changing context and they provide for the implementation of strategic skills, in which it is necessary to make decisions quickly, in relation to the behavior of one's companions and opponents.

A study carried out by Vestberg et al. (2012) has shown the existence of a strong link between the different processes involved in executive functions and the success on the field of young professional team players.

1.1.2. Cognitive effects

The cognitive dimension of football performance represents a fundamental component in the execution of efficient and adaptive in-game behaviors. Decision-making processes are continuously shaped by the dynamic analysis of spatial positioning, tactical configurations, and the evolving interactions between teammates and opponents. Core cognitive functions such as attention, working memory, perceptual processing, and anticipatory skills underpin a player's capacity to respond optimally under conditions of temporal and environmental pressure.

Description of the Agility Concept

Agility is a multifactorial ability starting from:

1. Mastery of the technical gesture;
2. Ability to transfer skills learned from another discipline;
3. Ability to find a variant to the execution of the gesture.

The difficulty of finding an accepted definition of agility could be the result of multiple factors, coming from various disciplines of sports science, that influence agility performance. Strength coaches could define agility in terms of the physical qualities involved in the change of direction.

However, in the context of comprehensive set of definitions, simple, temporal, spatial, and universal agility provides a unique framework for understanding the needs of many sports.

Young et al. (2015) outlined a comprehensive definition of agility as it is linked to the practice of sports such as football. In particular, the authors pointed out that there are two main components of agility: the speed of change of direction and perceptual and decision-making factors.

Perceptual and decision-making factors

The perceptual and decision-making factors refer to a series of information to draw on for the rapid and correct motor or technical response, linked not only to an increase in information in visual search, but also to highly specific information for a particular sport

A great source of information is the posture and kinematics of the opponent. For example, in football, experienced players use signals from the flanks to anticipate direction and dodge an opponent.

1.2. The impact of physical training aspects on sports performance

The influence of physical training variables on sports performance represents a critical domain within the field of exercise and sport sciences. Performance outcomes are significantly mediated by the development of fundamental biomotor capacities, including muscular strength, aerobic and anaerobic endurance, speed, flexibility, and motor coordination.

Anaerobic training

The practice of anaerobic training helps the player both in terms of performance capacity, especially in moments of high intensity, and to optimize recovery between one sprint and another without incurring fatigue.

By improving the individual components, a higher performance capacity should in theory be achieved, decreasing the time in the decision-making phase and / or that of the motor response.

Agility in football

Attempting to classify the ability to change direction among the normal conditional factors poses some difficulties. Little & Williams (2005), state that it is a relatively independent motor ability. It cannot be attributed to speed as it is related to neither maximum travel speed nor maximum shutter speed. It has also been shown that linear sprint training has no immediate effect on sprint ability under conditions of change of direction. And, on the other hand, training in conditions of change of direction has no significant effect on linear sprint (Young et al., 2001).

The possibility of changing direction quickly and effectively also relies on components that depend both on force and on an adequate use of coordination skills.

Plyometric training

This training, which its inventor Yury Verchoshansky, also called the shock method, is an elective method if one wants to improve reactive strength engagements. The objective of this method, for the definition of which the term plyometrics has now been established, which was created later, is to improve the realization of the stretching-shortening cycle.

In research by Miller et al. (2006), a controlled longitudinal study, conducted on a sample of 28 subjects of an unspecified level, the effects of a six-week plyometric training (two weekly training units) on the development of the ability to change direction in football were studied.

Thanks to the training program, the subjects of the research group were able to significantly improve their results both in the Agility Test, and in the Illinois Agility Test, both compared to the entrance test and compared to the control groups.

Coordination training

Jullien et al. (2008) were able to prove the positive effect on the ability to change direction of a special coordination training lasting three weeks. In the research, 26 football players from a professional team were divided into three different training groups. The "coordination" group (isolated coordination training with a combination of coordination, strength and sprint training) was compared with a "technique" group (specific training of football technique) and a group "squat exercise" (90% of 1 RM).

The results of the study demonstrate improvements in all three groups in the Agility Test but were greater in the "coordination" group than in the "squat exercise" group. These results are also attributed to an improvement in intra-muscular coordination.

SAQ training

This type of training, SAQ (Speed, Agility, Quickness), was developed in the United States and has been known since the 80s in American football training. This training must be considered a link between speed training and the ability to change direction and is based on the so-called Agility Drills.

The method contains a progressive system of exercises and aims at the development of the fundamental skills of players in "dynamic" sports, serving the development of dexterity and precision with an increase in the speed of players. The most frequently used training tools are the Agility Ladder, Speed Hurdles or Agility Cons.

Relationship between straight sprint speed and direction change speed

Paradoxically, it would seem that many strength coaches believe that there is indeed a strong relationship between straight-line sprint speed and direction change speed, as some articles and many training sessions tend to address both qualities at once.

Young et al. (1996) also investigated the relationship between speed and speed of change of direction among Australian Rules football players. In this study, researchers compared the sprint in a straight line, the sprint when bouncing a football ball, the sprint with three planned changes of direction at 90 degrees, the sprint with three planned changes of direction at 90 degrees when bouncing a football ball, and the sprint with three changes of direction at 120 degrees. The results supported the researchers' hypothesis that the correlations between sprint and agility tests were all very low, indicating that sprinting, sprinting during a ball bounce, and sprinting during change of direction were distinct and specific qualities.

Unilateral muscle strength and quality of power and speed of change of direction

However, Young et al. (2015) reported that muscle imbalances of the lower extremities affect the speed of the change of direction. Their participants were found to be significantly slower at changing direction from the weaker leg when performing a unilateral drop jump test for reactive force. The authors suggested that this was due to the similar thrust action of the drop jump (reactive force movement) and that of a dynamic push in the change of direction during the sprint.

Based on the results it would appear that reactive force imbalances are a good predictor of imbalances in the performance of stronger and weaker leg change sprints.

Anthropometry and speed of change of direction

Very little research has attempted to correlate anthropometric variables and the performance of the speed of change of direction. Theoretically, factors such as body fat and the length of body segments can contribute to agility performance. By comparing two athletes of equal body mass, the athlete with more fat mass will have less lean mass to contribute to agility performance speed requirements. In addition, the athlete with more weight will have a greater mass of excess adipose tissue (not lean body mass) and inertia, thus requiring greater force production per unit lean mass to produce a given change in speed or direction (Enoka, 2002).

Technique

The technique of running has been suggested to play a key role in the execution of sprints with changes of direction (Sayers, 2000). In particular, a center of gravity in a forward and low position appears essential to optimize acceleration and deceleration, as well as to increase stability.

1.3. The characteristics of effort in the game of football

The game of football is characterized by intense physical activity that requires players to have technical and tactical skills and excellent athletic preparation. During a match, a footballer runs a lot, alternating phases of slow running, sprinting, changes of direction, jumps and tackles. This variety of movements significantly challenges the muscular, cardiovascular and neuromuscular systems, making physical preparation a fundamental component of sports performance.

Performance model in football: performance analysis

A player during a game is engaged in an effort of about 90 minutes to which must be added those of recovery. Thanks to time motion analysis, a technique that describes the kinematic activity of the athlete, we know that the high-level football player travels about 9-12 km.

This method of investigation showed that about 2200-2400m are high-intensity routes and 850-950m are very high intensity routes (>19 km/h). Instead, 250-350m are done by sprinting (> 25.0 km/h).

The player's effort in the football performance model

The effort of the player is to be considered intermittent. In fact, from the analysis of the performance model, we know that he changes activity every 4-6s. This results in the execution of about 1300 motor patterns during the game.

During a football game, players are required to perform intermittent efforts of varying intensity. Numerous studies have highlighted how performance in football requires a balance between aerobic and anaerobic capacities. Castellano et al. (2019) highlighted that interval training, aimed at improving high-intensity endurance, can significantly contribute to match performance.

How far does a footballer travel?

The distance traveled is one of the first parameters that are sought in the analysis of the performance model in football.

The differences between players can be explained by the real physical needs of the race. These analyses form the basis of the football performance model. In the game every role and every player is dependent on many factors. His position on the field, and that of his teammates, opponents, the tactics of our team and the opposing one clearly influence his movement model.

High speed and high intensity: what changes in the performance model in football

For many years the evaluation of the player's performance has been linked only to the distance traveled and the relative speed thresholds. However, these do not consider the energy cost of running and the quantification of accelerations and decelerations.

However, following the introduction of the new match analysis approach, it was possible to evaluate and classify not only the distance traveled and the relative speed thresholds, but also the acceleration and deceleration thresholds, and the metabolic power bands, product of the energy cost (J/m/kg) for the speed (m/s). This has been a revolution in the analysis of the performance model in football.

CHAPTER 2. Injuries in the game of football – several general aspects

2.1. Training, monitoring and injury risk management in professional football

Football injuries can range from minor bruises to serious injuries that require surgery and long recovery periods. The consequences of an injury are not limited to the player, but also extend to the team, affecting performance and the chances of success in national and international competitions. For this reason, injury prevention has become a priority for professional teams. One of the most effective approaches to injury prevention is the implementation of specific training programs.

Injury prevention is not only a priority for football players health but also a fundamental strategy for maintaining individual and team performance. The most common injuries involve the lower limbs, particularly the hamstrings, quadriceps, and calf muscles, as well as ligament injuries such as anterior cruciate ligament (ACL) ruptures (Waldén et al., 2016).

Professional football teams are adopting scientific approaches to physical preparation, using advanced technologies to monitor players' performance and physical condition. The use of GPS devices and heart rate monitors allows coaches to collect valuable data on football players performance during training and matches (Lacome et al., 2018).

This information can be used to adapt training programs and ensure that players are always in top form (Beato et al., 2024). In addition, physical preparation must be customized to the individual needs of the players. Each athlete has a unique physique and responds differently to training stimuli (Woods et al., 2020). Therefore, it is essential that athletic trainers develop customized programs that take into account the physical characteristics, technical skills and playing positions of football players.

The use of GPS, wellness questionnaires, and internal load metrics allows coaching staffs to optimally manage training and reduce the incidence of injuries. Therefore, injury prevention in football requires a multidimensional approach that integrates neuromuscular warm-up protocols, eccentric exercises, load management strategies, and ongoing athlete education. However, compliance remains a critical factor: without consistent program adherence, benefits are reduced (Soligard et al., 2010).

The chances of injury increase when the player does not have adequate physical preparation (Jiang et al., 2022, Iraqui-Rato & Cuesta-Barriuso, 2024), especially in an amateur athlete, and when the game is played on uneven ground. For semi-professional or professional players, the presence of an athletic trainer is essential to regulate the type of exercise and its duration and regularity.

Physical preparation is a crucial element in injury prevention, especially in football, where physical stress and game dynamics can be extremely intense.

Today, in this first part of the third millennium, we find general characteristics that see some factors as fundamental for preparation, solid pillars on which to base the training process (Gabbet, 2016, Oliveira et al., 2020, Dupont et al., 2010):

- General Physical Conditioning;
- Specific Training;
- Injury Prevention through Data Analysis;
- Flexibility and Mobility;
- Active Recovery;
- Nutrition.

2.2. Overview of major injuries

Football injuries are common and can vary in severity and type. Here is a description of the major injuries, including sprains, muscle strains, ligament injuries, and fractures, along with the incidence of these injuries at different levels of the game.

Sprains: involve the ligament of a joint and occur when a joint is forced beyond its normal range of motion

Muscle Strains: are injuries that occur when muscle fibres become overstretched or torn. They can affect various muscles, but hamstring tears are particularly common

Ligament Injuries such as injuries to the anterior cruciate ligament (ACL) and the medial collateral ligament (MCL), are serious injuries that occur when the ligaments that stabilize the joints (especially the knee) break.

2.3. Risk factor of football injuries

Football injuries can be influenced by a variety of risk factors, many of which are related to the intensity of the game, physical preparation, and general well-being of the player. Here is an overview of the main risk factors that contribute to injuries (Ekstrand et al., 2011, Halson, 2014, Gabbett, 2016):

- Functional overload;
- Poor nutrition;
- Lack of adequate recovery;
- Poor Strength and Conditioning Training;
- Playing Surface;
- Environmental Factors.

2.4. Scientific research that links physical preparation to injury reduction

The science of prevention, that is, the link between physical preparation and injury reduction, is based on scientific evidence, research experiences and in-depth studies that include several years of research and experiments. This is an increasingly central area in modern sport, and especially in football, where the intense calendar and the high level of competition increase the risk of injuries.

Indeed, even FIFA has publicly expressed concern about the increase in injuries related to "calendar congestion". Scientific evidence to support this has been carried out by several authors, in fact, a 2019 UEFA research tells us that analysing 4000 injuries in top European club teams, players who play more than 50 games/year have double the risk of muscle injury compared to those who play less than 30 and for this reason the highest incidence is observed in the months with 2-3 games per week.

2.5. The science of prevention and insights from empirical research

The link between research and prevention has been widely demonstrated, numerous scientific studies have confirmed that correct physical preparation significantly reduces the risk of injuries.

In particular, strength training (especially eccentric): reduces muscle injuries, such as hamstring strains and tears, stability and neuromuscular control through exercises on unstable surfaces, balance, core stability decrease the risk of sprains (ankle, knee).

Recovery, as previously stated, also plays a fundamental role. In fact, recovery (sleep, nutrition, massages, cryotherapy) is an integral part of prevention and pre-race dynamic stretching and joint mobility improve the preparation of the musculoskeletal system.

2.6. Biomechanical techniques and movement analysis: how biomechanical techniques are used to prevent injuries and improve performance

Biomechanical techniques are used in football both to prevent injuries and to optimize athletic performance. This approach is based on the analysis of human movement, studying how muscles, bones, tendons and ligaments work together during the various game actions (running, jumping, shooting, changing direction etc.) (Bartlett, 2007).

In fact, biomechanical techniques help identify and correct incorrect or risky movement patterns for the integrity and health of the player. Some examples are the analysis of walking and running in which the posture and support of the foot are evaluated to identify imbalances that can cause injuries (such as plantar fasciitis, tendonitis or knee problems). The evaluation of the symmetry of a football players who always jumps with the same leg or always changes direction to one side can develop muscle imbalances this causes a high risk of injuries such as muscle tears or ligament injuries.

2.7. The relationship between physical fitness and injuries in European football

In European professional football, physical fitness is a fundamental determinant for both performance and injury prevention. A football player ability to maintain optimal levels of strength, endurance, agility and recovery has a direct correlation with the incidence of musculoskeletal injuries.

In numerous studies it was found that teams with structured fitness and prevention programs (neuromuscular training, eccentric exercises, load management) showed up to 30% fewer muscle injuries: faster recoveries and fewer relapses.

Therefore, teams with highly integrated medical staff and athletic trainers have better athlete availability indices. Instead, Gabbett (2016) hypothesizes that a good level of fitness protects against injuries, but acute loads do not proportionate to the chronic load increase them.

2.8. Future of injury prevention in football

In modern football, injury prevention has become a strategic priority at both professional and youth levels. With the increase in game intensity, schedule density and athletic demands, the incidence of injuries, especially muscle and joint injuries, has grown significantly (Ekstrand et al., 2021).

Traditional prevention systems are based on periodic tests (isokinetic, functional, subjective assessments), which offer a static snapshot of the athlete's state.

The future of prevention also involves continuous and real-time monitoring of the athlete through wearable devices, inertial measurement units (IMU), integrated into footwear, clothing or bands, detect accelerations, rotations, joint angles and joint loads during activity.

In conclusion, artificial intelligence and real-time monitoring represent the new frontier in injury prevention in football. These tools allow us to move from a reactive approach to a predictive and proactive one, based on objective and continuously updated data.

2.9. Impact of injuries on football players careers: recovery, retirement and post-injury psychology

In professional football, injuries represent one of the main threats to athletes' careers. In addition to direct physical effects (loss of performance, downtime), injuries can compromise contractual stability, influence club dynamics and, above all, cause significant psychological consequences that affect recovery and the decision to continue or end a career.

According to the UEFA Elite Club Injury Study (Ekstrand et al., 2021), a professional football player suffers on average 2 injuries per season; muscle injuries represent approximately 40% of the total; knee (especially ACL) and joint injuries represent those with the greatest impact on a career.

Injuries in football are not only a physical interruption, but also a complex psychological challenge that can compromise future performance, motivation and career duration. The integrated scientific approach, which combines physical rehabilitation and psychological support, remains essential to optimize the return to the field, prevent early retirement and promote the long-term well-being of the football players.

2.10. Injury management and recovery: how professional teams manage injuries and post-injury recovery strategies

Injury management and post-injury recovery strategies in professional football have become increasingly scientific, personalized and multidisciplinary in recent years, thanks to the integration of sports medicine, physiotherapy, athletic training, nutrition and advanced technologies.

The most used techniques are cryotherapy and compression, rest, anti-inflammatories and physical therapies. In the second phase, an early mobilization is carried out that aims to restore the ROM (Range Of Motion), neuromuscular activation and the reduction of atrophy.

The most used methods are isometric and then eccentric exercises, active/passive mobilizations, manual and electrical physiotherapy. Once the physical therapies are finished, the re-atheization begins through the recovery of strength, balance, coordination, specific resistance.

The most used workouts are those in water, anti-gravity treadmills (Alter G), core stability exercises and plyometrics.

CHAPTER 3. Modern systems of physical preparation in football and their impact on performance and injury prevention

3.1. Athletic preparation in football

Football, as stated in the previous sections, is a multifactorial sport that includes different coordination and conditional skills. Unlike other sports such as athletics or weightlifting, football is a sporting game and like all sporting games it does not have one component that prevails over the others.

However, some factors remain constant and thanks to this stability in general gestures, fundamental factors can be identified. In fact, training focuses on several key areas to improve the overall performance of the players:

- Strength;
- Endurance;
- Agility;
- Mobility;
- Speed.

3.2. Training programmes for football players

In European football, athletic trainers play a fundamental role in ensuring that players are in excellent physical shape and ready to compete at the highest level. The methodologies used for training and physical preparation focus on various aspects, including specific training, active recovery and stretching.

The analysis of the methodologies used by athletic trainers in European football shows an increasingly scientific and personalized evolution, in line with the growing intensity of the modern game. The main areas of intervention are analysed below: specific training, active recovery and stretching, with practical examples and references to the most widespread trends in top European clubs.

As for active recovery, there are various methodologies that can be applied to accelerate recovery and allow the player to be able to return to performing in the shortest possible time, accelerating recovery:

- Post-match cool-down workouts;
- Recovery technologies;
- Stretching and Mobility;
- Emerging trends.

3.3. Advanced training techniques for monitoring physical condition in football

Contemporary football requires football players to perform increasingly higher, with intense rhythms, quick decisions and a high frequency of matches. In this context, advanced training techniques are based on the integrated use of technology, the personalization of the load and the scientific analysis of movement.

Current technologies used in professional football to monitor the physical condition of football players aim to optimize performance and prevent injuries. These methodologies evaluate football players through real-time monitoring of their physical condition, both in terms of internal and external load.

For wearable technologies, the most used are those based on the GPS (Global Positional System) signal that through the signal that from the device worn by the player arrives at the satellite allows you to monitor the distance travelled, the average and maximum speeds reached, the number and intensity of sprints as well as accelerations and decelerations.

For internal load, there are different fabrics with integrated sensors (Hexoskin, Kymira) and they collect data on heart rate, breathing, body temperature and superficial electromyography (sEMG). Systems that detect player performances remotely, on the other hand, do not need devices worn by football players because they work through high-speed cameras and optical systems. In fact, high-resolution and high frame rate cameras are used (Vicon, Dartfish, STT Systems).

3.4. Role of coaches and athletic trainers

In modern football, characterised by intense rhythms and congested calendars, injury prevention is one of the main responsibilities of the technical staff. Coaches and athletic trainers work closely together to design programmes that guarantee physical efficiency, continuity of performance and the protection of the football players muscular integrity.

Prevention is not an isolated activity, but a multidisciplinary process based on adequate warm-up, preventive training, active recovery and constant monitoring.

Preventive workouts are designed to reduce the risk of muscle injuries (especially hamstrings, adductors, calves), strengthen joint structures (knees, ankles, hips), work on balance, core stability, and neuromuscular control.

Coaches and athletic trainers are called upon to build an environment that promotes continuity of performance, minimizing risk factors.

3.5. Prevention programs and studies based on physical preparation

We present an overview of specific prevention programs aimed at reducing injuries in football, with a focus on initiatives promoted by international organizations such as UEFA, FIGC and other sports bodies:

- UEFA – "UEFA Injury Study" and "UEFA Elite Club Injury Study" (ECIS);
- FIGC – Prevention Programs of the Italian Technical Sector;
- FIFA – "FIFA 11+";
- Norwegian Prevention Program – The Oslo Sports Trauma Research Center (OSTRC).

PART II. AUTHOR'S OWN CONTRIBUTIONS

CHAPTER 4. Investigative approach 1

4.1. The evolution of coaching in football

To be able to achieve high levels of performance it is essential to plan and manage training loads following a precise methodology.

Over time, various theories have emerged on training methodology based on developments in physiology applied to sport. In this area, research has contributed effectively to developing working methods aimed at developing and maintaining performance.

The presence of athletes was supported and maintained by coaches, athletic trainers, masseurs who selected the most capable talents, organized specific training courses with loads periodized over time, took care of the technical-tactical aspects of the competition through auxiliary means (tools, overloads), improved means and methods to have maximum functionality and adherence between training and competition.

In fact, a coach or athletic trainer has several ways at his disposal to be able to hit a certain conditional ability. A preparer's quiver is very large and there are many arrows inside it. However, the arrows available to the preparer are not all the same. The trainer must have the sensitivity to choose the right one and fire it at the most appropriate time.

4.2. Research premises

The contemporary development of football training reflects the evolution of sport science, integrating physiological, biomechanical, psychological, and methodological knowledge into a structured performance system. The modernization of training planning, load monitoring, recovery strategies, and evaluation procedures has become essential for optimizing performance and preventing injuries in elite football.

At the same time, Strength and Conditioning (S&C) coaching has undergone significant professionalization, with increasing emphasis on academic training, certification, individualized workloads, and technological monitoring tools. However, the extent to which training and evaluation strategies have evolved over time within elite football remains insufficiently documented.

Therefore, the present research is grounded in the premise that the methodological approaches, evaluation tools, and conditioning strategies adopted by S&C coaches in elite football have undergone measurable transformations over the last decade, influenced by scientific advances and performance demands.

4.3. Research methodology and instruments

A descriptive research design was used in this study. All those responsible for the athletic training of the teams belonging to the Italian football championship (Serie A) were interviewed in 2014 and 2024 (**20 S&C coaches for 2014** and **20 S&C coaches for 2024**).

In the two interview sessions the questions were identical. Each trainer carried out the interview independently using a questionnaire that was sent via email. Each subject had no time limit to complete the questionnaire.

The nature of the questions was varied and ranged from personal information (education qualification, previous experience) to methodological questions. The answers had a different form: closed answers with pre-filled options and open answers in which the subject illustrated examples of his working method.

4.4. Research hypotheses

The present study is based on the following hypotheses:

H1. Training and evaluation strategies adopted by S&C coaches have significantly evolved between 2014 and 2024.

H2. The professionalization of S&C coaching has increased, reflected by higher academic qualifications, certifications, and professional experience.

H3. The use of systematic performance testing has increased, particularly during the competitive season.

H4. Modern strength and conditioning programs emphasize individualized, functional, and technology-assisted approaches more than in the past.

H5. Coaches in 2024 attribute greater importance to neuromuscular and speed-related performance characteristics compared with 2014.

4.5. Research objectives and tasks

General objective

To investigate the evolution of training, evaluation, and management strategies adopted by strength and conditioning coaches in elite Italian football (Serie A) between year 2014 and year 2024.

Specific objectives

1. To identify the professional profile and background of S&C coaches in the two reference periods.
2. To analyze changes in testing procedures used during pre-season and in-season phases.
3. To examine the evolution of methodologies applied for strength, power, aerobic conditioning, and plyometric training.
4. To assess the importance attributed by coaches to different performance characteristics of players.
5. To identify the monitoring systems and tools used to regulate training loads.
6. To determine trends in periodization and strength-training targets.

Research tasks

- Reviewing the theoretical foundations of football training and performance development.
- Designing and distributing a standardized questionnaire for S&C coaches.

- Collecting data from two temporal cohorts (2014 and 2024).
- Organizing and processing responses using descriptive statistical analysis.
- Comparing methodological trends between the two periods.
- Interpreting findings in relation to contemporary sport-science frameworks.

4.6. Statistical procedures

The subjects interviewed remained completely anonymous during the statistical analysis of the data. The data was processed through Excel. The data is divided into two periods, 2014 and 2024, and all responses have been grouped under the period to which they belong.

Based on the type of variable, a summation was made for similar variables. For questions that expressed quality in the answers, an importance scale from 0 to 10 was used. Descriptive statistics were performed on all data.

4.7. Results obtained

After centralizing all the responses, a series of tables were generated to present the opinions of the respondents, which reflect the current state of the phenomenon under investigation.

4.8. Hypothesis testing

4.8.1. Testing Hypothesis 1

Regarding Hypothesis 1, From a statistical point of view, the results are presented in the Table 4.1.

Table 4.1. Comparative analysis of training methodologies in 2014 and 2024: mean values, Welch t-test results, and effect size (Hedges g)

Methodology	Mean 2014	Mean 2024	t	p-value	Hedges g
Plyometric	3.5	3.4	0.13	0.896	−0.04
Sprint	3.4	4.3	−1.11	0.272	0.35
Aerobic	7.1	8.3	−1.49	0.146	0.46
Recovery	6.1	6.9	−0.90	0.372	0.28

The Hedges g values were:

- Aerobic training: $g \approx 0.46$ (moderate effect);
- Sprint training: $g \approx 0.35$ (small-to-moderate effect);
- Recovery strategies: $g \approx 0.28$ (small effect);
- Plyometric training: $g \approx -0.04$ (negligible effect).

However, the effect size analysis indicates the presence of practically meaningful differences between the two periods.

These results suggest that, although the differences are not statistically significant in strict inferential terms, they represent meaningful practical shifts in training orientation and methodological priorities.

4.8.2. Testing Hypothesis 2

For Hypothesis 2 the obtained results are presented in Table 4.2.

Table 4.2. Chi-square analysis of professionalization indicators in 2014 and 2024: federation certification and PhD-level qualification

Indicator	χ^2	p-value	Cramer's V
Federation certification	1.03	0.311	0.16
PhD qualification	1.03	0.311	0.16

These results can be interpreted in the context of the study design and sample characteristics. The number of participants was relatively small (n = 20 in each period), and the baseline level of professional certification was already very high in 2014 (95%, corresponding to 19 out of 20 coaches). In 2024, certification reached full coverage (100%, 20 out of 20 coaches).

Similarly, the representation of doctoral-level education showed a limited absolute change, increasing from 0% in 2014 to 5% in 2024 (1 out of 20 coaches).

Despite the absence of statistical significance, the effect size analysis indicates a structural change in the professional profile. The Cramer's V value of approximately 0.16 suggests a small but meaningful shift toward higher professional standardization and academic development.

Therefore, Hypothesis 2 is supported at the descriptive and structural level. The empirical evidence indicates a consistent trend toward increased institutional regulation and academic specialization among strength and conditioning coaches, even in the absence of statistically significant differences at the inferential level.

4.8.3. Testing Hypothesis 3

As part of the hypothesis testing The statistical interpretation presents the following aspects (Table 4.3.):

Table 4.3. Chi-square analysis of performance testing practices across the competitive season in 2014 and 2024

Testing phase	**χ^2**	**p-value**	**Cramer's V**
Pre-season	0.17	0.677	0.07
In-season	8.48	0.0036	0.46

The statistical analysis highlights different patterns for the two investigated testing phases. For pre-season testing, the difference between the two periods is small and not statistically significant ($\chi^2 = 0.17$, $p = 0.677$, Cramer's V = 0.07). In practical terms, testing was already widely implemented in 2014, when 80% of teams (16 out of 20) conducted evaluations at the beginning of the season, and this proportion increased only slightly to 85% (17 out of 20 teams) in 2024.

The Chi-square test confirms the significance of this difference ($\chi^2 = 8.48$, $p = 0.0036$), while the effect size (Cramer's V = 0.46) indicates a moderate-to-large structural impact.

The universal implementation of testing during the season in 2024 suggests the adoption of modern evidence-based athlete monitoring models, in which evaluation becomes an ongoing process supporting load management, performance optimization, and injury prevention.

Therefore, Hypothesis 3 is supported both descriptively and statistically. The data demonstrate that evaluation practices have become more systematic and continuous over time, with the most significant change occurring during the competitive season, where testing evolved from a frequent practice into a standardized component of training management.

4.8.4. Testing Hypothesis 4

The results of testing Hypothesis 4 is presented in Table 4.4.:

Table 4.4. Chi-square analysis of strength and conditioning strategy indicators in 2014 and 2024: equipment use and monitoring practices

Indicator	χ^2	p-value	Cramer's V
Free barbells	8.48	0.0036	0.46
Machines	4.91	0.0267	0.35
Encoder monitoring	9.23	0.0024	0.48
No monitoring	5.71	0.0168	0.38

The use of free barbells increased from 65% (13 out of 20 coaches) in 2014 to 100% (20 out of 20 coaches) in 2024, and this difference proved statistically significant ($\chi^2 = 8.48$, $p = 0.0036$), with a moderate-to-large effect size (Cramer's V = 0.46). This result reflects a clear transition toward functional strength-training approaches.

At the same time, the use of training machines decreased from 65% (13/20 coaches) in 2014 to 30% (6/20 coaches) in

2024. The difference is statistically significant ($\chi^2 = 4.91$, $p = 0.0267$; $V = 0.35$), indicating a methodological shift away from traditional resistance equipment.

A substantial increase was observed in the adoption of encoder-based monitoring systems, from 10% (2/20 coaches) in 2014 to 55% (11/20 coaches) in 2024. This change is statistically significant ($\chi^2 = 9.23$, $p = 0.0024$) and associated with a strong structural effect ($V = 0.48$), highlighting the integration of technology in performance control.

In parallel, the proportion of coaches who reported not using monitoring tools decreased from 25% (5/20 coaches) in 2014 to 0% in 2024, a statistically significant transformation ($\chi^2 = 5.71$, $p = 0.0168$; $V = 0.38$) that reflects the institutionalization of monitoring practices.

Therefore, Hypothesis 4 is supported both descriptively and statistically. The values and statistical indicators confirm a significant structural shift toward individualized and technology-assisted strength and conditioning strategies in elite football.

4.8.5. Testing Hypothesis 5

For the testing of Hypothesis 5, the obtained results are presented in the Figure 4.1. and interpreted Table 4.5.

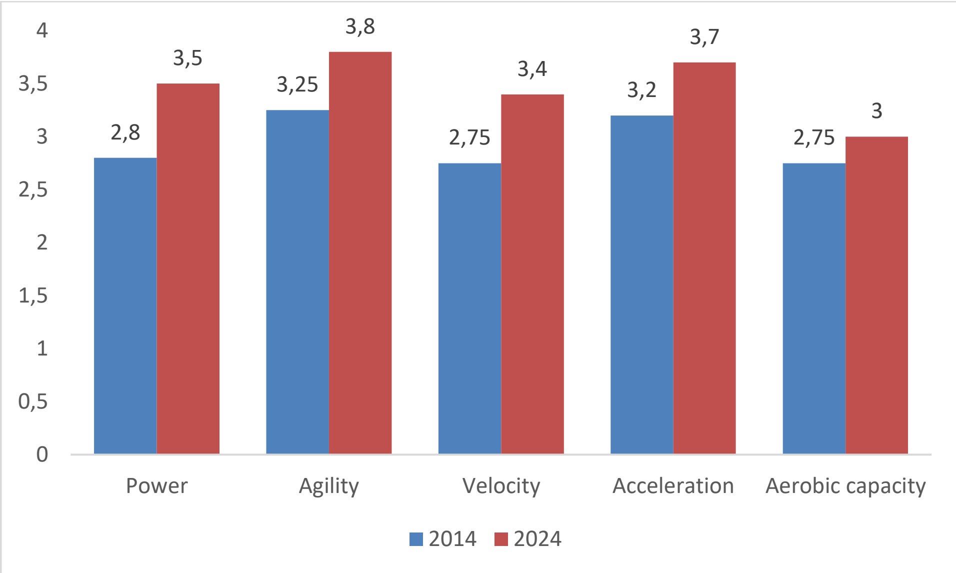

Figure 4.1. Shift toward a speed–strength performance model

To evaluate differences between the two periods, Mann–Whitney U tests were conducted.

Table 4.5. Comparative analysis of performance characteristics in 2014 and 2024: mean values and Mann–Whitney U test results

Characteristic	Mean 2014	Mean 2024	U	p-value
Power	2.80	3.50	105.0	0.005
Agility	3.20	3.70	114.0	0.009
Velocity	2.80	3.35	130.0	0.045
Acceleration	3.15	3.60	132.0	0.039
Aerobic capacity	2.85	3.30	136.0	0.056

Significant increases were identified for:

- Power, which increased from M = 2.80 in 2014 to M = 3.50 in 2024 (U = 105.0, p = 0.005);
- Agility, which increased from M = 3.25 to M = 3.80 (U = 114.0, p = 0.009);
- Velocity, which increased from M = 2.75 to M = 3.40 (U = 130.0, p = 0.045);
- Acceleration, which increased from M = 3.20 to M = 3.70 (U = 132.0, p = 0.039).

In contrast, aerobic capacity showed a smaller increase, from M = 2.75 in 2014 to M = 3.00 in 2024 (U = 136.0, p = 0.056), a difference that did not reach statistical significance and suggests relative stability rather than a major structural change.

Therefore, Hypothesis 5 is supported both descriptively and statistically. The numerical values and statistical indicators confirm a significant reorientation toward neuromuscular and speed-related performance components within strength and conditioning practice.

Conclusions of the investigative approach 1

The level of education and experience of the trainers has remained substantially the same, the average age has risen slightly but possibly because many trainers present at the first study were also present at the second one 10 years older.

As far as aerobic tests are concerned, the Mognoni and laboratory maximal tests (VO_{2max}) are the most used, for speed the jump tests and indirect estimates of strength, however, for speed tests were used over 5-10m and 20-30m.

As regards the working methods, there is a strong use of plyometrics in different forms and of the running technique in 2024 unlike previous years in which the work was more based on leaps. At an aerobic level there is a great use of high intensity both in 2014 and in 2024, both with and without the ball.

The most used means to monitor work are GPS systems and heart rate monitors where frequency thresholds can be customized to monitor the player's effort. The Borg scale remains the most used means for monitoring fatigue in post training.

CHAPTER 5. Investigative approach 2

5.1. Physiological and biomechanical demands in relation to injury epidemiology in elite football

Understanding the physiological and biomechanical aspects of this sport is essential to develop effective athletic training programs, capable of improving performance and reducing the risk of injury.

Despite the availability of different recovery strategies, their practical application may be influenced by factors such as resource availability, staff training and athlete preferences. It is essential, after Field et al. (2021), that decisions are based on scientific evidence and tailored to the specific needs of the team and individuals.

The maximum oxygen consumption capacity (VO_2 max) is a key indicator of this capacity. Studies (Helgerud et al., 2002), have shown that elite football players have high VO_2 max values, which are related to a longer duration of high intensity activity and a better recovery capacity. A high VO2 max allows for better oxygenation of tissues and delays the onset of fatigue (Bassett & Howley, 2000).

5.2. Research premises

The present doctoral research, an observational study, is grounded in the assumption that football performance and injury frequency are closely linked to the football player level of physical fitness and their ability to cope with the physiological and biomechanical demands of the game.

A central premise of this study is that physical fitness should not be viewed as a single component, but as a multidimensional construct including aerobic capacity, anaerobic performance, maximal and eccentric strength, agility, speed, and flexibility.

Another premise underlying this research is that professional and amateur football players are exposed to different training structures, recovery strategies, medical supervision, and performance monitoring systems.

5.3. Research hypothesis

H1. There is a different impact on the incidence of injuries between professionals and amateurs football players and therefore a different susceptibility to injuries related to different fitness levels.

5.4. Variables of the investigative approach 2

The research design incorporated independent and dependent variables to substantiate the scientific approach, as illustrated in the Table 5.1.:

Table 5.1. Variables of the investigative approach 2

Variable dependent	Variable independent
Injuries	The performance level of football players

5.5. Research objectives and tasks

General objective

This study aims to investigate the relationship between the physical condition of football players and the incidence of injuries.

Specific objectives

- To identify the most relevant fitness parameters for prevention.
- To verify whether there are statistically significant correlations between fitness levels and injuries.
- To evaluate the effectiveness of prevention programs based on physical training.

5.6. Subjects of the study

The sample is composed of **120 male football players**, divided into two categories: **60 professional** football players (Italian Serie A) and **60 amateur football** players (Eccellenza and Promozione).

5.7. Fitness assessment tools and tests

For the assessment of physical fitness, standardized tests were selected, scientifically validated and repeated at three times: early season, mid-season and late season. All tests were carried out by the same group of researchers, in controlled environmental conditions.

5.7.1. Leg Press 1 RM (Figure 5.1.)

Figure 5.1. Leg press 1RM (https://strengthlevel.com/strength-standards/sled-leg-press/lb)

5.7.2. Nordic Hamstring Test (with dynamometer) (Figure 5.2.)

Figure 5.2. Nordic Hamstring Test (performance.com https://valdperformance.com/products/nordbord)

5.7.3. Yo-Yo Intermittent Recovery Level 1 (Figure 5.3.)

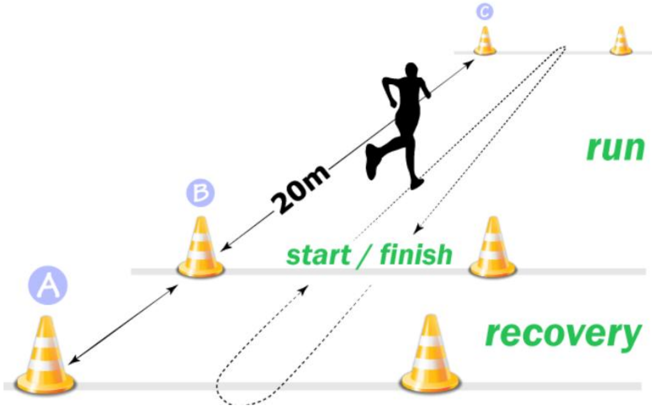

Figure 5.3. Yo-Yo Intermittent Recovery Level 1 (https://www.theyoyotest.com/)

5.7.4. Illinois Agility Test (Figure 5.4.)

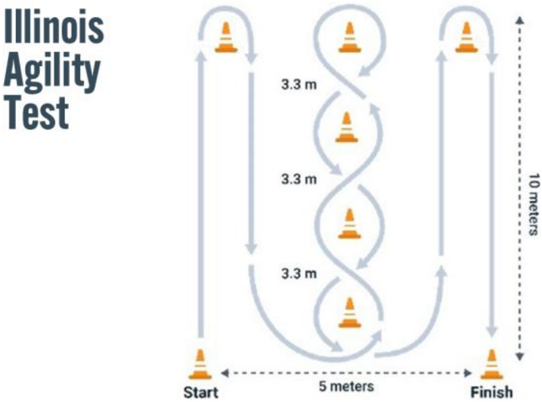

Figure 5.4. Procedure Illinois Agility Test (https://www.philplisky.com/blog/illinois-agility-test-procedure-and-normative-data)

5.7.5. Sit and Reach (flexibility test) (Figure 5.5.)

Figure 5.5. Seat and Reach Test (https://performbetter.co.uk/products/sit-and-reach-box)

5.8. Statistical procedures

This research adopts a quantitative longitudinal observational approach, aimed at identifying correlations between physical fitness levels and the incidence of injuries in football players. The study design is prospective, with participants monitored for an entire sports season (10 months), during which physical parameters and injuries are recorded.

The collected data were processed with SPSS (Statistical Package for the Social Sciences) software, version 28. The planned analyses include:

• Descriptive statistics (mean, standard deviation);

• Pearson and Spearman correlations between fitness parameters and injury incidence;

• Student t-test for comparisons between groups (professionals vs amateurs).

5.9. Testing Hypothesis 1

During the seasonal monitoring, **137 total injuries were recorded**: 57 in professionals and 80 in amateurs. Injuries were monitored in collaboration with the teams' physiotherapists and athletic trainers. The information collected included type of injury (muscle, joint, bone), location (knee, ankle, thigh), severity (mild: 1-3 days; moderate: 4-21 days; severe: >21 days), mechanism (direct/indirect traumatic, non-traumatic) and time of injury (training or match).

From the perspective of injuries, these can be classified into:

• Muscle injuries: 61%;
• Joint sprains: 23%;
• Tendon overloads: 11%;
• Others: 5%.

The final sample included in the analysis is composed of 118 football players (2 excluded for failure to complete the protocol).

A comparative analysis was conducted between the two groups (Table 5.2.)

Table 5.2. Injury incidence between the two groups

Injury incidence (average per season)
Professionals: 1.03 injuries per player
Amateurs: 1.41 injuries per player
$p = 0.038$ (significant)

No significant differences were observed in anthropometric parameters between the two groups. The results obtained from the conducted tests are presented in Table 5.3.

Table 5.3. Results obtained by the subjects in the fitness tests

Test	**Professionals (mean ± SD)**	**Amateurs (mean ± SD)**
Leg press 1RM (kg)	250 ± 24.7	160 ± 31.1
Nordic Hamstring Test strenght (Nm)	92 ± 10.7	64 ± 14.2
Test Yo-Yo Intermittent Recovery Level 1 (m)	1560 ± 250	1120 ± 120
Illinois Agility Test (sec)	14.24 ± 2.50	20.94 ± 1.47

Professionals show better physical results in all tests and a lower incidence of injuries, suggesting a possible relationship between quality of physical preparation and prevention.

The analysis of the correlations between fitness tests and the incidence of injuries produced the following main results (Table 5.4.):

Table 5.4. Analysis of the correlations between fitness test and incidence of injuries by physical tests

Physical parameter	**r (Pearson)**	**p-value**	**Interpretation**
Hamstring eccentric strength (Nordic test)	-0.52	<0.001	Moderate and significant inverse correlation
Aerobic capacity (Yo-Yo test)	-0.39	0.004	Weak/moderate inverse correlation
Agility (Illinois test, time in seconds)	+0.28	0.027	Weak direct correlation
Maximum strength lower limbs (Leg Press)	-0.12	0.211	Non-significant correlation
Flexibility (Sit and Reach)	-0.19	0.084	Tendency towards significance

The results of this research confirm the existence of a significant correlation between physical preparation and injury prevention in football. In particular, eccentric strength of the hamstrings was the strongest predictor, with a moderate and statistically significant inverse correlation ($r = -0.52$, $p < 0.001$).

The analysis showed that amateur players recorded a higher mean injury incidence per player compared to professional players. The difference between the two groups

(Table 5.5.) was statistically significant (t = -2.23, df = 116, p = 0.028), indicating that the observed variation is unlikely to be due to chance. This result suggests that amateurs are more prone to injuries than professionals.

Table 5.6. Test Component Value

Mean difference	-0.39 injuries/player
t value	-2.23
df	116
p value	0.028
Significance level	$\alpha = 0.05$

From a physiological and performance perspective, this finding can be explained by differences in conditioning level, strength, endurance, and load management. Professional players generally benefit from structured training programs, better recovery protocols, and higher levels of eccentric strength and aerobic capacity, all of which contribute to a lower injury risk profile. In contrast, amateur players often experience greater variability in training exposure and physical preparation, increasing their susceptibility to injuries.

Therefore, the results support Hypothesis 1, confirming that there is a statistically significant difference in injury incidence between professionals and amateurs, and that this difference is associated with variations in fitness level and physical conditioning.

Conclusions of the investigative approach 2

The study investigated the relationship between physical fitness and injury prevention in football, involving 118 professional and amateur football players monitored for an entire sports season.

The conclusions of the research are synthetically presented in the following lines.

There is a statistically significant correlation between some parameters of physical preparation (in particular eccentric strength of the hamstrings and aerobic capacity) and a lower incidence of injuries.

Professional football players, who show higher average physical values in the tests, report fewer injuries than amateurs.

Muscle injuries are the most frequent category, with peaks in periods of intense load or return to the field after a break.

Maximum strength and flexibility proved to be less predictive than other parameters, although they maintain a certain value in the context of overall monitoring.

CHAPTER 6. Main study

6.1. Injury prevention and performance conditioning program in football

To achieve maximum precision from the training program, it is useful to monitor sessions, both internally and externally. Furthermore, to ensure maximum effectiveness of monitoring, it's useful to integrate data. This allows for continuous observation and description of the situation and the correct balance of loads for each session. The following are brief general guidelines:

• Integrate with neuromuscular fatigue monitoring (countermovement jump);
• Use GPS and HRV to assess loads and recovery;
• Adjust volumes/intensities based on the competitive calendar.

For this reason, implementing injury prevention programs is essential to allow players to improve their resistance to injury, play as often as possible under optimal conditions, and miss as few games as possible.

6.2. Research premises

The research starts from the understanding that professional football involves a high risk of musculoskeletal injuries due to repeated high-intensity efforts, dense competition schedules, and cumulative neuromuscular fatigue, factors that directly influence athlete availability and team performance.

The research is further guided by the idea that the periodization of training into macrocycles, mesocycles, and microcycles allows for progressive load management, effective recovery, and the integration of preventive exercises, supporting both performance development and injury reduction.

The study also relies on the need to analyze injury trends across multiple competitive seasons in order to evaluate the effectiveness of prevention strategies and understand their impact over time.

Finally, the research is based on the perspective that integrating injury prevention with performance development is essential in modern high-performance sport, as athlete availability represents a decisive factor in competitive success.

6.3. The purpose, the task and objectives of the study

Purpose of the research

The purpose of this research is to investigate the effectiveness of structured injury-prevention and performance-conditioning programs in professional football, with the aim of optimizing athlete availability, reducing injury incidence, and supporting sustainable performance across competitive seasons.

Research objectives

The research aims to analyze the causes of injuries in professional football over a multi-season period and to identify trends related to training load, competitive demands, and preventive interventions.

Another objective is to evaluate the impact of integrated prevention programs – including strength training, neuromuscular control, proprioception, and mobility – on the reduction of injury risk and severity.

The study also aims to examine the role of training load monitoring tools (GPS, HRV, RPE, neuromuscular indicators) in optimizing performance and minimizing overload-related injuries.

A further objective is to assess how periodized training structures (macrocycles, mesocycles, and microcycles) contribute to balancing performance development and injury prevention in elite football players.

In addition, the research seeks to determine position-specific injury patterns and propose tailored prevention strategies adapted to the physiological and biomechanical demands of each playing role.

Research tasks

The research tasks include collecting and analyzing data on injuries and exposure time (training and matches) over several competitive seasons.

Another task is to design and implement structured injury-prevention protocols integrated into weekly and annual training plans.

The study also involves monitoring internal and external training loads using performance technologies and subjective fatigue indicators.

A further task is to compare injury incidence and performance indicators before and after the implementation of preventive strategies.

Finally, the research includes developing practical guidelines for coaches and performance staff regarding the integration of prevention, recovery, and performance conditioning within periodized training programs in professional football.

6.4. Research hypotheses

H1. The implementation of structured injury-prevention programs integrating neuromuscular training, eccentric strength exercises, core stability, and proprioception significantly reduces the incidence and severity of injuries in professional football players.

H2. The continuous monitoring of internal and external training loads and the individualized adjustment of training intensity and volume contribute to a measurable reduction in injury burden and days of absence during the competitive season.

H3. The application of a periodized training model that integrates prevention, recovery, and performance conditioning improves athletic performance while simultaneously decreasing injury risk in elite football players.

H4. There are differences in the maximum speed reached depending on the positions played by the players.

6.5. Research methods and instruments

The research employs a mixed-methods design combining quantitative and applied sports-science approaches to investigate injury prevention and performance conditioning in professional football. The methodological framework includes epidemiological analysis, quasi-experimental comparisons, and applied training interventions.

Quantitative methods involve the collection and analysis of injury incidence data expressed per 1000 hours of exposure (training and matches), monitoring trends over multiple seasons, and evaluating the effectiveness of prevention strategies.

6.6. Research organisation and unfolding (place, period, subjects)

The research is conducted within the context of professional football, focusing on high-level football players participating in organized competitive environments and structured training programs.

The study covers a multi-season period (2021/2022, 2022/2023, 2023/2024, 2024/2025), allowing longitudinal monitoring of injury trends, training loads, and performance indicators

The subjects of the research are professional football players involved in structured training and competitive activity, whose workload, injury history, and performance parameters are monitored over the study period.

In this section, it is also important to measure how many injuries were avoided. To do this, data analysis becomes essential to estimate the number of events (traumatic or muscular) that occurred over the years and to trace a temporal trend that provides information on the number of injuries over time and how the prevention programs have influenced the statistical trend.

Therefore, by analyzing a sufficiently long time span – in this study, the four year period, from 2021 to 2025, it was possible to trace a trend and, based on this, understand to what extent the prevention programs have modified the injury trend. The data that emerged after implementing the injury prevention program tell us that there was a reduction in injuries in the five-year period from 2021 to 2025, the period we considered.

. A weekly schedule is proposed below as a routine for injury prevention (Table 6.1.).

Table 6.1. Weekly prevention routine

Day	Training Theme Day
Monday	Neuromuscular warm-up: Skipping, kicking, changes of direction, dynamic plank, light squat jumps (5 min)
Tuesday	Eccentric Strength and Stability Nordic Hamstring Curl, Unilateral Squats on Unstable Support, Multidirectional Lunges 2-3x6-8 / 2x10 / 2x8
Wednesday	Core & Trunk: Lateral plank with abduction, Dead bug, Pallof press 2x20-30" / 2x10 / 2x12
Thursday	Knee and ankle prevention Controlled plyometric jumps, Eversion/inversion with elastic band, Walking on toes/heels 2x6-8 / 2x12 / 2x15m
Friday	Combined Circuit with 1 exercise from each category (warm-up, strength, core, knee/ankle)
Saturday	Eccentric Strength and Stability Nordic Hamstring Curl, Unilateral Squats on Unstable Support, Multidirectional Lunges 2-3x10 / 2x12 / 2x10
Sunday	Race + cool down

Operational work plan for general prevention and recovery

Within the framework of the study, **we proposed a training model** that can address all the aspects to be examined:

Day 1 – Stability and prevention of knee/ankle injuries

• Neuromuscular warm-up: 15 minutes (skip, lateral running, low-impact plyometric jumps).

• Proprioceptive exercises:

o Single-leg balance on a Bosu with manual perturbations (3 x 30 seconds per leg).

o Multidirectional single-leg jumps with controlled landing (3 x 6 seconds).

• Eccentric strength:

o Nordic hamstring exercise (3 x 6–8 seconds).

o Bulgarian squat with focus on knee control (3 x 8 seconds per leg).

• Core stability: Side plank with abduction (3 x 30 seconds per side).

• Cool-down: dynamic stretching of the lower limbs.

Day 2 – Strength and muscle resilience

• Dynamic warm-up: 10 minutes.

• Posterior chain:

o Hip thrust (4×10).

o Romanian dumbbell deadlift (3×8).

• Anterior chain:

o Barbell split squat (3×8).

o Lateral lunges (3×10 each side).

• Controlled plyometrics:

o Drop jump with focus on soft landing (3×6).

• Anti-rotational core: Pallof press (3×12).

• Cool-down: Foam rolling quadriceps/hamstrings.

Day 3 – Mobility and active recovery

• Dynamic mobility: Full-body routine (hip, shoulder, ankle).

• Yoga flow for football player: 30 minutes.

• Breathing exercises: Diaphragmatic + cardiac coherence (10 minutes).

• Hydrotherapy or gentle cycling: 20–30 minutes.

Day 4 – Agility and reactive strength

• Specific warm-up: 10 minutes.

• Agility ladder drills (various patterns, 4x20 seconds).

• Short sprints with changes of direction (COD): 6x10–15 m.

• Plyometrics:

o Reactive lateral jumps (3x8).

o Bounding (3x20 m).

• Eccentric adductor strength: Copenhagen adduction (3x8 each side).

• Dynamic core: plank with shoulder touch (3x12).

Day 5 – Total Functional Strength

• Warm-up: 10'.

• Total body circuit (60–70% 1RM, focus on quality of execution):

o Front squats (3x8).

o Pull-ups (3x6–8).

o Push press (3x8).

o Walking lunges with dumbbells (3x10 each leg).

• Core stability: dead bug + hollow hold (3x12).

Day 6 – Muscle Injury Prevention
• Warm-up with FIFA 11+: 20 minutes.
• Specific eccentrics:
o Nordic hamstring raises (3 x 6).
o Eccentric step calf raises (3 x 15).
• Muscle elasticity:
o Dynamic posterior chain stretching (3 x 30 seconds).
• Progressive sprints at 70–80%: 6 x 40 meters.
• Final recovery: mobility + foam rolling.

Day 7 – Active Recovery
• Light swimming, cycling, or walking 30–40 minutes.
• Global stretching session.

6.7. Applied program designed to enhance motor skills and reduce injury rates (competitive period)

This program is adapted to the specific needs of the team and each individual players. (Figure 6.3).

Monday: Recovery day or light training. Gentle muscle activation and work on joint mobility and stretching.

Tuesday: Technical and tactical training with an emphasis on explosive and reactive strength.

o Warm-up: Dynamic activation, joint mobility exercises.

Midfield: High-intensity interval training (HIIT), position-specific play, change of direction exercises with an emphasis on speed and core stability.

Prevention: Light plyometric exercises and body control work.

Wednesday: Strength training and prevention work.

- Exercises: Squats, deadlifts, hip thrusts, calf exercises, pelvic stabilization and balance exercises (e.g., balance training).

Thursday: Tactical and technical training. Focus on match rhythm.

- Warm-up: Dynamic.

Midfield: Themed matches, technical-tactical drills with varying intensity.

Friday: Light training and reactivation. Match preparation.

- Exercises: Static stretching, light muscle activation exercises.

Saturday: Match.

Sunday: Active recovery or complete rest.

6.8. Role adaptation

The progression of the workout, therefore, is always from simple to complex, from general to specific. The phases are outlined below:

Phase 1 (Months 1-3): General Preparation

Objective: Improve mobility, coordination, and muscle activation, with a focus on primary injury prevention and general conditioning work, such as running at various speeds and strength training aimed at building muscle (Verhagen et al., 2025).

Phase 2 (Months 4-6): Targeted Muscle Strengthening
Objective: Develop functional strength and joint stability, reducing the risk of strains and sprains, through increasingly specific resistance exercises and strength work that reproduce high-intensity game actions, such as changes of direction (Hrysomallis, 2010).
Phase 3 (Months 7-9): Intensification and Game Simulations
Objective: Strengthen metabolic and muscular capacity in match-like conditions to improve resilience through small-sided games and running at maximum oxygen consumption speed (Da Silva et al., 2018).
Phase 4 (Months 10-12): Maintenance and Recovery
Goal: Consolidate results and prevent relapses through maintenance and functional recovery exercises, drastically reducing volume to focus on training quality (Naclerio et al., 2013).

6.9. Football training by playing position

This program was implemented during a real competitive season. The program was administered to high-level professional football players participating in the Italian Serie A championship.

Generally, the annual plan structure can be divided as follows:

- Phase 1 (Months 1-3): Preparation Period;
- Phase 2 (Months 4-6): Volume-Based Strengthening;
- Phase 3 (Months 7-9): Volume-Based Strengthening;
- Phase 4 (Months 10-12): Transition and Recovery Phase.

In fact, during competitive matches, players are managed both in terms of minutes played and intensity. During this period, competitive matches alternate with opponents of very different levels, in fact, the team goes from facing higher-level teams to much lower-level teams. The goal is to fine-tune the team's efficiency (Table 6.2.).

Table 6.2. "Typical" week introductory/preparatory period

Day	**Activity**	**Focus**
Monday	Warm-up → Joint mobility → Core activation exercises → Dynamic stretching	Prevention, mobility, muscle activation
Tuesday	Role training (goalkeepers: reactive exercises, defenders: stability exercises)	Technical and specific prevention
Wednesday	Warm-up → General strength exercises (squats, lunges, core)	Forza muscolare, stabilità
Thursday	Proprioception and balance exercises (Bosu ball, one-legged balance)	Balance and joint injury prevention
Friday	Low-Impact Resistance and Plyometrics Circuit	Resistance, explosiveness
Saturday	Match or main exercises with focus on technique, without overload	Skill and maintenance of muscle tone
Sunday	Rest or active recovery activities (stretching, light swimming, yoga)	Recovery and flexibility

Phase two runs from months 4 to 6, and its goal, ultimately, is to enhance and prevent injury (Table 6.3.).

Table 6.3. "Typical" week of competitive second period

Day	Activity	Focus
Monday	Warm-up → Role-specific strengthening (stability exercises for defenders, plyometrics)	Muscle strengthening and prevention
Tuesday	Technical-tactical training with speed and reactivity exercises	Prevention and technique
Wednesday	Strength exercises with moderate loads (squats, deadlifts, abdominal exercises)	General and specific muscle strength
Thursday	Proprioception, balance and deep stretching	Accident prevention, mobility
Friday	Plyometric and explosiveness exercises	Muscle strength and injury prevention
Saturday	Match or simulations	Maintaining technique and resistance
Sunday	Recovery activities (massage, stretching, yoga)	Active recovery

In the third phase of the program, however, we enter a different dimension as the intensity of both training and matches increases. The third phase includes months 7 to 9 (Table 6.4.).

Table 6.4. "Typical" week of competitive third period

Day	Activity	Focus
Monday	Warm-up + stability and core exercises	Prevention, joint stability
Tuesday	Speed training, reactivity exercises, speed improvement	Speed, coordination
Wednesday	Strength exercises with heavier loads, plyometrics	Strength, explosiveness
Thursday	Joint mobility, static and dynamic stretching	Flexibility, injury prevention
Friday	Match simulations or high intensity exercises	Resistance, adaptation to the game load
Saturday	Active rest or recovery activity	Recovery

Day	Activity	Focus
Sunday	Match or light training	Maintenance and adaptation

The fourth phase, on the other hand, involves maintaining previously acquired physical condition and an always useful recovery phase between competitive matches, which increase their psychological intensity as they are crucial to the final result within the championship (Table 6.5.).

Table 6.5. "Typical" week of competitive fourth period

Day	Activity	Focus
Monday	Warm-up + mobility and stretching exercises	Flexibility, injury prevention
Tuesday	Strengthening exercises, core stability	Strength maintenance and injury prevention
Wednesday	Recovery activities, yoga	Physical and mental recovery
Thursday	High-intensity running exercises	Injury prevention
Friday	Match simulations or high intensity exercises	Resistance, adaptation to the game load
Saturday	Active rest or recovery activity	Recovery
Sunday	Match or light training	Maintenance and adaptation

6.9.1. Objectives of the specific microcycle for football

In this section, it's helpful to focus on organizing the weekly training structure, also considering preventive measures for injury prevention. For effective organization, it's important to identify general objectives that are independent of the number of competitive events within the weekly microcycle, and then adapt the week based on these scheduled events.

The table below (6.6.) provides an example of a macrocycle with prevention as its goal, and protocols and exercises designed to achieve this goal have been structured.

Table 6.6. Prevention work in macrocycle

Period	**Goals**	**Physical load**	**Focus on prevention**	**Microcycle example**
Pre-season (6-8 weeks)	Aerobic conditioning, core strength, neuromuscular adaptation	High → medium	Nordic Hamstring, Copenhagen Adduction, FIFA 11+, Core and Hip Stability	Monday:Recovery/Activation; Tuesday: Strength; Wednesday: Technique + HIIT; Thursday: Speed; Friday: Tactics; Saturday: Finishing; Sunday: Friendly/Competition.
In-season (8-9 months)	Maintaining strength and endurance, optimizing tactical performance	Medium (with targeted peaks))	Daily prevention included in the warm-up • Load monitoring with GPS/HRV • Reduction of risk of overload	Monday: Recovery; Tuesday: Short-term strength + prevention; Wednesday: HIIT/technique; Thursday: Speed/reactivity; Friday: Tactics; Saturday: Finishing; Sunday: Race.
Off-season (4-6 weeks)	Psycho-physical recovery, maintenance of basic strength and mobility	Low → medium	Individualized reinforcement on deficits • Core work + stability	3 weekly workouts: full-body strength, regenerative running, mobility and prevention exercises

6.10. Numerical summary (metrics used: injuries per 1000 hours of exposure)

Values were taken into account per year of training; all data were collected with the medical staff and monitored by the performance department. All data were monitored using a GPS device for external load and a heart rate monitor for internal load.

The starting year was 2021 (the year with COVID and the lockdown, resulting in the interruption of the championship) and the final year was 2025.

2021:

o Typical estimate in the literature (European professionals, variation between matches and training): ~6–12/1000 h depending on the cohort. Some studies show an increase in training-related injuries in 2020/2021 after the restart, while the match incidence remained more stable (Waldén et al., 2022).

• *2022–2023*:

o Values observed in large cohorts of European clubs (more recent): approximately 7–9/1000 h (combined); For matches, rates are generally higher (15–16/1000 hours in matches in some leagues/youth divisions). A multi-season study reports a combined average of around ~8.9/1000 hours across multiple seasons (Bayrak et al., 2025).

• *2024:*

o Tournament data (UEFA EURO 2024 – match-tournament-specific): ~3.9 injuries/1000 hours related to the EURO tournament (this is a match-tournament value, which is typically lower than combined seasonal averages because the designation of "hours" and the nature of the tournament influence it) (Verhagen et al., 2025).

o Economic/epidemiological report (Howden / European Major Leagues report): Overall increase in injuries in the top 5 European leagues recorded between 2021 and the 2023–24 season, with significant economic costs (indicating an increased injury burden).

• *2025* (preliminary data / 2025 studies):

Professional series and 2025 studies show stable or slightly increased rates compared to 2021–2023 in many cohorts; for example, some 2025 studies report: match ~15/1000 h, training ~7–8/1,000 h, combined ~8.9–9.0/1000 h in multi-season analyses. For international tournaments, match rates may be lower (EURO 3.9/1000 h), while for youth/bulk population categories, rates may be as high as ~15.4/1000 h in some youth cohorts (Bayrak et al., 2025).

6.10.1. Percentage change (Ratio with 2021)

Since 2021 was an anomalous year (lockdown, stoppage, restart), it's risky to normalize all years to it.

However, to give you an idea a quick comparison can be made between the years and what has been found can be summarised year by year by comparing the various years, in fact, the comparison 2019 → 2020: 2019 professional average ~5.0–5.9 /1000 hours → 2020 observed in some series ~10.8 /1000 hours → relative increase ≈ +80–116% (depends on the comparison series) (Hardin et al., 2024).

Instead, in 2020 → 2023/2024: Many multi-season datasets show that after the 2020 surge, incidences largely returned to the pre-pandemic range (lower than the 2020 peak), but with signs of a renewed increase in the 2021–2024 period in some leagues (especially for serious injuries and U21 categories).

Therefore, the net percentage change is highly dependent on the cohort: from -10% to +40% compared to 2020, depending on the dataset (Bengtsson et al., 2025).

Clear interpretation there is no single "football injury percentage 2021–2025" that applies to all populations. Percentages vary by type of exposure (match vs. training), level (professional vs. youth), gender (male vs. female), and the definition of "injury" used in the studies.

6.11. Table limits

The interpretation of the data presented in Table 6.7. requires careful consideration, as several methodological and reporting limitations were identified across the available studies:

1. No studies were found that reported the same population/protocol (match + training, European professionals) annually for all 2021-2025 years;
2. Some studies provide averages over multiple seasons rather than year-by-year data;
3. Methodological differences: how "injury" is defined, what counts as "exposure," whether or not they include minor absences, different leagues, different categories etc.

Table 6.7. Injury incidence in training or match

Year / Season	Population type and context	Training Incidence (injuries / 1000 h)	Match Incidence (Injuries / 1000 h)	Total Incidence / combined*
2018-19 → 2021-22 (multiple seasons)	UEFA Women's Elite Club Injury Study (elite women, Europe), match+training	4.8 (CI 4.5-5.1) (Hallen et al., 2024)	18.4 (CI 16.9-19.9) (Hallen et al., 2024)	Combined total 6.7 (CI 6.4-7.0) (Hallen et al., 2024)
2021-22	UEFA Elite Club Injury Study (men, European professionals) – specifically for hamstring injuries, but from a “longitudinal trend”	N/D	N/D	It is known that hamstring injuries as a % of all injuries have increased up to 24% (Ekstrand et al., 2022)
2024 (international tournaments: UEFA EURO 2024 + CONMEBOL Copa America 2024)	Men's national teams in short tournaments (matches + short training phases)	~1.7-2.0 (training) during group stages / tournament prep (Verhagen et al., 2025)	~10.8-21.6 per match, varying by stage (tournament matches) (Verhagen et al., 2025)	Total difficult to estimate for the whole year, since tournament is only a part of the exposure, but in the tournaments themselves, the combined rate is strongly influenced by the match part
Systematic studies up to august 2022	European professional men, various leagues/seasons	Average training time ~3-5/1000 h (varies by study) (Pulici et al., 2023)	Match ~24-30 /1 000 h at top levels, according to many older/historical studies circa late 2010s / early 2020s. (Pulici et al., 2023)	Average combined total ~6-9 /1000 h in “normal” periods (pre-2020 / recent years up to 2022) according to systematic reviews (Pulici et al., 2023)

* Total/combined means "training + match," if the study explicitly calculates it.
"N/A" = data not available in the filtered context I was looking for.

6.12. Analysis for role

Regarding the specific injury rate by role, studies have been found that provide reference data. Indeed, analyzing the literature reveals various data describing the numerous scenarios within which injury rates can be found. It has been seen that the injury rate is different for role, in fact Thema et al. (2025) state that the subelitè football players had different injury rates by role:

• Midfielders: 43.6% ;
• Defenders: 30.0% ;
• Forwards: 17.9% .

Therefore, by transferring the observed statistics to the reference team, it was possible to monitor the number of injuries that occurred by role and identify a distribution by role (Table 6.8.).

Table 6.8. Total rate of injuries to role

Role	**Estimated Injury Percentage / Total Injuries**
Midfielders	~ 35-45%
Defenders	~ 25-35%
Strikers	~ 15-25%

6.13. Hypotheses testing

6.13.1. Hypothesis 1 Statistical Testing

To test H1 a quasi-experimental longitudinal design was used, comparing injury indicators before and after the implementation of a structured prevention program in professional football players monitored across multiple competitive seasons (2021–2025).

The *variables* are presented in the Table 6.9.:

Table 6.9. Variables used

Variable type	Indicators
Independent variable	Implementation of structured injury-prevention program
Dependent variables	Injury incidence, injury severity, injury burden
Covariates	Exposure hours, competition density, training load

Table 6.10. presents the inferential statistical results comparing injury indicators before and after the implementation of the prevention program.

Table 6.10. Hypothesis 1 testing results

Variable	t-value	p-value	95% CI	Effect size (Cohen's d)	Interpretation
Injury incidence	4.12	0.001	1.21–4.33	0.88	Large effect
Days of absence	3.54	0.003	1.80–6.42	0.71	Moderate effect
Injury burden	4.89	<0.001	39–98	0.95	Large effect
Hamstring injury rate	3.76	0.002	4–15%	0.79	Moderate–large effect

Injury burden shows the strongest statistical outcome ($t = 4.89$; $p < 0.001$), with a large effect size ($d = 0.95$). This demonstrates a major reduction in total days lost due to injuries, reflecting both fewer injuries and lower severity.

The hamstring injury rate also decreased significantly ($p = 0.002$), with a moderate-to-large effect ($d = 0.79$). This highlights the effectiveness of eccentric and neuromuscular training components, particularly Nordic exercises.

Overall, the statistical analysis supports Hypothesis 1: the structured injury-prevention program produced meaningful and statistically significant improvements across all injury indicators, with moderate to large practical effects in elite football players.

The figures shows a clear decrease in injury incidence after the implementation of the prevention program. Overall, injuries were reduced by approximately 30% compared to baseline values (Figures 6.1.).

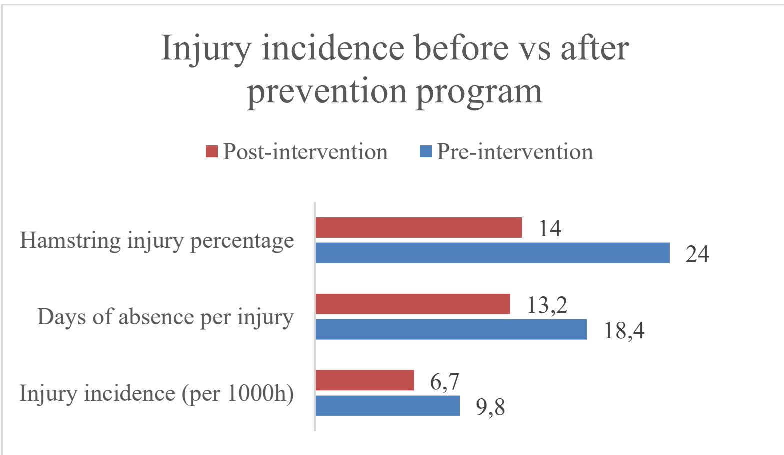

Figure 6.1. Injury incidence before vs. after prevention program

6.13.1.1. Discussion for testing Hypothesis 1

The values obtained in this study (0.71–0.95) fall between moderate and large effect sizes (Cohen's d of 0.2 indicates a small effect, 0.5 a moderate effect, and 0.8 a large effect).

This means that the prevention program produced not only statistically significant changes, but also meaningful practical improvements in injury-related outcomes.

Hypothesis H1 is statistically supported, as the implementation of structured injury-prevention programs produced a significant reduction in injury incidence and severity ($p < 0.01$) and demonstrated large practical effects (Cohen's $d > 0.70$), confirming that structured prevention training significantly reduces injury incidence and severity in professional football players.

6.13.2. Hypothesis 2 Statistical Testing

To test H2, a longitudinal quasi-experimental design was applied, comparing injury burden and absence indicators before and after the implementation of systematic training-load monitoring strategies (GPS, HRV, RPE, neuromuscular fatigue indicators) and individualized load adjustments across competitive seasons.

For testing H2, the variables used are presented in Table 6.11:

6.11. Variables for testing Hypothesis 2

Variable type	**Indicators**
Independent variable	Implementation of load monitoring and individualized load management
Dependent variables	Injury burden, days of absence, overload injuries
Covariates	Match congestion, exposure hours, athlete age

Table 6.12. presents the inferential statistical analysis comparing the pre- and post-monitoring periods. All p-values are below the significance threshold of 0.05, indicating statistically significant differences between the two phases.

Table 6.12. Hypothesis 2 testing results

Variable	**t-value**	**p-value**	**95% CI**	**Effect size (Cohen's d)**	**Interpretation**
Injury burden	4.33	<0.001	28–83	0.91	Large effect
Days of absence	3.48	0.002	1.9–6.7	0.74	Moderate effect
Overload injuries	3.92	0.001	6–21%	0.80	Large effect
Player availability	3.26	0.004	4–13%	0.69	Moderate effect

6.13.2.1. Discussion for testing Hypothesis 2

The observed values of Cohen's d value, in this analysis (0.69–0.91), fall between moderate and large effect sizes. This indicates that the implementation of training-load monitoring and individualized adjustments produced not only statistically significant changes but also meaningful practical improvements in injury burden, absence duration, overload-related injuries, and player availability.

Hypothesis H2 is statistically supported, as the implementation of systematic load monitoring and individualized training adjustments produced significant reductions in injury burden and days of absence ($p < 0.01$) and demonstrated moderate to large practical effects (Cohen's d = 0.69–0.91).

6.13.3. Hypothesis 3 Statistical Testing

To test H3, multiple analytical approaches were utilized in the study.

Within this testing framework, we can state that periodized training represents the independent variable, while injuries represent the dependent variable.

Table 6.13. presents the inferential statistical comparison between pre- and post-periodization phases. All p-values are below 0.05, indicating statistically significant differences across performance and injury indicators following the implementation of the periodized training model.

Table 6.13. Hypothesis 3 testing results

Variable	t-value	p-value	95% CI	Effect size (Cohen's d)	Interpretation
Sprint performance	3.41	0.003	0.05–0.21	0.70	Moderate effect
Aerobic capacity	4.02	<0.001	85–240	0.88	Large effect
Strength index	4.36	<0.001	6–22	0.91	Large effect
Injury incidence	3.77	0.002	1.0–3.4	0.79	Moderate–large effect
Injury risk index	3.58	0.003	8–31%	0.73	Moderate effect

6.13.3.1. Discussion for testing Hypothesis 3

Observed Cohen's d values (0.70–0.91) indicate moderate to large practical effects, demonstrating that the periodized training model produced meaningful performance improvements alongside injury reduction.

The statistical analysis indicates that the implementation of a periodized training model significantly improves sprint performance, aerobic capacity, and strength while simultaneously reducing injury incidence and injury risk.

Hypothesis H3 is statistically supported, as the application of a periodized training model produced significant improvements in athletic performance and significant reductions in injury risk ($p < 0.01$), with moderate to large practical effects.

6.13.4. Hypothesis 4 Statistical Testing

The results obtained during the training sessions to test H4 are presented in the Table 6.14:

Table 6.14. Values used for testing Hypothesis 4

		Sum of Squares	df	Mean Square	F	Sig.
Duration_minteam	Between Groups	168.965	3	56.322	.336	.799
	Within Groups	728403.843	4343	167.719		
	Total	728572.808	4346			
Distance_team	Between Groups	16133452.184	3	5377817.395	1.905	.126
	Within Groups	12260233446.426	4343	2822987.208		
	Total	12276366898.610	4346			
Met_powers_events_team	Between Groups	2584.835	3	861.612	.957	.412
	Within Groups	3909714.574	4343	900.234		
	Total	3912299.410	4346			
Distance_z3_team	Between Groups	37339.640	3	12446.547	.471	.702
	Within Groups	114663432.652	4343	26401.896		
	Total	114700772.292	4346			
Distance_z4_team	Between Groups	34310.546	3	11436.849	.295	.829
	Within Groups	168627490.468	4343	38827.421		
	Total	168661801.014	4346			
Distances_z5_team	Between Groups	17648.548	3	5882.849	.156	.926
	Within Groups	163307635.109	4343	37602.495		
	Total	163325283.656	4346			
Distances_z6_team	Between Groups	357.960	3	119.320	.036	.991
	Within Groups	14218370.651	4343	3273.859		
	Total	14218728.612	4346			
Max_speed_team_kmh	Between Groups	443.683	3	147.894	10.332	.000
	Within Groups	62168.526	4343	14.315		
	Total	62612.209	4346			

The results obtained using ANOVA are F = 10,332 and Sig = 0,00. Because the sig value < 0.001, that indicates a high level of statistical significance. Since the sig value is much lower than the threshold $\alpha = 0.05$, we conclude that the player's position significantly influences the maximum speed reached. This result suggests that maximum speed truly differs between groups.

6.13.4.1. Discussion for testing Hypothesis 4

The means plot supports the conclusions of the ANOVA test, visually illustrating how maximum speed differs according to the player's role (Figure 6.2.). A distinct profile can be observed: Strikers and Defenders reach the highest average speeds, confirming the need for rapid sprints during attacking phases and defensive recovery, while Midfielders record the lowest maximum speed, reflecting a playing style based more on mobility and ball distribution rather than explosive accelerations.

Wingers are positioned in between, which corresponds to their mixed role that combines sprinting down the flanks with repeated high-intensity actions over longer distances.

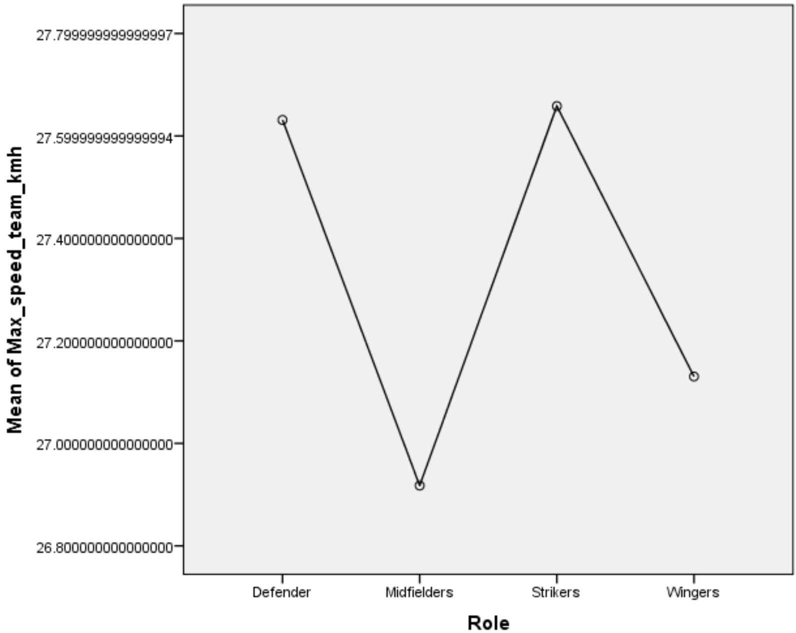

Figure 6.2. The means plot for maximum speed by playing position

The main study's conclusions

The research demonstrated that structured injury-prevention programs integrating neuromuscular training, eccentric strength exercises, proprioception, and core stability lead to a significant reduction in injury incidence and severity.

The use of monitoring tools such as GPS systems, heart rate variability, perceived exertion scales, and neuromuscular fatigue assessments allowed for better regulation of training stress and improved recovery management.

The implementation of structured periodization led to clear improvements in physical performance indicators, including speed, aerobic capacity, and strength, while simultaneously reducing injury incidence and overall injury risk.

Taken together, the findings of the study demonstrate that the integration of injury-prevention strategies, continuous load monitoring, and periodized conditioning forms a coherent and effective model for high-performance football.

CONCLUSIONS

Through this complex research, we aimed to analyze the interaction between the physical training of professional football players, competing at the highest competitive level, and the injuries they sustain throughout their period of activity.

By going through the three distinct approaches (Investigative approach 1, Investigative approach 2 and the Main study), which intertwine in a logical sequence, we were able to thoroughly investigate various aspects of football players' preparation in relation to the most unfortunate moments of their careers – injuries.

The comparative analysis conducted between the 2014 and 2024 groups of athletic trainers highlights both continuity and evolution within the profession. While the educational background and experiential profile of practitioners remained relatively stable, methodological refinements were evident. Testing batteries continue to be strategically positioned at the beginning of the competitive season, reflecting the practical constraints imposed by dense match calendars. Preference is given to functional, minimally invasive assessments (such as the Mognoni test, VO_2max laboratory evaluations, sprint tests over short distances), and jump-based power assessments – thereby balancing diagnostic accuracy with injury prevention considerations.

In synthesis, the evolution observed between 2014 and 2024 does not represent a radical methodological rupture but rather a process of progressive refinement. Modern athletic preparation in professional football is characterized by greater specificity, technological integration, individualized load management, and holistic attention to athlete welfare – elements that collectively define the current paradigm of performance optimization and injury prevention.

The second investigation examined the association between selected physical fitness parameters and injury occurrence in football players, monitoring a group of 118 professional and amateur athletes over the course of a full competitive season.

The findings demonstrate a statistically significant relationship between certain neuromuscular and metabolic indicators and injury incidence. In particular, greater eccentric hamstring strength and superior aerobic capacity were associated with a reduced likelihood of sustaining injuries.

These results reinforce the protective role of targeted conditioning strategies that enhance muscle resilience and optimize physiological efficiency under competitive stress.

In summary, the results highlight that injury prevention in football is strongly influenced by specific, performance-oriented physical qualities rather than by generalized conditioning measures alone.

The main study provides compelling evidence for the effectiveness of a comprehensive training framework in professional football, integrating structured injury-prevention programs, systematic load monitoring, and periodized performance conditioning. The study demonstrates that these components, when implemented cohesively, enhance athlete availability, reduce injury incidence, and support sustainable performance across competitive seasons.

Structured injury-prevention programs proved highly effective in reducing the frequency and severity of injuries, particularly muscle-related injuries such as hamstring strains. Incorporating neuromuscular training, eccentric strengthening, proprioceptive exercises, and core stability work resulted in meaningful decreases in recovery time and overall injury burden. These findings confirm the critical role of proactive preventive measures in maintaining consistent athlete participation and ensuring continuity of competitive performance.

Periodized training models that integrate performance conditioning, recovery, and preventive strategies were also shown to produce superior outcomes

Overall, the results support an integrated high-performance model in which injury-prevention programs, individualized load monitoring, and periodized conditioning work synergistically.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

While the longitudinal comparisons between 2014 and 2024 groups of athletic trainers provided valuable insight into methodological evolution, the study relied on retrospective recollections and self-reported practices in some areas.

Prospective, multi-season tracking with standardized reporting protocols would allow for more precise and objective evaluation of the long-term effects of methodological refinements on injury prevention and performance outcomes.

Another limitation concerns the monitoring and assessment tools used. Although GPS tracking, heart rate monitoring, and standardized performance tests provide robust internal and external load metrics, they cannot capture all dimensions of fatigue, neuromuscular stress, or psychological strain that may influence injury risk.

Incorporating emerging technologies such as wearable biochemical sensors, automated motion-capture systems, or machine learning-based injury prediction models could provide more granular, real-time insight into individual responses to training and competition.

At the same time, a similar type of research could be conducted across multiple top-tier football clubs in Europe, allowing for a comprehensive overview of training practices and injury patterns. Such an approach would provide future football S&C coaches (with robust, evidence-based insights) to develop new methodologies aimed at reducing injury incidence through optimized physical preparation.

DISSEMINATION OF RESULTS

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