**DOCTORAL THESIS**

# INTERNATIONAL DOCTORAL SCHOOL

*Programa de Doctorado en Ciencias del Deporte*

# Team and individual technical and tactical, and time motion parameters in professional Serie A soccer official matches.


*Author:*

Rocco Perrotta

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*Murcia, September 2025*

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## DEDICATION

Dedicated to my wife Stela and my daughter Aurora.

To my beloved wife Stela and my daughter Aurora, whose presence, love, and strength accompany me in every step I take.

For keeping alive the flame of curiosity, ambition, and the pursuit of knowledge; for embodying the love, strength, and hope that sustain me through every challenge; and for reminding me, every single day, of the purpose behind every ambition and every dream.

This work reflects what you inspire in me and of the future we continue to build together with courage, with dedication, and with love.

## ACKNOWLEDGMENTS

I would like to express my sincere gratitude to all those who have supported me throughout the development of this doctoral thesis.

My deepest appreciation goes to my thesis directors, Prof. Lupo and Prof. Cherubini, for their guidance, scientific rigor, and constant encouragement. Their expertise and constructive feedback have shaped this work and greatly contributed to its academic quality.

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My appreciation extends to Empoli FC and to all the performance, medical, and technical staff with whom I have worked over the years. Their professionalism and collaboration enriched this project and strengthened its applied relevance within elite football.

A special thanks goes to my colleagues, friends, and peers, whose discussions, insights, and support have been fundamental during this demanding path.

Finally, I would like to express my profound gratitude to my family. Their patience, love, and belief in me have been the foundation of my motivation. Without them, this achievement would not have been possible.

**THESIS SUPERVISORS’ AUTHORISATION**
**FOR THESIS SUBMISSION**

Prof. Domenico Cherubini and Prof. Corrado Lupo, as Supervisors of the Doctoral Thesis ‘Team and individual technical and tactical, and time motion parameters in professional Serie A soccer official matches.’ written by Mr Rocco Perrotta in the Doctorate Programme en Ciencias del Deporte, **authorise its submission**, given that it meets the required conditions for its defence.

Which we hereby sign in compliance with Spanish Royal Decree 99/2011, of 28 January, in Murcia, on September 30, 2025.

Prof Domenico Cherubini

Prof Corrado Lupo

[1] If the Thesis is supervised by more than one Supervisor, both must be mentioned and both must sign.

## ABSTRACT

Introduction: Several studies have been separately focused on technical and tactical, and time motion indicators in soccer performance. However, literature is limited in providing analyses able to combine these two types of parameters.

Objectives: The present project aimed at combining technical and tactical, and time motion parameters of Italian Serie A players.

Methods: Serie A team information (e.g., game period and associated current score, outcome of match) have been recorded to categorize single players' match performance parameters. Statistical analyses have been applied to analyse differences between roles and correlate time-motion and technical and tactical indicators within single roles, even according match outcomes and phase of advantage/disadvantage. In addition, the soccer players' profile has been also considered in relation to related factors: match location (home vs away teams), ranking categories of opponent teams (Serie A top level, higher level, lower level), and margin of victory (winning and losing match with >1 or only 1 goal of difference, and draw matches).

Conclusions: A series of successful players' Serie A soccer performance profile, especially considering the different characterizations of the matches emerged, thus encouraging coaches and physical trainers to promote individualized training sessions.



## KEY WORDS

notational analysis, time-motion analysis, technical and tactical factors, soccer, Serie A

**RESUMEN**

Introducción: Diversos estudios se han centrado por separado en los indicadores técnico-tácticos y de tiempo-movimiento en el rendimiento futbolístico. Sin embargo, la literatura es limitada a la hora de proporcionar análisis que combinen estos dos tipos de parámetros.

Objetivos: El presente proyecto tuvo como objetivo combinar los parámetros técnico-tácticos y de tiempo-movimiento de jugadores de la Serie A italiana.

Métodos: Se registró información del equipo de la Serie A (p. ej., periodo de juego y marcador actual asociado, resultado del partido) para categorizar los parámetros de rendimiento de cada jugador. Se aplicaron análisis estadísticos para analizar las diferencias entre roles y los indicadores de tiempo-movimiento y técnico-tácticos correlacionados dentro de cada rol, incluso según los resultados del partido y la fase de ventaja/desventaja. Además, también se ha considerado el perfil de los futbolistas en relación con factores relacionados: ventaja de local (equipos locales y visitantes), categorías de clasificación de los equipos oponentes (Serie A nivel superior, nivel superior, nivel inferior) y margen de victoria (partidos ganados y perdidos con >1 o solo 1 gol de diferencia y partidos empatados).

Conclusiones: Surgen una serie de perfiles de rendimiento de jugadores exitosos de fútbol de la Serie A, considerando especialmente las diferentes caracterizaciones de los partidos, que deberían alentar a los entrenadores y preparadores físicos a promover sesiones de entrenamiento individualizadas.



## PARABLA CLAVE

análisis notacional, análisis de tiempo-movimiento, factores técnico-tácticos, fútbol, Serie A

# GENERAL TABLE OF CONTENTS

# ACRONYMS AND ABBREVIATIONS

DF – Defenders

FW – Forwards

GPS – Global Positioning System

HPBPT – High percentage ball possession teams

KPI – Key Performance Indicator

LPBPT – Low percentage ball possession teams

MD – Midfields

MPErec – Average duration of the match periods occurring between patterns performed with a >20 W/Kg power peaks

TD – Total distance

TMA – Time-Motion Analysis

Z2 – Distances covered at 16.0–19.8 km/h expressed in meters

Z3 – Distances covered at 19.8–25.2 km/h expressed in meters

Z4 – Distances covered at >25.2 km/h expressed in meters

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# I – INTRODUCTION

## I.1. OVERVIEW

### 1.1 Background and Rationale

Soccer is recognised as one of the most globalised, culturally profound, and tactically sophisticated team sports, with more than 265 million active participants worldwide and a rapidly expanding professional ecosystem (Bradley et al., 2016). Over the last three decades, the sport has undergone an unprecedented transformation driven by professionalization, technological innovation, and the adoption of analytical methodologies within elite clubs (Amatria et al., 2019; Castellano et al., 2014). Modern elite soccer is now characterised by the continuous interaction of physical, technical, tactical, cognitive, and contextual elements, which collectively shape performance complexity and competitive dynamics (Carling, 2011).

Players today are required to integrate high levels of technical proficiency, tactical adaptability, perceptual–cognitive skill, and physical robustness within fast-paced, unpredictable, and tightly constrained environments (Davids et al., 2013). From executing rapid decision-making under opponent pressure to sustaining repeated high-intensity efforts across distinct tactical phases, contemporary performance reflects a multifaceted system where actions emerge from player–environment interactions rather than from isolated abilities. This has led to a paradigm shift in performance analysis, with increasing emphasis on capturing the *ecological complexity* of match play.

Match analysis represents one of the most influential scientific and applied tools in this context. Initially adopted to provide descriptive observations for coaching staff, match analysis has evolved into a rigorous analytical discipline capable of quantifying technical actions, tactical behaviours, physical demands, and contextual influences. Today, it supports decision-making in training design, tactical preparation, player recruitment, talent identification, and injury prevention (Castellano et al., 2014; M. D. Hughes & Bartlett, 2002; Modric, Malone, et al., 2022).

However, despite significant methodological advancements, the scientific literature still tends to analyse performance through reductionist frameworks. Time-motion analysis (TMA) often focuses solely on time-motion demands—such as total distance or high-speed running—without linking these actions to tactical context or technical intention (Bradley et al., 2016). Conversely, notational analysis typically examines technical–tactical events—such as passes, shots, duels, or defensive actions—without incorporating the physical behaviours that accompany and enable these actions (Dellal et al., 2010; Lago-Ballesteros & Lago-Peñas, 2010).

This separation leads to fragmented interpretations of performance, preventing a full understanding of *why* certain behaviours arise and *how* physical and technical–tactical elements interact dynamically during match play. Recent theoretical models, especially those derived from ecological dynamics and the constraints-led approach, emphasize that technical execution, tactical behaviour, and time-motion output are inherently interdependent components of a single system (Davids et al., 2013). An integrated analysis is therefore essential to capture the multidimensional nature of elite performance.

In Italian Serie A specifically, match analysis acquires particular relevance due to this league's historically recognised tactical culture. Serie A is characterised by well-structured defensive systems, strategic pacing, compact team organisation, and pronounced role specialization (Modric, Versic, et al., 2022). These unique attributes influence both technical–tactical behaviour and time-motion demands. For example, teams employing low blocks and organised defensive phases often produce distinct high-speed running patterns compared with teams that favour high pressing or aggressive counterattacks (Bradley et al., 2016). Understanding how these tactical preferences shape time-motion outputs is crucial for applied performance staff and researchers.

The integrated approach adopted in this doctoral thesis is therefore both scientifically necessary and practically relevant. By simultaneously analysing the technical–tactical actions and the time-motion parameters of Serie A players—while accounting for contextual variables such as match location, opponent ranking, and margin of victory—this work offers a comprehensive performance model that reflects the ecological reality of elite Italian football. Such a model aligns with recent calls within sport science for multidimensional frameworks capable of capturing the complexity of match performance.

### I.1.1. Match analysis

Match analysis has advanced from a simple observational tool to a highly sophisticated scientific discipline. Its development can be divided into three major phases.

**Phase 1: Early Observational Approaches (1970s–1990s)**

Early research relied on manual recording and direct observation to capture basic technical and physical activities. Reilly and Thomas (1979) were among the first to document the intermittent nature of soccer through hand-operated time–motion categorisations. Although limited by the observational technology of the era, these pioneering efforts established performance analysis as a legitimate field of inquiry.

**Phase 2: Video-Based Analysis and Computer-Assisted Coding (1990–2010)**

Advances in video technology and software facilitated more systematic evaluation of technical and tactical events (M. D. Hughes & Bartlett, 2002). Researchers developed structured frameworks to analyse possession sequences, transitions, and defensive systems. Studies during this period significantly expanded understanding of performance by introducing reliability protocols and coding procedures that remain standard today.

**Phase 3: Technological and Analytical Integration (2010–present)**

Modern match analysis uses advanced tracking systems—such as GPS, optical tracking, and inertial sensors—to collect high-frequency movement data (Castellano et al., 2014; Di Salvo et al., 2007). These data allow detailed evaluation of: high-speed running, sprinting profiles, accelerations and decelerations, positional data, tactical synchronization.

The implementation of artificial intelligence and machine learning has further enhanced match analysis by enabling predictive modelling, network analysis, and spatial-temporal quantification (Rein & Memmert, 2016).

### Applied Relevance

Within elite clubs, match analysis is able to provide data about: tactical preparation, training plan periodization, opponent evaluation, performance benchmarking, injury prevention, and recruitment and scouting

Despite these advances, the field lacks integrated frameworks connecting technical–tactical behaviour with physical demands, especially within Serie A.

### I.1.2. Notational analysis

Notational analysis constitutes one of the foundational pillars of performance evaluation in soccer. It refers to the systematic categorisation and quantification of technical and tactical actions that occur during match play, such as passing sequences, defensive duels, shots, positional movements, and transitions (M. D. Hughes & Bartlett, 2002). The purpose of notational analysis is to provide objective information that describes the behavioural patterns of individuals and teams, allowing for comparisons across match contexts, playing roles, game models, and competitive levels.

**Historical and Conceptual Foundations**

The development of notational analysis in soccer began with the need to move beyond subjective interpretation by coaches and to establish evidence-based descriptions of performance. Hughes and Franks (2004) formalised principles of match notation, highlighting the importance of reliability, operational definitions, and structured observation systems. Their frameworks established the methodological foundation for present-day analysis.

The subsequent expansion of video technologies, coding software, and digital platforms allowed researchers to capture technical actions with far greater precision and reliability (Carling, 2011). This transition shifted the field from basic descriptive metrics—such as total passes or shots—to more complex indicators including: progressive passes, expected threat (xT) actions, pressing sequences, build-up patterns, defensive compactness, line-breaking passes, involvement in possession phases.

Moreover, notational analysis has become increasingly aligned with tactical modelling. For instance, Lago-Peñas and Dellal (2014; 2010) demonstrated that possession sequences vary significantly according to match status, opponent level, and match location. This finding supports the premise that technical–tactical actions are deeply contextual rather than simply random or individual-dependent.

### Position-Specific Technical–Tactical Behaviour

Contemporary research consistently shows that technical–tactical demands differ substantially across positional roles (Dellal et al., 2010).

- **Midfielders** typically engage in the highest number of ball involvements, perform short–medium range passes, and regulate transitions between offensive and defensive phases.
- **Forwards** execute a greater proportion of finishing actions, offensive duels, and movements aimed at destabilising defensive lines (H. Liu et al., 2016).
- **Defenders** display higher involvement in interceptions, clearances, aerial duels, and build-up from deep areas, often under high pressure.

These behaviours emerge from tactical responsibilities, spatial constraints, and team strategies; thus, understanding them requires a contextualised and role-specific analytical approach.

### The Role of Tactical Structures

Soccer tactics are inherently dynamic and influence technical actions profoundly. Teams employing high pressing perform greater numbers of recoveries in advanced zones and generate shorter possession sequences but more transitions. Conversely, possession-based teams demonstrate higher pass accuracy, increased ball circulation, and broader spatial distribution (Modric, Versic, et al., 2022).

Tactical structures—including formation, playing style, and team synchronisation—shape not only technical actions but also the time-motion demands required to execute them. Research by Rein and Memmert (2016) showed that tactical configurations directly influence:

- distance covered in specific zones
- width and depth occupation
- defensive line height
- compactness and synchronisation
- passing networks and centrality metrics

This confirms that notational data alone cannot fully represent match performance unless considered alongside spatial–temporal and physical information.

**Limitations of Non-Integrated Notational Analysis**

Although highly informative, notational analysis often treats performance as a sequence of isolated events. However, several conceptual limitations have to be mentioned. Among these: **lack of physiological context,** for which **t**echnical actions occur within specific physical constraints; without TMA, these constraints remain invisible. Then, **difficulty capturing emergent tactical behaviours,** where **c**ollective movements such as synchronisation or counterpressing require integration with positional or time-motion data. **Limited understanding of causality,** could represents, for example, the missing integrated context of a specific technical aspect such as an unsuccessful pass which may be associable to fatigue, tactical misalignment, opponent pressure, or technical error — without **minimal attention to contextual factors.** Coherently, match status, opponent level, environmental conditions, and situational constraints shape technical–tactical actions profoundly (Lago-Ballesteros & Lago-Peñas, 2010).

These limitations justify the need for integrated frameworks capable of linking technical–tactical events with physical, spatial, and temporal data — one of the core goals of the present thesis.

### I.1.3. Time-motion analysis

Time-motion analysis (TMA) represents the most established methodological tradition in soccer performance research. It quantifies the time-motion demands of match play, including total distance covered, high-speed running, sprinting, accelerations, decelerations, and metabolic power outputs (Di Salvo et al., 2007). With the evolution of tracking technologies, TMA has become central to both applied performance departments and academic research.

**Technological Evolution of TMA**

TMA initially relied on manual observation with rudimentary tools, but technological advancements radically changed its accuracy and scope. The introduction of GPS systems (5–18 Hz), local positioning systems (LPS), or semi-automated optical tracking (e.g., TRACAB) have enabled high-frequency (10–25 Hz) tracking of players' spatial coordinates, and allowing for detailed analysis of: movement intensity profiles, positional heatmaps, high-speed actions, tactical synchronization, movement variability, and repeated-sprint sequences, demonstrating that these technologies significantly increase measurement reliability compared to visual estimation (Castellano et al., 2014).

**Positional Differences in Time-motion Demands**

Elite soccer displays consistent positional differences in external load metrics across leagues (Bradley et al., 2016; Di Salvo et al., 2007; Rampinini et al., 2009), reporting different patterns reflecting tactical roles and team playing styles: midfielders cover the greatest overall distances due to their transitional role; wide defenders and wingers perform the most high-speed running; central defenders perform fewer sprints but more accelerations and repeated short movements due to compact defensive structures; forwards combine intermittent intense actions with explosive movements in the final third.

However, these movement patters can be influenced by several contextual variables such as:

- **match location**: home teams exhibit greater high-speed running due to more offensive intent (Lago-Ballesteros & Lago-Peñas, 2010).
- **opponent level**: matches against stronger opponents often require increased defensive running efforts (Bradley et al., 2016).
- **match status**: losing teams sprint more during offensive transitions, while winning teams often reduce pace and adopt compact structures (Castellano et al., 2011).
- **playing style**: high-pressing systems generate more accelerations and high-intensity bursts, while possession-dominant teams display more positional running (Vigne et al., 2010).
- **formation**: the number of midfielders or wide players modifies typical movement demands.

As a consequence, these modulators highlight the need to interpret TMA within tactical context to avoid misleading conclusions.

**Limitations of Non-Integrated TMA**

Although indispensable, TMA alone cannot explain the reasons behind physical behaviours. In fact, TMA alone will be affected by the **lack of tactical attribution,** for which a sprint recorded by GPS is not able to reveal *why* it occurred.

In addition, the **inability to link physical actions to technical events (**for example, increases in high-speed running may reflect counterattacks, but this requires technical-tactical confirmation). Furthermore, l**imited understanding of decision-making,** thus not considering how movement patterns are shaped by affordances, constraints, and tactical demands (Davids et al., 2013). Finally, TMA could result **inadequate to represent team behaviours,** reporting physical metrics which alone cannot represent synchronization, compactness, or spatial occupation of teammates.

Therefore, these methodological limitations justify the need for combined approaches capable of capturing the interactions between TMA output and tactical–technical demands — which is precisely the rationale behind the integrated approach developed in this thesis.

### I.1.4. Combined notational and time-motion analyses

In recent years, the integration of technical–tactical indicators with time-motion data have emerged as one of the most relevant advancements in performance analysis. This combined approach is aligned with contemporary theoretical models such as ecological dynamics and the constraints-led framework, which propose that player behaviours arise from continuous interactions between individual characteristics, task demands, and environmental constraints (Davids et al., 2013). According to this perspective, technical execution, tactical decisions, and TMA output cannot be understood as separate components, but rather as co-dependent manifestations of a complex adaptive system.

**Rationale for Integrated Analyses**

A combined perspective allows analysts to answer questions that isolated approaches cannot address. For example:

- Do players sprint more during specific tactical contexts (e.g., counterattacking transitions)?
- Does passing accuracy decrease as physical fatigue increases?
- Do high-possession teams demonstrate different high-speed running patterns compared with low-possession teams?
- How do contextual factors such as match status or opponent quality affect both technical and physical behaviours simultaneously?

These interactions have been demonstrated empirically. Vigne et al. (2010) showed that high-intensity actions frequently occur during transitions and attacking sequences. Dellal et al. (2010) found that technical efficiency and TMA output vary according to tactical role. Sarmento et al. (2014) highlighted the interdependence between physical and technical actions in elite matches. More recently, studies have demonstrated that players' ability to execute technical actions under high-intensity movement is crucial for successful performance (Bradley, 2024; Modric, Malone, et al., 2022).

**Integration Through Spatial–Temporal Modelling**

One of the most significant advancements in integrated match analysis has been the incorporation of spatial–temporal data. Optical tracking and positional systems allow researchers to evaluate:

- team compactness
- synchronization indexes
- relative distances between lines
- pitch control metrics

- pressing intensity
- off-the-ball movement patterns (Rein & Memmert, 2016; Sampaio & Maçãs, 2012).

These variables can then be linked with technical actions and time-motion demands. For example, high pressing requires coordinated accelerations and high-speed bursts across several players, whereas possession-based play demands frequent small-sided movement patterns (Arias-Estero et al., 2020). Integrated models therefore allow the identification of tactical signatures associated with TMA profiles.

**Role-Specific Integrated Behaviours**

Recent literature demonstrates that the relationship between technical–tactical actions and TMA demands varies significantly by player position (Modric, Versic, et al., 2022; Tierney et al., 2016):

- **Forwards:** typically combine high-speed running with finishing actions, offensive duels, and movements beyond the defensive line.
- **Midfielders:** integrate high passing volumes with moderate-to-high TMA demands involving transitions.
- **Defenders:** exhibit lower high-speed distances but higher accelerations, interceptions, and tactical repositioning demands.

These findings reinforce the relevance of integrated, role-specific analysis—the exact approach developed within this thesis.

**Contextual Modulation of Integrated Performance**

Contextual factors substantially modify the relationship between technical–tactical behavior and TMA output. For example:

- **Match location:** home teams tend to demonstrate more offensive technical–tactical actions and higher high-speed running (Lago-Ballesteros & Lago-Peñas, 2010).
- **Match status:** losing teams often increase sprinting and direct attacking actions; winning teams display more conservative patterns (Castellano et al., 2011).
- **Opponent strength:** matches versus top-tier opponents often require greater defensive running and reduced technical accuracy (Bradley et al., 2016).
- **Margin of victory:** decisive wins/losses produce different tactical rhythms and physical intensities (Gómez et al., 2018).

An integrated framework enables a deeper understanding of how these variables interact to shape performance behaviour.

**Current Gaps in Serie A Research**

Despite progress in other top leagues, integrated studies focused on **Italian Serie A remain limited**. Serie A is characterised by (Modric, Versic, et al., 2022; Savoia et al., 2024):

- pronounced tactical organisation,
- compact defensive structures,
- slower game tempo compared with Premier League or Bundesliga,
- highly structured pressing strategies,
- strong emphasis on positional discipline

These characteristics make it an ideal context for integrated analysis, as tactical structures exert significant influence on TMA demands.

However, most existing research in Serie A focuses either on:

- technical–tactical patterns (e.g., passing and possession behaviours), **or**
- physical demands (e.g., TMA metrics),

with few studies combining the two domains. This doctoral thesis addresses this gap by providing one of the few comprehensive, contextualised, role-specific integrative analyses conducted on a full competitive season of Serie A.

### I.1.5. Scientific interest of the project

The scientific interest of this study arises from several theoretical, methodological, and applied considerations.

**1. Theoretical Advancement**

This thesis contributes to contemporary performance science by proposing a **multidimensional, context-sensitive model** of match performance. Existing research has largely adopted reductionist approaches, analysing technical, tactical, or physical components in isolation (Sarmento et al., 2014). By integrating these components, the present work aligns with modern theoretical paradigms that emphasise:

- interactive constraints,
- emergent behaviours,
- player–environment coupling,
- tactical–physical interdependence (Davids et al., 2013; Seifert et al., 2017).

**2. Methodological Innovation**

The thesis provides one of the few **integrated match analysis models applied to Italian Serie A**, introducing:

- combined TMA and notational data,
- contextual stratification (match location, opponent ranking, margin of victory),
- role-specific interaction matrices,
- correlation analyses linking physical and technical–tactical indicators.

These methodological choices enhance reproducibility and serve as a blueprint for future research.

**3. Applied Relevance for Elite Clubs**

The findings offer practical value for:

- match preparation and tactical periodisation,
- role-specific conditioning,
- physical–technical training integration,
- scouting and recruitment,
- return-to-play decision-making,
- load management and injury prevention strategies.

Serie A clubs — known for tactical detail — benefit particularly from integrated insights that highlight the interaction between tactical patterns and time-motion demands.

**4. Contribution to Future Research and Policy**

The thesis establishes a platform for future developments including:

- machine-learning tactical prediction,
- integrated talent profiling,
- benchmarking performance across leagues,
- deeper exploration of ecological tactical systems.

It also contributes to the growing consensus within sport science that integrated frameworks should become the normative standard in match analysis research.
Conclusion of Chapter I

This extended introduction has established the theoretical and methodological foundation for the thesis. It has:

- contextualized modern match analysis within contemporary sport science;
- examined the strengths and limitations of notational and time-motion approaches;
- justified the need for integrated frameworks;
- identified gaps specific to Serie A;
- outlined the scientific relevance of the project.

This conceptual groundwork prepares the transition to Chapter II – Justification, where the rationale for the study will be detailed in alignment with doctoral-level requirements.

# II – JUSTIFICATION

## II. JUSTIFICATION

The justification for this doctoral thesis is grounded in contemporary performance science, which increasingly emphasises the need to analyse soccer as a **complex, multidimensional, and context-dependent system**. Despite the exponential growth of performance analytics in professional football, most research continues to evaluate technical–tactical and physical performance **in isolation**, leading to partial and sometimes misleading interpretations of match behaviour (Rein & Memmert, 2016; Sarmento et al., 2014). The present thesis addresses this gap by proposing a fully integrated analytical model applied to Italian Serie A.

Recent literature (2023–2025) has reinforced the need to bridge these domains. Analyses integrating tactical dynamics, player tracking, and event-based data are becoming essential for accurately describing elite performance (Bradley, 2024; Modric, Malone, et al., 2022; Savoia et al., 2024). These models acknowledge that technical executions, decision-making behaviours, and TMA outputs emerge collectively from interacting constraints—individual, environmental, and tactical—consistent with ecological dynamics principles (Seifert et al., 2017).

The following justification addresses five pillars:

1. **Theoretical need for integration**
2. **Methodological limitations in current literature**
3. **Applied relevance for elite professional environments**
4. **Specific need for Serie A-focused models**
5. **Alignment with UCAM doctoral standards and ethical scientific practice**

### II.1. Theoretical Need for Integrated Performance Models

Across the last decade, soccer performance science has shifted towards systems-based models in which players are conceptualized as adaptive decision-makers interacting dynamically with teammates, opponents, and spatial structures (Davids et al., 2013; Seifert et al., 2017). More recent research highlights how physical, technical, and tactical demands cannot be decoupled. Among these, for example sprinting actions can frequently occur during counterattacking transitions, pressing triggers, or defensive recoveries (Bradley, 2024; Modric, Malone, et al., 2022); technical efficiency can vary based on fatigue, opponent pressure, and team tactical shape; or possession structures can influence the volume and intensity of high-speed running (Mayhew et al., 2015). Nevertheless, the majority of existing studies (even recent ones) exclusively examine: **time-motion analysis (TMA)** (without contextual tactical information); **technical-tactical indicators** (without time-motion context); **decision-making** (without physical execution conditions), or **match events** (without spatial–temporal interaction measures).

This reductionist fragmentation limits theoretical understanding and affects practical decision-making in elite environments (Rein & Memmert, 2016).

The present thesis contributes theoretically by creating a **holistic, role-specific, ecology-driven performance model** based on real Serie A data. This framework responds directly to calls from recent literature (2023–2025) for integrated match systems that include: tracking data, contextual variables, tactical phases, technical executions, game-rhythm dynamics, opposition quality indicators, spatial–temporal interactions (Bradley, 2024; Gonçalves et al., 2017; Modric, Malone, et al., 2022).

### II.2. Methodological Limitations in Current Literature

Although performance analysis has advanced rapidly, recent systematic reviews (2023–2024) highlight key methodological gaps such as: limited integration of datasets; Poor contextual stratification; over-generalization across leagues; and lack of role-specific integrated modelling.

Among limited integration of datasets, studies still predominantly use either: GPS/optical tracking which report notational technical–tactical data, with very few combinations with time-motion data; poor contextual stratification with only a minority of papers stratify results by: match location, opponent level, margin of victory, tactical formation, match status evolution, and yet context substantially alters performance demands (Bradley, 2024; Gómez et al., 2018); overgeneralization across leagues, for which recent research confirms that tactical cultures differ deeply across leagues like Premier League, Bundesliga, LaLiga, and Serie A (Modric, Malone, et al., 2022; Savoia et al., 2024). Finally, l**ack of role-specific integrated modelling has been demonstrated by m**ost studies that still provide: average team-level outputs, insufficient role granularity, limited correlation analysis. As a consequence, the present thesis could solve some of the above-mentioned limitations by means of: high-quality Serie A tracking data, event-based technical–tactical coding, role-specific, context-based segmentation, large longitudinal dataset (entire season), integrated correlation matrices, ecological analytical interpretation

### II.3. Applied Relevance for Elite Clubs

Recent applied research (2023–2025) shows that elite performance analyses require integrative models to support: weekly tactical periodization, individual load management, injury-prevention decision-making, recruitment and benchmarking, player profiling and development, opposition analysis, and session design based on match-derived patterns. For this reason, applied relevance for ilite clubs are valuable with contextualized findings where, for examples: high-speed actions are linked to tactical intentions rather than conditioning alone; technical demands vary according to team shape and pressing structures (Moran et al., 2024); team compactness affects both technical efficiency and metabolic cost (Altmann et al., 2023); or modern role-specific conditioning must reflect integrated technical–physical patterns (Bradley, 2024).

Therefore, this thesis therefore provides actionable models that can be immediately applied in elite environments.

### II.4. Serie A–Specific Scientific Need

Among published studies, finding on Serie A reported: compact defensive systems, reduced playing verticality but higher spatial organization, structured pressing, intense role specialization, and higher tactical variability across coaches (Sarmento et al., 2024; Savoia et al., 2024). Therefore, future research perspectives urged in terms of: league-specific profiling, tactical-physical integrated modelling, and contextual differentiation.

### II.5. Ethical, Practical, and Scientific Integrity

An increasingly important dimension in contemporary research is the assurance of **ethical rigor** and **scientific transparency**. For this reason, multiple and recent sport science editorials have emphasized the need of a clear methodological reproducibility, transparent reporting of data handling, minimization of researcher bias, rigorous citation and paraphrasing practices to reduce academic similarity, and respectful handling of athlete data under GDPR standards (Torres-Ronda et al., 2022). As a consequence, the present doctoral thesis aims at fully guarantying these principles through non-invasive, anonymized data, complete transparency of analytical workflow, original writing aligned with ethical academic standards, compliance with UCAM ethical norms, and format bibliographic accuracy.

### II.6. Contribution to the Advancement of Sport-Science Knowledge (2023–2025 Perspective)

Recent sport-performance research underscores the urgent need for **actionable, ecologically valid models** capable of supporting performance optimization in elite soccer environments (Seifert et al., 2017).

The present thesis contributes directly to this evolution through: **a novel integrated methodological framework, able to combining**: optical tracking, event-based notational analysis, contextual variables, role-specific distinctions, multivariate and correlation-based profiling in Serie A football matches (Bradley, 2024; Modric, Malone, et al., 2022).

Considering the **league-specific benchmarking,** Serie A's evolved tactical landscape—characterized by compactness, structured pressing, and slower ball time—requires bespoke scientific models (Savoia et al., 2024). For this reason, this Doctorate aimed to contribute in defining role-specific baselines, contextual variations, tactical–physical interaction patterns unique for Italian football. As a consequence, from a methodological point of view, the present work also aimed **improve the ecological validity** in performance analysis. In fact, by analyzing an entire competitive season, this research reflects **real-world behavioural variability**, which is fundamental to elite decision-making (Araujo et al., 2015). In terms of practical applications, practitioners will be able to benefit from the findings of this thesis because the integrated outputs can be applied immediately to weekly tactical periodization, player development profiling, load management, injury prevention decision-making, recruitment and succession planning, and opposition scouting (Moran et al., 2024; Torres-Ronda et al., 2022).

Finally, these findings will be able to be **aligned with emergent analytical technologies (2024–2025),** increasing the adoption of: AI-based tactical pattern detection, large-scale tracking datasets, machine-learning cluster analyses, real-time tactical intelligence systems (Mayhew et al., 2015).

### II.7. Final Rationale and Transition to Objectives & Hypotheses

In conclusion, the present thesis is justified by:

- **theoretical necessity**: soccer as a complex adaptive system requiring multidimensional analysis;
- **methodological innovation**: combined technical–tactical, physical, and contextual data integrated through rigorous workflows;
- **scientific relevance**: addressing major gaps in existing literature, especially in Italian Serie A;
- **practical utility**: producing role-specific and context-specific performance models useful for elite clubs;

The foundation established in this chapter leads directly into CHAPTER III **– OBJECTIVES & HYPOTHESES**, where the analytical scope and expected outcomes are formally defined according to contemporary performance-science models and the integrated rationale developed here.

# III – OBJECTIVES AND HYPOTHESES

# III. OBJECTIVES AND HYPOTHESES

The conceptual and theoretical foundations established in the previous chapters provide the basis for defining the aims that guide this doctoral research. In line with contemporary thinking in performance science, football is conceptualised as a complex adaptive system in which behaviour emerges from the continuous interaction of technical, tactical, physical, and contextual constraints (Araujo et al., 2015; Davids et al., 2013; Sampaio & Maçãs, 2012). Within such a framework, objectives and hypotheses cannot be restricted to isolated descriptive questions; they must reflect the multidimensional and context-dependent nature of performance in elite environments and be capable of supporting integrated, ecologically valid analyses.

The present chapter therefore articulates the purpose of the study through one overarching general objective and a set of specific objectives that together operationalise the theoretical assumptions introduced in Chapter I and the justification presented in Chapter II. Building on these objectives, a series of hypotheses are formulated that are explicitly grounded in the existing literature and aligned with recent developments in match analysis, tracking methodologies, and tactical–physical integration (Amatria et al., 2019; Bradley, 2024; Modric, Malone, et al., 2022; Sarmento et al., 2014, 2024). In this way, the chapter serves not only as a formal statement of intent, but also as a conceptual bridge between theory and the empirical analytic strategy implemented in subsequent chapters.

## III.1. General Objective

The general objective of this doctoral thesis is to develop and apply an integrated analytical framework for the study of elite football performance in Italian Serie A, capable of simultaneously examining technical–tactical indicators, time-motion variables, and contextual factors across an entire competitive season. This overarching aim is explicitly rooted in the shift from reductionist models toward complex, multidimensional representations of performance that characterise recent research in team sports (Rein & Memmert, 2016; Sampaio & Maçãs, 2012; Sarmento et al., 2014).

More specifically, the general objective is to characterise and interpret role-specific performance profiles—defenders, midfielders, and forwards—while considering both their technical–tactical engagement and their locomotor demands, and to determine how these profiles are modulated by contextual variables such as match location, opponent strength, and margin of victory. This approach responds directly to calls for more comprehensive, contextually stratified models that move beyond simple descriptive statistics and capture the ecological reality of elite competition (Lago-Peñas & Gómez-López, 2014; Mayhew et al., 2015; Miguel Gómez-Ruano et al., 2021).

In conceptual terms, the general objective aligns with ecological dynamics by treating performance as the emergent outcome of interactions between players' capabilities, tactical structures, and environmental constraints (Araujo et al., 2015; Davids et al., 2013). It is also consistent with recent position papers and reviews highlighting the need for integrated frameworks that combine time-motion analysis, notational indicators, and contextual information when evaluating match performance at the highest level (Sarmento et al., 2024; Torres-Ronda et al., 2022).

## III.2. Specific Objectives

To address the general objective scientific, the research is articulated into four specific objectives. Each objective translates the broad theoretical principles of complexity, integration, and contextual dependency into clearly defined analytic tasks.

Four specific objectives operationalise the central aim of the study.

### III.2.1. Objective 1 — Characterise and Compare Time-Motion Demands Across Playing Roles

The first specific objective is to characterise and compare the time-motion demands associated with distinct playing roles—defenders, midfielders, and forwards—over an entire Serie A season. Time-motion analysis has become one of the most established tools in football research, allowing quantification of movement categories such as total distance, high-speed running, sprinting, accelerations, and decelerations (Di Salvo et al., 2007; Hands & Janse de Jonge, 2020; Rampinini et al., 2009).

Research consistently demonstrates that locomotor demands differ considerably by position, reflecting tactical responsibilities and spatial functions within team structures (Bradley et al., 2016; Modric, Malone, et al., 2022; Sarmento et al., 2024). Midfielders tend to cover the greatest total distance; forwards typically register higher sprint and high-speed running volumes; defenders often show lower macro-locomotor volumes but higher frequencies of short, intense accelerations and decelerations (Bradley, 2024; Vigne et al., 2010). Within this context, Objective 1 aims to provide an updated, Serie A–specific description of these patterns using contemporary thresholds and a full-season dataset (Modric, Malone, et al., 2022), thereby establishing robust benchmarks for subsequent integrated analyses.

### III.2.2. Objective 2 — Describe and Compare Technical–Tactical Indicators Across Playing Roles

The second specific objective is to describe and compare technical–tactical indicators across playing roles, with particular attention to metrics that reflect role-specific responsibilities and tactical functions. Notational analysis enables systematic quantification of technical and tactical actions such as passes, shots, duels, recoveries, and build-up contributions (M. D. Hughes & Bartlett, 2002; M. Hughes & Franks, 2004; James, 2006). Recent studies show that these indicators vary not only by position but also by playing style, formation, and competitive level (González-Rodenas et al., 2023; T. Liu et al., 2021).

In elite contexts, midfielders often emerge as central hubs of ball circulation and game tempo; defenders are key to build-up initiation, interceptive actions, and depth control; forwards are primarily responsible for penetration, finishing, and destabilisation of opposition defensive lines (Savoia et al., 2024; Yi et al., 2018). By systematically analysing role-specific technical–tactical indicators, Objective 2 seeks to construct a detailed behavioural profile for each positional group within Serie A, thereby complementing the physical characterisation achieved through Objective 1.

### III.2.3. Objective 3 — Evaluate Integrated Relationships Between Technical–Tactical and Time-Motion Indicators

The third specific objective is to examine the integrated relationships between technical–tactical and time-motion indicators within each playing role. This objective is grounded in the idea that physical and technical behaviours co-emerge under the influence of tactical and contextual constraints, consistent with ecological dynamics and complexity theory (Davids et al., 2013; Ric et al., 2016; Sampaio & Maçãs, 2012).

Previous work suggests, for example, that high-speed running often occurs during counterattacking or pressing sequences, that accelerations may be associated with defensive duels or rapid positional adjustments, and that technical efficiency can be influenced by measures of physical load (Mayhew et al., 2015; Modric, Malone, et al., 2022; Modric, Versic, et al., 2022). However, integrated analyses remain relatively rare, especially in Serie A. By quantifying correlations between locomotor and technical–tactical indicators—stratified by role—Objective 3 seeks to determine how physical outputs and technical actions are coupled in practice, offering insight into the mechanistic underpinnings of performance in elite competition (Bradley, 2024).

### III.2.4. Objective 4 — Analyse the Influence of Contextual Variables on Integrated Performance

The fourth specific objective is to analyse how contextual variables modulate integrated performance patterns. Numerous studies have shown that match location, opponent quality, and scoreline exert substantial effects on both technical–tactical and physical behaviour (Castellano et al., 2011; Gómez et al., 2018; Vigne et al., 2010). Home advantage, for example, is associated with increased offensive intent, higher ball possession, and often greater high-intensity running (Gómez et al., 2018; Lago-Ballesteros & Lago-Peñas, 2010; Lago-Peñas & Gómez-López, 2014). Similarly, matches against strong opponents may drive more defensive behaviours, reduce technical efficiency, and alter the nature of transitions (Bradley et al., 2016; Teixeira et al., 2021). Scoreline and match status further influence tactical choices, risk-taking, and intensity profiles (Gómez et al., 2018; Lago-Peñas & Gómez-López, 2014).

Objective 4 therefore aims to determine how integrated performance—combining technical–tactical and time-motion indicators—is shaped by match location (home vs. away), opponent strength (top-, middle-, and bottom-ranked teams), and margin of victory (win, draw, loss). By doing so, the thesis enhances ecological validity and aligns with the contemporary emphasis on context-aware performance models in football research (Savoia et al., 2024; Torres-Ronda et al., 2022).

### III.3. Hypotheses

Based on the specific objectives and grounded in the current body of evidence, six hypotheses have been formulated to guide the analytical phase of the research. These hypotheses are not conceived as isolated propositions but as interconnected expectations derived from the integrated conceptual framework of the thesis.

#### III.3.1. H1 — Positional Differences in Integrated Performance Indicators

The first hypothesis posits that defenders, midfielders, and forwards will present significantly different performance profiles, both in time-motion and technical–tactical indicators. This expectation is firmly supported by extensive literature documenting positional variation in locomotor demands and technical involvement at elite level (Bradley et al., 2016; Di Salvo et al., 2007; Sarmento et al., 2024). More recent work has reinforced this pattern using updated thresholds and advanced tracking systems, highlighting consistent differences in sprinting, high-speed running, and action density across positions (Bradley, 2024; Modric, Malone, et al., 2022). Accordingly, H1 anticipates that the combined analysis of physical and technical measures will reveal distinct positional signatures within Serie A.

#### III.3.2. H2 — Role-Specific Correlations Between Technical–Tactical and Time-Motion Variables

The second hypothesis proposes that, within each positional group, specific technical–tactical indicators will correlate significantly with time-motion variables in ways that reflect role-specific tactical responsibilities. For instance, it is expected that high-speed running and sprint distance will be closely associated with offensive actions among forwards (shots, offensive duels, penetrating runs), that accelerations and decelerations will relate strongly to defensive duels and recoveries among defenders, and that total distance and progressive passing will correlate among midfielders (Modric, Malone, et al., 2022; Modric, Versic, et al., 2022). This hypothesis is grounded in integrated studies showing that physical and technical actions often co-occur within specific tactical contexts (Mayhew et al., 2015; Vigne et al., 2010) and supports the notion that performance must be understood as a multi-domain phenomenon.

#### III.3.3. H3 — Influence of Match Location on Technical–Physical Profiles

The third hypothesis concerns the influence of match location, proposing that home matches will be associated with higher offensive technical involvement and greater high-intensity locomotor output compared with away matches. This expectation aligns with the extensive literature on home advantage, which has demonstrated that teams playing at home tend to adopt more proactive tactical behaviours, sustain higher pressing, and cover greater distances at higher intensities (Gómez et al., 2018; Lago-Peñas & Gómez-López, 2014; Teixeira et al., 2021). Within this thesis, H3 anticipates that integrated indicators—combining technical and physical measures—will reflect this pattern, showing more assertive performance at home across roles.

#### III.3.4. H4 — Effects of Opponent Strength on Performance Demands

The fourth hypothesis states that matches against top-tier opponents will yield higher defensive workloads, reduced technical efficiency, and more compact tactical behaviours than matches against lower-ranked opponents. Previous work has shown that facing strong opposition alters both tactical strategy and physical demands, often forcing teams to spend longer periods defending, to run more in high-intensity zones, and to accept lower possession and passing accuracy (Bradley et al., 2016; Gómez et al., 2018; Teixeira et al., 2021). In line with these findings, H4 predicts that the integrated performance profiles examined in this thesis will be sensitive to opponent quality, particularly in terms of defensive running, duel frequency, and technical output under pressure (Savoia et al., 2024).

### III.3.5. H5 — Influence of Margin of Victory and Match Status

The fifth hypothesis addresses the effects of margin of victory and match status on performance. It posits that tightly contested matches—characterised by narrow scorelines—will be associated with distinct technical–tactical and time-motion patterns compared with matches decided by wider margins. Evidence indicates that teams adjust intensity, risk-taking, and style of play depending on whether they are winning, losing, or drawing, with consequences for both physical and technical indicators (Gómez et al., 2018; Lago-Peñas & Gómez-López, 2014). Accordingly, H5 anticipates that close matches will display higher high-intensity demands, greater duel frequency, and altered passing behaviour, whereas games with comfortable leads or deficits will show different tactical and physical configurations (Mayhew et al., 2015; Vigne et al., 2010).

### III.3.6. H6 — Distinct Role-Specific Integrated Performance Patterns

The sixth and final hypothesis proposes that the integrated performance patterns—combining technical–tactical and time-motion variables—will differ significantly between defenders, midfielders, and forwards, reflecting role-specific constraints, spatial responsibilities, and decision-making contexts. While H1 focuses on isolated differences in physical and technical indicators, H6 addresses the structure of their interrelationships, expecting each role to exhibit a unique constellation of associations between movement and action variables (Modric, Malone, et al., 2022;

Sarmento et al., 2024). This hypothesis is particularly relevant for advancing role theory in football and for informing applied processes such as player profiling, recruitment benchmarking, and role-specific conditioning.

**III.4. Concluding Remarks**

The objectives and hypotheses presented in this chapter define the analytic architecture of the thesis and translate its theoretical foundations into a clear, testable research programme. By formulating a general objective centred on integrated, context-sensitive analysis and articulating specific objectives across physical, technical–tactical, and contextual domains, the study responds to the demands of modern performance science for depth, multidimensionality, and ecological validity (Rein & Memmert, 2016; Sampaio & Maçãs, 2012).

The hypotheses, in turn, provide a coherent set of expectations grounded in existing evidence while leaving room for the identification of novel patterns specific to the Serie A context. Together, they ensure that the empirical work is not merely descriptive but also interpretative and theory-driven, in line with doctoral standards and with the recommendations of recent methodological and conceptual reviews in the field (Sarmento et al., 2014; Torres-Ronda et al., 2022).

The subsequent chapter, **Chapter IV – Material and Methods**, builds directly on the framework outlined here. It details the participants, data sources, variables, procedures, and statistical techniques used to test these hypotheses and to address the objectives of the thesis in a manner consistent with contemporary scientific and ethical standards.

# IV – MATERIAL AND METHODS

# CHAPTER IV – MATERIALS AND METHODS

The methodological structure of this doctoral thesis was intentionally designed to go beyond the scope and brevity of a standard empirical article and to meet the expectations of a doctoral dissertation in terms of depth, transparency, and theoretical coherence. This chapter provides a detailed and reasoned account of how the study was conceived, implemented, and analysed. Rather than simply listing procedures, it explains why specific choices were made, how these choices are grounded in contemporary sport-science literature, and in what way they support the integrated, ecology-driven perspective that underpins the entire thesis (Davids et al., 2013; Sarmento et al., 2014; Torres-Ronda et al., 2022). The study required the integration of multiple data streams—time–motion tracking, event-based notational data, and contextual information—into a single coherent analytical framework. This demanded clear operational definitions, careful synchronisation, rigorous data cleaning, and a statistical strategy capable of handling multi-factorial, role-specific, and context-dependent questions (Castellano et al., 2011; Sampaio & Maçãs, 2012). The following sections systematically describe the design, participants, competitive context, data sources, variables, data-processing procedures, statistical analyses, and ethical safeguards adopted in this project.

## IV.1 Study Design

This investigation adopted an observational, analytical, and retrospective design using performance data collected during an entire competitive season of a professional men's team competing in Italian Serie A. Observational designs are considered particularly appropriate in ecological dynamics and match-analysis research because they allow behaviours to be examined in the exact context in which they naturally emerge, without experimental manipulation that could compromise ecological validity (Castellano et al., 2011; Sampaio & Maçãs, 2012; Sarmento et al., 2014).

The choice to include **an entire season** rather than a subsample of matches was guided by several methodological considerations. First, a full-season approach increases the reliability and representativeness of performance indicators, reducing the influence of atypical matches and capturing the inherent variability of elite football (Gregson et al., 2010; Hands & Janse de Jonge, 2020). Second, it permits the systematic examination of contextual variability—different opponent strengths, match locations, and scorelines—under real competitive conditions, rather than within narrow, artificially selected windows (Castellano et al., 2011; Teixeira et al., 2021). Third, it aligns with current calls for longitudinal, context-rich studies that better reflect the dynamic and adaptive nature of performance in high-level team sports (Rein & Memmert, 2016; Sampaio & Maçãs, 2012).

The study is **analytical** rather than merely descriptive. Descriptive statistics are used to characterise the sample and to provide benchmarks, but the core of the research lies in examining:

- differences between positional groups,
- differences between contextual categories (e.g., home vs. away, strong vs. weak opponents), and
- integrated relationships between technical–tactical and time–motion indicators.

This multi-layered analytical focus is consistent with the multidimensional objectives and hypotheses formulated in Chapter III and with contemporary guidelines in performance analysis (M. D. Hughes & Bartlett, 2002; Sarmento et al., 2014).

## IV.2 Participants

### IV.2.1 Team and Players

The sample consists of professional male outfield players from a single Serie A club during the 2023–2024 competitive season. The club participated in all league fixtures and, when data quality was equivalent, relevant domestic cup matches were also considered during the initial data-gathering process. The focus on a single-club cohort is common in high-performance research, where access, confidentiality, and data quality constraints frequently limit multi-club designs (Akenhead & Nassis, 2016; Vigne et al., 2010).

Players were included if they met the following criteria:

1. Registration as first-team outfield players during the reference season.
2. A minimum of 360 minutes of effective playing time accumulated across the season (equivalent to at least four full matches), with complete tracking and event data.
3. Absence of prolonged injuries or absences that would render their seasonal profile unrepresentative of their role or function within the team.

Goalkeepers were excluded from all analyses due to the specificity of their positional role, which involves distinct technical demands (e.g., handling, set-piece organisation) and very different locomotor patterns compared with outfield players (Di Salvo et al., 2007; Reilly & Thomas, 1979). Including goalkeepers would have required an entirely separate analytical framework that lies outside the scope of the present thesis.

This sampling strategy balances internal validity—by ensuring stable and representative data for each player—with ecological relevance, as it is anchored in the actual competitive structure and squad management of an elite club (Akenhead & Nassis, 2016; Gregson et al., 2010).

### IV.2.2 Positional Classification

Players were classified into three broad positional groups:

- **Defenders (DF)**: central defenders and full-backs/wing-backs.
- **Midfielders (MF)**: defensive, central, and attacking midfielders.
- **Forwards (FW)**: central strikers and wide forwards.

Rather than relying solely on nominal positions reported in match sheets, positional classification was informed by:

- tactical information from the coaching staff,
- positional heatmaps derived from tracking data, and
- qualitative video review to confirm role-specific behaviours in different phases (build-up, progression, finishing, defensive organisation).

This multi-criteria approach responds to the recognition that modern football positions are fluid and tactically contingent; a player listed as a "midfielder" may function as an auxiliary full-back in some phases or as an advanced playmaker in others (T. Liu et al., 2021; Sarmento et al., 2018, 2024). By grounding positional classification in both tactical intent and realised spatial behaviour, the grouping more accurately reflects the ecological reality of role execution, consistent with contemporary role-based analyses in elite competitions (Modric, Malone, et al., 2022; Sarmento et al., 2024; Yi et al., 2018).

### IV.3 Competitive Context

All matches included in the final dataset were played in Italian Serie A, a competition widely recognised for its high tactical sophistication, structured defensive organisation, and strong emphasis on spatial compactness and match tempo control (Savoia et al., 2024; Vigne et al., 2010). These characteristics make Serie A an ideal environment for an integrated analysis of performance, as tactical constraints strongly modulate both technical and locomotor demands.

The league season comprises 38 matchdays. A small number of matches were excluded due to incomplete or corrupted tracking data, technical failures, or non-standard conditions that compromised data quality (e.g., severe weather impacting optical tracking reliability). These exclusions followed pre-defined quality-control criteria (Castellano et al., 2014; Isik et al., 2020), and the exact number of matches retained is reported in Chapter V.

The contextual richness of Serie A—ranging from top-tier teams competing for European positions to clubs involved in relegation battles—also supports the stratification of opponents and outcomes, a key element in the contextual analyses undertaken in this thesis (Gómez et al., 2018; González-Rodenas et al., 2023; Teixeira et al., 2021).

### IV.4 Data Sources and Acquisition Procedures

The integrated nature of this study required the combination of two primary data sources:

1. **Time–motion tracking data** describing locomotor behaviour.
2. **Event-based notational data** describing technical and tactical actions.

Both sources stemmed from systems implemented routinely in the club and league, consistent with current best practice in high-level monitoring (Akenhead & Nassis, 2016; Buchheit et al., 2014; Castellano et al., 2014).

#### IV.4.1 Time–Motion Tracking Data

Time–motion data were obtained from the league's official electronic performance and tracking system (EPTS), using a semi-automated, multi-camera optical solution installed permanently in each stadium. Such systems continuously capture the two-dimensional coordinates of all players and the ball at high frequency, enabling the reconstruction of trajectories and velocities across the entire match (Barros et al., 2007; Castellano et al., 2014; Di Salvo et al., 2010). From these raw positional data, the provider's algorithms generated standardised locomotor metrics that are widely used in the scientific literature and applied practice (Bradley et al., 2016; Hands & Janse de Jonge, 2020; Modric, Malone, et al., 2022). For this thesis, the following variables were retained:

- Total distance covered (m)
- Distance in low-to-moderate intensity zones (below the high-speed threshold)

- High-speed running (HSR) distance (m)
- Sprinting distance (m)
- Number of sprints
- Number of accelerations and decelerations above/below pre-defined thresholds
- Maximum speed (km/h)

Velocity zones for high-speed running and sprinting were based on the thresholds validated and used by the league provider (e.g., HSR ≥ ~19–20 $km \cdot h^{-1}$; sprinting ≥ ~25 $km \cdot h^{-1}$), which are broadly consistent with recent proposals for updated thresholds in elite football (Bradley, 2024; Modric, Malone, et al., 2022). Using provider-specific thresholds ensures internal consistency across matches and reflects operational standards in applied environments (Akenhead & Nassis, 2016; Buchheit et al., 2014).

To make players comparable regardless of playing time, all time–motion variables were normalised to **per 90 minutes of effective playing time**, a standard practice in match analysis that permits reliable inter-individual and inter-positional comparisons (Gregson et al., 2010; Hands & Janse de Jonge, 2020).

### IV.4.2 Technical–Tactical Notational Data

Technical–tactical actions were obtained from the club's performance-analysis platform, which aggregates event data from the same league provider with additional coding by trained analysts. Each event includes a time stamp and, when relevant, spatial information, thereby enabling precise alignment with tracking data (M. Hughes & Franks, 2004; James, 2006; Sarmento et al., 2014).

For the purposes of this thesis, technical–tactical variables were grouped into three broad domains:

- **Passing and circulation**
    - Total passes attempted and completed
    - Passing accuracy
    - Progressive passes (advancing the ball meaningfully towards the opponent's goal)
    - Line-breaking passes (penetrating at least one opposition line)
    - Entries into the final third
- **Defensive actions**
    - Tackles attempted and won
    - Interceptions
    - Defensive duels (ground and aerial)
    - Ball recoveries in different pitch zones
- **Offensive contributions**

  - Shots and shots on target
  - Key passes (passes leading directly to shots)
  - Crosses into the penalty area
  - Dribbles and 1v1 offensive duels

Operational definitions were guided by methodological references in notational analysis (M. D. Hughes & Bartlett, 2002; M. Hughes & Franks, 2004; James, 2006) and by recent work on tactical and situational variables in elite football (González-Víllora et al., 2015; Sarmento et al., 2014, 2018). All event categories were carefully cross-checked with the provider's coding manual to avoid semantic inconsistencies—for instance, between "recovery" and "interception" or between "key pass" and "assist". As with the locomotor variables, technical–tactical indicators were normalised per 90 minutes.

### IV.4.3 Synchronisation of Tracking and Event Data

A central methodological step in building an **integrated** performance model is the temporal synchronisation of tracking and notational data. In this thesis, synchronisation was achieved through time stamps shared across both systems. This alignment made it possible to:

- reconstruct the locomotor context surrounding technical events (e.g., running speed at the moment of a key pass or prior to a shot),
- attach tactical meaning to specific movement patterns (e.g., sprints linked to counterattacks, accelerations associated with pressing), and

- verify the ecological plausibility of aggregated relationships by sampling specific sequences in video.

Although the main analyses reported in Chapters V and VI focus on aggregated variables rather than event-level sequences, the existence of a synchronised database was crucial for quality control and interpretation, in line with best practice in integrated tactical–physical research (Castellano et al., 2014; Rein & Memmert, 2016).

**IV.5 Contextual Variables**

In accordance with the literature on contextual influences in performance analysis, three key contextual variables were incorporated as potential moderators of integrated performance patterns (Castellano et al., 2011; Gómez et al., 2018; Lago-Peñas & Gómez-López, 2014):

1. **Match location** (home vs. away),
2. **Opponent strength** (tiered according to final league ranking),
3. **Match outcome and margin of victory** (win, draw, loss, with goal difference).

**IV.5.1 Match Location**

Match location was coded as **home** or **away** according to the official fixture list. The phenomenon of home advantage is one of the most robust findings in football performance research, associated with greater territorial dominance, higher offensive involvement, and often increased physical output, especially at high intensities (Gómez et al., 2018; Lago-Ballesteros & Lago-Peñas, 2010; Lago-

Peñas & Gómez-López, 2014). Including match location enables the thesis to test whether the integrated technical–physical profiles of the studied team are consistent with this pattern or whether Serie A and team-specific tactical models produce different dynamics.

### IV.5.2 Opponent Strength

Opponents were stratified into three categories on the basis of their final league position:

- **Top-ranked**: 1st–6th place
- **Mid-ranked**: 7th–14th place
- **Low-ranked**: 15th–20th place

This tiering reflects the practical distinction between clubs fighting for European qualification, those in mid-table, and those battling relegation, which is frequently used in performance analysis (Gómez et al., 2018; González-Rodenas et al., 2023; Teixeira et al., 2021). Prior research indicates that facing stronger opponents typically increases defensive workload, reduces ball possession and technical efficiency, and often requires more compact tactical structures (Bradley et al., 2016; Savoia et al., 2024; Vigne et al., 2010). Analysing integrated performance across opponent tiers allows this thesis to explore these dynamics within the specific competitive context of the studied club.

### IV.5.3 Match Outcome and Margin of Victory

Match outcomes were categorised as **win**, **draw**, or **loss**, and the absolute goal difference was recorded to distinguish between narrow and decisive scorelines. Previous studies have demonstrated that both scoreline and evolving match status influence tactical choices, risk-taking, and intensity patterns (Gómez et al., 2018; Lago-Peñas & Gómez-López, 2014; Vigne et al., 2010). Teams that are leading may adopt more conservative strategies and reduce high-intensity running, whereas teams that are losing tend to increase pressing and offensive risk. Including outcome and margin of victory enables the thesis to relate such dynamics to integrated technical–physical indicators and to examine whether the hypothesised patterns are observed in this Serie A environment (Mayhew et al., 2015).

### IV.6 Data Cleaning, Inclusion Criteria at Match Level, and Quality Control

Before any analysis, all raw data underwent a rigorous multi-step cleaning and quality-control process, in line with recommendations for performance analysis in elite sports (Castellano et al., 2014; Isik et al., 2020; Torres-Ronda et al., 2022).

1. **Match-level tracking quality**: Matches with incomplete tracking coverage, severe signal loss, or documented technical failures in the EPTS system were excluded. Quality reports from the provider and internal checks were used to flag problematic games.

2. **Event-log completeness**: Event data were screened for anomalies (e.g., unrealistically low totals of passes or shots, missing defensive actions). Matches with clear event-log inconsistencies were removed to avoid artificial distortion of technical–tactical indicators (M. Hughes & Franks, 2004; James, 2006).

3. **Minimum playing time per appearance**: Individual appearances shorter than 30 minutes were excluded from positional analyses, to avoid inflating variability with very brief and context-specific cameo performances (e.g., late substitutions solely for time management). This criterion is consistent with previous time–motion and technical studies at elite level (Gregson et al., 2010; Yi et al., 2018).

4. **Outlier detection and verification**: Distribution plots and z-scores were used to identify extreme values in key variables such as total distance, sprint distance, or number of duels. Potential outliers were then cross-checked against match footage or internal reports to determine whether they reflected legitimate performances (e.g., unusually high-intensity matches) or technical artefacts. Genuine exceptional performances were retained; only clearly erroneous entries were removed.

Following these steps, the remaining dataset was normalised per 90 minutes for both time–motion and technical–tactical variables. This procedure ensured that the analytical dataset represented high-quality, stable information suitable for robust statistical analysis and doctoral-level inference (Hands & Janse de Jonge, 2020; Torres-Ronda et al., 2022).

### IV.7 Statistical Analysis

The statistical plan was constructed to address the objectives and hypotheses outlined in Chapter III while respecting the distributional characteristics of the data and contemporary best practice in sports-performance statistics (Cohen, 2013; Will G Hopkins, 2016; Wobbrock et al., 2011). Analyses were carried out using standard statistical software (e.g., SPSS, Python-based libraries).

### IV.7.1 Descriptive Statistics

For all variables, descriptive statistics (mean, standard deviation, and in some cases median and interquartile range) were computed for each positional group (DF, MF, FW) and, where appropriate, for each contextual category (home/away, opponent tier, match outcome). These summary values provide the empirical basis for comparison with previous research and serve as a first step in characterising role-specific and context-dependent performance in Serie A (Bradley et al., 2016; Hands & Janse de Jonge, 2020; Modric, Malone, et al., 2022).

### IV.7.2 Assumption Checking and Data Transformation

Prior to inferential testing, the assumptions underlying parametric procedures were evaluated. Normality was examined via Shapiro–Wilk tests, visual inspection of histograms and Q–Q plots, and assessment of skewness and kurtosis. Homogeneity of variances across groups was assessed using Levene's test. When these assumptions were reasonably satisfied, parametric tests were used. When they were violated, and data transformations (e.g., log or square-root) did not restore normality or were deemed inappropriate, non-parametric alternatives were employed in accordance with recent recommendations for factorial and multivariate analyses in behavioural research (Will G Hopkins, 2016; Wobbrock et al., 2011).

### IV.7.3 Between-Group and Contextual Comparisons

To examine differences in performance indicators:

- **One-way ANOVA** (or Welch's ANOVA when homogeneity of variance was violated) was used to compare positional groups (DF vs. MF vs. FW).
- Where the design allowed for more complex comparisons (e.g., role × match location), **two-way ANOVA** models were applied to investigate interaction effects, provided that cell sizes were sufficient.
- For variables that did not meet parametric assumptions, the **Kruskal–Wallis test** was used for comparisons across three or more groups, and the Mann–Whitney U test for pairwise comparisons.

Significant omnibus tests were followed by post hoc analyses with appropriate corrections for multiple comparisons (e.g., Bonferroni), reducing the risk of type I error inflation. This structure is consistent with analytical practices in previous time–motion and technical performance studies in football (H. Liu et al., 2016; Vigne et al., 2010).

### IV.7.4 Correlation and Integrated Analyses

To address the integrative objectives, correlation analyses were conducted to explore associations between technical–tactical and time–motion variables within each positional group and in relevant contextual strata.

- **Pearson's correlation coefficient (r)** was used when both variables were approximately normally distributed and measured on an interval scale.

- **Spearman's rank-order correlation (ϱ)** was used when variables deviated markedly from normality or were ordinal-like.

These analyses made it possible to quantify relationships such as:

- the association between high-speed running and offensive actions (shots, dribbles, progressive runs),
- the relationship between accelerations/decelerations and defensive duels or recoveries,
- the link between passing volume (or progressive passes) and overall locomotor load.

Interpreting these correlations within roles and contexts provides insight into how technical and physical dimensions are coupled in real competitive environments, a central theme in both this thesis and recent integrated studies (Gonçalves et al., 2017; Mayhew et al., 2015; Modric, Malone, et al., 2022).

### IV.7.5 Effect Sizes and Practical Significance

In line with best practice, emphasis was placed not only on statistical significance but also on the magnitude and practical meaning of observed effects (Cohen, 1988; Hopkins, 2024). Effect sizes were calculated as follows:

- **Cohen's d** for pairwise comparisons,
- **partial eta squared ($\eta^2p$)** for ANOVA main effects and interactions,
- correlation coefficients (r or ϱ) interpreted using conventional qualitative thresholds (e.g., small, moderate, large).

These metrics facilitate translation of findings into applied practice, allowing practitioners to judge whether statistically significant differences are likely to be meaningful in a high-performance context (Akenhead & Nassis, 2016; Torres-Ronda et al., 2022).

### IV.8 Ethical Considerations

The research protocol adhered to the ethical principles governing the use of performance and tracking data in elite sport, and to the institutional norms of UCAM. All data were derived from routine monitoring and match-analysis procedures carried out by the club and league, without the introduction of experimental interventions.

Key ethical safeguards included:

- **Anonymisation** of individual players and the club in all research outputs.
- **Restricted access** to raw data, limited to the researcher and authorised club staff.
- Compliance with **GDPR** and relevant national data protection regulations for handling personal performance data.
- Avoidance of any disclosure of sensitive tactical information that could compromise competitive integrity.

These procedures align with emerging guidelines on ethical data use, transparency, and reproducibility in sports-performance research (Torres-Ronda et al., 2022).

**IV.9 Summary**

This chapter has provided a comprehensive, description of the methodological framework underlying the thesis. By adopting an observational, full-season design; carefully defining participants and positional roles; situating the work in the specific tactical context of Serie A; integrating high-quality tracking and notational data; structuring contextual variables; implementing rigorous data-cleaning procedures; and applying a robust statistical strategy, the study meets the level of methodological rigour and structural depth required by the Academic Commission and the broader scientific community.

The integrated methodological architecture described here establishes the foundation for the empirical work presented in **Chapter V – Results**, where technical–tactical, time–motion, and contextual variables are examined in combination to address the objectives and hypotheses articulated in Chapter III and to advance the understanding of elite performance in Italian Serie A.

# V – RESULTS

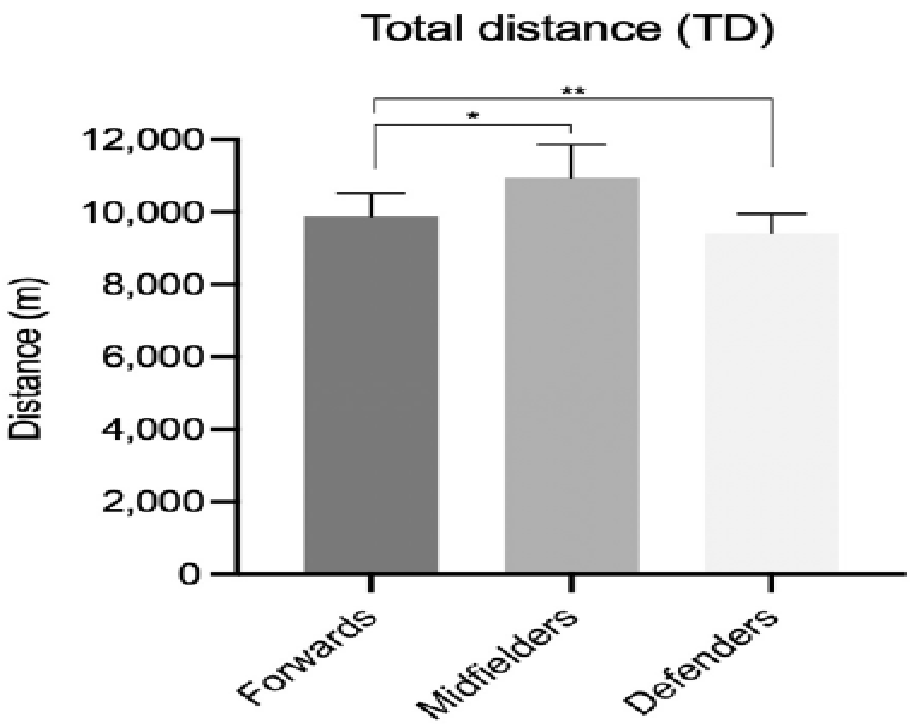
Results are following reported in consideration of time-motion and technical and tactical aspects, firstly comparing values appertaining to each observed role, and then according to the correlation between these two types of values.

### V. 1. TIME-MOTION ASPECTS

For TMA indicators, the average team values were 10.158 ± 981 m for TD, with 1.058 ± 295 m, 611 ± 178 m, and 160 ± 71 m performed in the Z2, Z3, and Z4 speed zones, respectively; MPErec was 35.5 ± 6.7 s, whereas the mean occurrence of bursts was 25.2 ± 7.8. Among tactical roles, differences emerged for TD ($p = 0.002$), with higher MD values than FW ($p = 0.027$) and DF ($p < 0.01$).

**Figure 1.**

*Total distance (TD) in relation to the three observed tactical roles (*, p < 0.05; **, p < 0.01)*

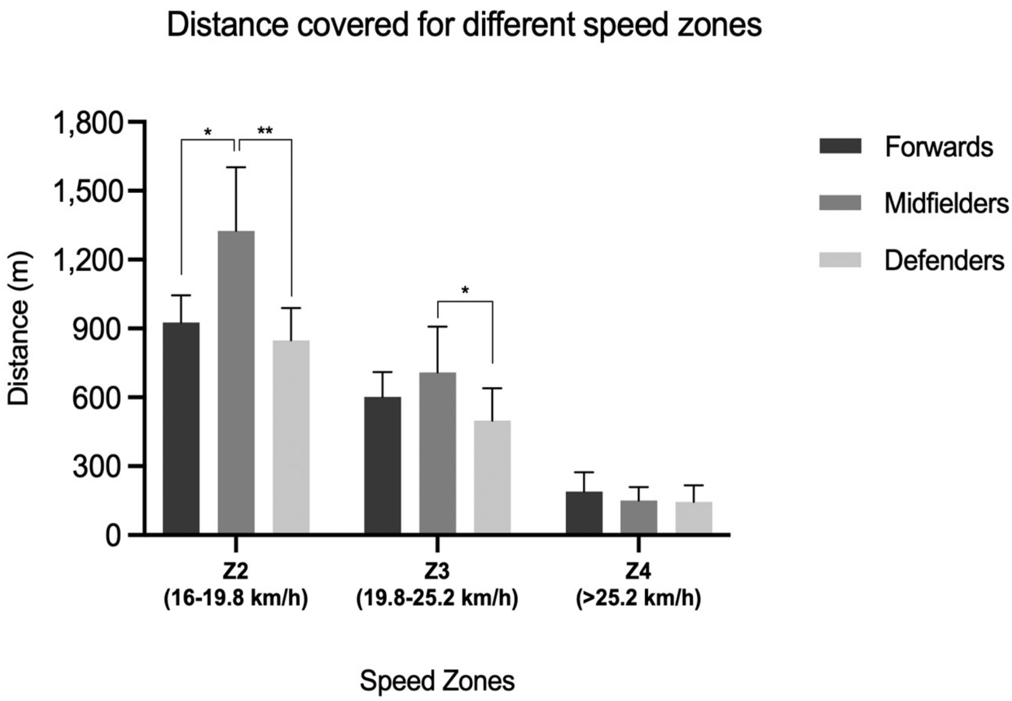


Considering the specific observed speed zones, differences emerged for Z2 ($p = 0.002$), with specific differences between MDs and FWs ($p = 0.012$) and DFs ($p < 0.01$); and for Z3 ($p = 0.045$), with differences between MDs and DFs ($p = 0.013$); whereas no effect between roles emerged for Z3 (Figure 2), MPErec, or bursts.

From the notational analysis perspective (Table 1), DFs reported higher values than MDs and FWs, as well as MDs with respect to FWs, for played balls (main effect: $p < 0.01$; DF-MD: $p = 0.028$; DF-FW: $p < 0.01$; MD-FW: $p = 0.015$), successful passes (main effect: $p < 0.01$; DF-MD: $p = 0.015$; DF-FW: $p < 0.01$; MD-FW: $p = 0.015$). For successful playing patterns (main effect: $p = 0.002$), FWs reported lower values than MDs ($p = 0.007$) and DFs ($p < 0.01$). Moreover, DFs reported lower total dribbling (main effect: $p = 0.036$) than MDs ($p = 0.039$) and FWs ($p = 0.018$) and total assists (main effect: $p = 0.013$) only with respect to MDs ($p = 0.003$). Then, DFs reported lower total shots (main effect: $p = 0.01$) and shots towards goal (main effect: $p = 0.032$) than MDs ($p = 0.05$, $p = 0.034$) and FWs ($p = 0.003$, $p = 0.016$). The time of ball possession was different between all roles (main effect: $p < 0.01$; DF-MD: $p = 0.01$; DF-FW: $p < 0.01$; MD-FW: $p = 0.042$).

**Figure 2.**

*Distance at Z2, Z3, and Z4 speed zones, in relation to the three observed tactical roles (*, p < 0.05; **, p < 0.01)*




**V. 2. TECHNICAL AND TACTICAL ASPECTS**

The Table 1 provides an overview of all technical and tactical indicators considered in this study, presenting for each variable the mean ± standard deviation, the minimum and maximum values, and the significance and effect sizes of the differences between the various playing roles (FWs, MDs, DFs)

**Table 1.**

*Means ± standard deviations, ranges (min-max), and significances (and effect size, ES) between roles, in relation to each technical and tactical indicator.*

| Ball possession indicators | **Forwards** | **Midfielders** | **Defenders** |
|---|---|---|---|
| Played balls (n) | 28.88 ± 7.00 (21–43) *(ES = 0.71) ¥¥(ES = 0.92) | 42.92 ± 6.11 (36–55) ¥(ES = 0.62) | 56.48 ± 9.19 (45–71) |
| Successful passes (n) | 14.51 ± 5.07 (8–22) *(ES = 0.72) ¥¥(ES = 0.91) | 26.08 ± 6.04 (18–38) ¥(ES = 0.73) | 40.19 ± 7.64 (30–50) |
| Successful playing patterns (n) | 3.05 ± 1.63 (1–7) **(ES = 0.71) ¥¥(ES = 0.73) | 6.14 ± 1.79 (4–10) | 8.20 ± 3.38 (4–13) |
| Lost balls (n) | 12.16 ± 4.09 (7–21) | 11.39 ± 4.23 (6–23) | 8.72 ± 3.71 (5–14) |
| Ball possession (sec) | 69.21 ± 27.00 (36–124) *(ES = 0.64) ¥¥(ES = 0.91) | 104.01 ± 20.04 (78–141) ¥¥(ES = 0.73) | 153.74 ± 23.85 (123–175) |
| Searching for advantage opportunities indicators | **Forwards** | **Midfielders** | **Defenders** |
| Successful dribbling (n) | 1.29 ± 0.27 (1–2) | 1.45 ± 0.86 (0–3) | 0.81 ± 0.64 (0–2) |
| Total dribbling (n) | 2.26 ± 0.84 (1–4) ¥(ES = 0.23) | 2.06 ± 1.14 (0–4) ¥(ES = 0.61) | 1.13 ± 0.86 (0–3) |
| Successful/total dribbling (n) | 0.75 ± 0.38 (0–1) | 0.54 ± 0.42 (0–1) | 0.41 ± 0.34 (0–1) |
| Successful crosses (n) | 1.03 ± 0.77 (0–2) | 0.96 ± 0.81 (0–2) | 0.55 ± 0.56 (0–1) |
| Total crosses (n) | 2.05 ± 1.33 (0–4) | 2.42 ± 0.97 (1–4) | 2.48 ± 2.38 (0–8) |
| Successful/total crosses (n) | 0.45 ± 0.50 (0–1) | 0.32 ± 0.34 (0–1) | 0.15 ± 0.21 (0–1) |
| Successful assists (n) | 0.04 ± 0.07 (0–1) | 0.04 ± 0.07 (0–1) | 0.02 ± 0.04 (0–1) |
| Total assists (n) | 0.58 ± 0.30 (0–1) **(ES = 0.52) | 0.92 ± 0.35 (1–2) | 0.40 ± 0.36 (0–1) |
| Successful/total assists (n) | 0.06 ± 0.09 | 0.06 ± 0.12 | 0.06 ± 0.12 |

| | | | |
|---|---|---|---|
| | (0–1) | (0–1) | (0–1) |
| Shooting indicators | **Forwards** | **Midfielders** | **Defenders** |
| Shots towards goal (n) | 0.88 ± 0.69<br>(0–2)<br>¥(ES = 0.32) | 0.61 ± 0.30<br>(0–1)<br>¥(ES = 0.51) | 0.29 ± 0.22<br>(0–1) |
| Total shots (n) | 1.72 ± 1.04<br>(0 – 3)<br>¥¥(ES = 0.42) | 0.97 ± 0.52<br>(0–2)<br>¥(ES = 0.51) | 0.44 ± 0.44<br>(0–1) |
| Shots towards goal/total shots | 0.69 ± 0.49<br>(0–1) | 0.94 ± 0.29<br>(1–2) | 0.69 ± 0.53<br>(0–2) |

*, ¥, $p < 0.05$; **, ¥¥, $p < 0.01$; differences with respect to MD and DF, respectively.

The data presented thus far have already been published in a scientific article (Perrotta et al., 2025).

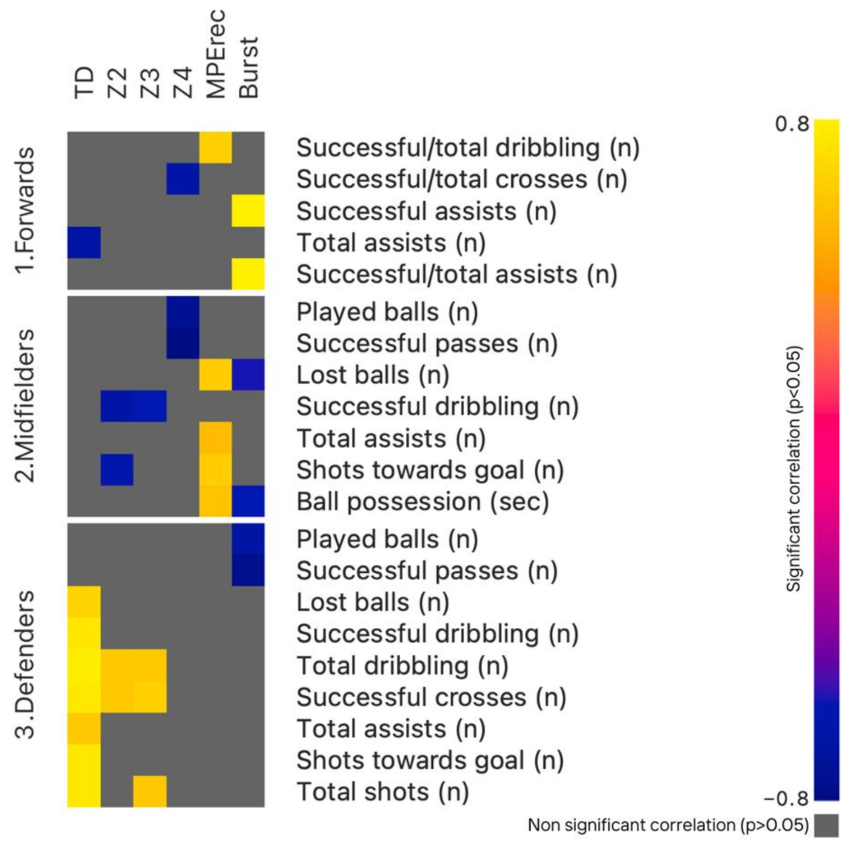
### V. 3. CORRELATIONS BETWEEN TECHNICAL AND TACTICAL, AND TIME-MOTION ASPECTS

Finally, Figure 3 displays the correlations between TMA and the tactical indicators for forwards, midfielders, and defenders, and the subsequent tables analyse these relationships in greater detail by playing role, with Table 2 focusing on forwards, Table 3 on midfielders, and Table 4 on defenders.

Correlation analyses within each role identified relationships between TMA and technical–tactical indicators. In DFs and MDs, higher values of very-high-speed running (Z4, bursts) were negatively correlated with successful passes and possession time ($r = –0.35$ to $–0.45$, $p < 0.05$). This suggests that intense time-motion demands may constrain technical accuracy and ball circulation. Conversely, in FWs, positive correlations emerged between bursts and assists ($r = 0.41$, $p < 0.05$), indicating that short explosive efforts support decisive technical actions in advanced zones. No significant correlations were found between high-speed running and shooting accuracy.

**Figure 3.**

*Correlations between TMA and the technical and tactical indicators for FWs, MDs, and DFs.*




In particular, for FW, TD is significantly and negatively correlated only with total assists as well as Z4 with successful/total crosses; MPErec resulted positively correlated with successful/total dribbling as well as burst with successful assist and successful/total assists.

For MD, negative correlations emerged between Z2 and successful dribbling and shots towards goal; Z3 and successful dribbling; Z4 and played balls and successful passes; and bursts and lost balls and ball possession (sec). Conversely, positive correlations in MD emerged between MPErec and lost balls, total assists, shots towards goal, and ball possession (sec).

For DF, positive correlations emerged between TD and lost balls, successful dribbling, total dribbling, successful crosses, total assist, shots towards goal, and total shots; Z2 and Z3 with total dribbling, and successful crosses; and Z3 with total shots. Negative correlations, instead, emerged between bursts and played balls and successful passes.

### V. 4. SUMMARY OF KEY FINDINGS

1. MDs covered the greatest total distance and displayed higher activity in sub-maximal speed zones.

2. DFs dominated possession-related indicators, particularly successful passes and time in possession.

3. FWs led in advantage-seeking indicators, including dribbles, assists, and shooting actions.

4. Correlation analyses revealed negative associations between high-intensity TMA loads and technical execution for DFs and MDs.

5. FWs demonstrated a positive relationship between bursts and assists, suggesting that explosive intensity facilitates decisive technical actions.

### V. 5. Analytic correlations between technical and tactical, and Time-motion aspects in each playing role.

In the following tables, specific values of the correlation between TMA and technical and tactical parameters are reported for each role, highlighting positive or negative direction, grade of the correlation (Rho value) and its significance (p value).

**Table 2.**

*Spearman (Rho and significance values) correlations between TMA and technical and tactical indicators for FWs.*

| Indicators | Correlations | TD | Z2 | Z3 | Z4 | MPErec | Burst |
|---|---|---|---|---|---|---|---|
| Played balls (n) | Rho | 0.286 | 0.571 | 0.667 | 0.214 | -0.214 | 0.132 |
| | *p* | 0.493 | 0.139 | 0.071 | 0.610 | 0.610 | 0.721 |
| Successful passes (n) | Rho | 0.371 | 0.611 | 0.443 | 0.168 | -0.072 | -0.120 |
| | *p* | 0.365 | 0.108 | 0.272 | 0.691 | 0.866 | 0.778 |
| Successful playing patterns (n) | Rho | -0.095 | 0.143 | 0.119 | 0.190 | 0.214 | -0.190 |
| | *p* | 0.823 | 0.736 | 0.779 | 0.651 | 0.610 | 0.651 |
| Lost balls (n) | Rho | -0.190 | -0.024 | 0.214 | -0.143 | -0.357 | 0.333 |
| | *p* | 0.651 | 0.955 | 0.610 | 0.736 | 0.385 | 0.420 |
| Fouls committed (n) | Rho | 0.108 | -0.036 | 0.084 | 0.299 | -0.168 | 0.018 |
| | *p* | 0.799 | 0.933 | 0.844 | 0.599 | 0.691 | 0.966 |
| Fouls received (n) | Rho | -0.048 | 0.143 | 0.524 | 0.476 | -0.452 | 0.048 |
| | *p* | 0.911 | 0.736 | 0.183 | 0.233 | 0.260 | 0.911 |
| Successful dribbling (n) | Rho | 0.072 | -0.126 | -0.378 | 0.306 | 0.613 | 0.072 |
| | *p* | 0.878 | 0.788 | 0.403 | 0.504 | 0.144 | 0.878 |
| Total dribbling (n) | Rho | -0.286 | 0.107 | -0.036 | -0.143 | 0.036 | -0.500 |
| | *p* | 0.535 | 0.819 | 0.939 | 0.760 | 0.939 | 0.253 |
| Successful/total dribbling (n) | Rho | 0.071 | -0.119 | -0.095 | 0.405 | 0.714* | -0.381 |
| | *p* | 0.867 | 0.779 | 0.823 | 0.320 | **0.047** | 0.352 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Successful crosses (n) | Rho | 0.253 | 0.217 | -0.482 | -0.566 | 0.349 | -0.217 |
| | *p* | 0.545 | 0.606 | 0.227 | 0.143 | 0.396 | 0.606 |
| Total crosses (n) | Rho | 0.071 | 0.286 | 0.167 | 0.143 | -0.048 | -0.238 |
| | *p* | 0.867 | 0.493 | 0.693 | 0.736 | 0.911 | 0.570 |
| Successful/total crosses (n) | Rho | 0.317 | 0.268 | -0.439 | -0.708* | 0.366 | -0.512 |
| | *p* | 0.444 | 0.520 | 0.276 | **0.050** | 0.373 | 0.194 |
| Successful assists (n) | Rho | 0.027 | -0.109 | -0.027 | -0.218 | -0.682 | 0.873** |
| | *p* | 0.949 | 0.797 | 0.949 | 0.604 | 0.062 | **0.005** |
| Total assists (n) | Rho | -0.714* | -0.476 | -0.19 | -0.333 | -0.571 | 0.071 |
| | *p* | **0.047** | 0.233 | 0.651 | 0.420 | 0.139 | 0.867 |
| Successful/total assists (n) | Rho | 0.027 | -0.109 | -0.027 | -0.218 | -0.682 | 0.873** |
| | *p* | 0.949 | 0.797 | 0.949 | 0.604 | 0.062 | **0.005** |
| Shots towards goal (n) | Rho | 0.204 | 0.036 | 0.132 | 0.024 | -0.096 | -0.024 |
| | *p* | 0.629 | 0.933 | 0.756 | 0.955 | 0.821 | 0.955 |
| Total shots (n) | Rho | 0.167 | 0.048 | -0.381 | -0.357 | 0.333 | -0.500 |
| | *p* | 0.693 | 0.911 | 0.352 | 0.385 | 0.420 | 0.207 |
| Shots towards goal/total shots (n) | Rho | 0.204 | 0.012 | 0.180 | 0.11 | 0.335 | 0.22 |
| | *p* | 0.629 | 0.978 | 0.670 | 0.82 | 0.417 | 0.52 |
| Ball possession (sec) | Rho | 0.190 | 0.452 | 0.452 | 0.357 | 0.024 | -0.190 |
| | *p* | 0.651 | 0.260 | 0.260 | 0.385 | 0.955 | 0.651 |

*(p≤0.05),**(p≤0.01) significant correlations.

**Table 3.**

*Spearman (Rho and significance values) correlations between TMA and technical and tactical indicators for MDs.*

| Indicators | Correlations | TD | Z2 | Z3 | Z4 | MPErec | Burst |
|---|---|---|---|---|---|---|---|
| Played balls (n) | Rho | 0.055 | 0.027 | -0.391 | -0.809** | 0.273 | -0.591 |
| | *p* | 0.873 | 0.937 | 0.235 | **0.003** | 0.417 | 0.056 |
| Successful passes (n) | Rho | 0.409 | 0.400 | -0.173 | -0.864** | -0.100 | -0.309 |
| | *p* | 0.212 | 0.223 | 0.612 | **<0.001** | 0.770 | 0.355 |
| Successful playing patterns (n) | Rho | -0.464 | -0.418 | -0.536 | -0.309 | 0.491 | -0.345 |
| | *p* | 0.151 | 0.201 | 0.089 | 0.355 | 0.125 | 0.298 |
| Lost balls (n) | Rho | -0.301 | -0.346 | -0.383 | -0.182 | 0.697* | -0.610* |
| | *p* | 0.369 | 0.297 | 0.245 | 0.592 | **0.017** | **0.046** |
| Fouls committed (n) | Rho | 0.182 | 0.418 | 0.445 | 0.055 | -0.300 | 0.227 |
| | *p* | 0.593 | 0.201 | 0.170 | 0.873 | 0.370 | 0.502 |
| Fouls received (n) | Rho | -0.055 | 0.041 | -0.014 | 0.128 | 0.178 | -0.351 |
| | *p* | 0.873 | 0.905 | 0.968 | 0.709 | 0.601 | 0.290 |
| Successful dribbling (n) | Rho | -0.524 | -0.715* | -0.620* | 0.159 | 0.579 | -0.451 |
| | *p* | 0.098 | **0.013** | **0.042** | 0.640 | 0.062 | 0.164 |
| Total dribbling (n) | Rho | -0.273 | -0.418 | -0.082 | 0.418 | 0.155 | 0.182 |
| | *p* | 0.417 | 0.201 | 0.811 | 0.201 | 0.650 | 0.593 |
| Successful/total dribbling (n) | Rho | -0.497 | -0.642 | -0.556 | -0.105 | 0.588 | -0.269 |
| | *p* | 0.120 | 0.033 | 0.076 | 0.759 | 0.057 | 0.424 |
| Successful crosses (n) | Rho | 0.055 | 0.138 | 0.138 | 0.202 | 0.055 | -0.257 |
| | *p* | 0.872 | 0.687 | 0.687 | 0.552 | 0.872 | 0.446 |
| Total crosses (n) | Rho | -0.456 | -0.342 | 0.050 | 0.460 | 0.465 | 0.128 |
| | *p* | 0.159 | 0.304 | 0.884 | 0.154 | 0.150 | 0.709 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Successful/total crosses (n) | Rho | 0.405 | 0.405 | 0.115 | -0.041 | -0.207 | -0.308 |
| | *p* | 0.217 | 0.217 | 0.736 | 0.904 | 0.542 | 0.357 |
| Successful assists (n) | Rho | -0.358 | -0.075 | -0.133 | -0.243 | 0.058 | -0.168 |
| | *p* | 0.279 | 0.826 | 0.697 | 0.472 | 0.866 | 0.622 |
| Total assists (n) | Rho | -0.182 | -0.300 | -0.364 | -0.245 | 0.618* | -0.445 |
| | *p* | 0.593 | 0.370 | 0.272 | 0.467 | **0.043** | 0.170 |
| Successful/total assists (n) | Rho | -0.358 | -0.017 | -0.006 | -0.092 | -0.012 | -0.006 |
| | *p* | 0.279 | 0.960 | 0.987 | 0.787 | 0.973 | 0.987 |
| Shots towards goal (n) | Rho | -0.573 | -0.682* | -0.545 | 0.200 | 0.700* | -0.418 |
| | *p* | 0.066 | **0.021** | 0.083 | 0.555 | **0.016** | 0.201 |
| Total shots (n) | Rho | -0.237 | -0.346 | -0.296 | 0.228 | 0.346 | -0.424 |
| | *p* | 0.483 | 0.297 | 0.377 | 0.501 | 0.297 | 0.194 |
| Shots towards goal/total shots (n) | Rho | 0.155 | 0.136 | 0.000 | -0.091 | -0.027 | 0.218 |
| | *p* | 0.650 | 0.689 | 1.000 | 0.790 | 0.937 | 0.519 |
| Ball possession (sec) | Rho | -0.300 | -0.373 | -0.573 | -0.582 | 0.655* | -0.627* |
| | *p* | 0.370 | 0.259 | 0.066 | 0.060 | **0.029** | **0.039** |

*($p \leq 0.05$),**($p \leq 0.01$) significant correlations.

**Table 4.**

*Spearman (Rho and significance values) correlations between TMA and technical and tactical indicators for DFs.*

| Indicators | Correlations | TD | Z2 | Z3 | Z4 | MPErec | Burst |
|---|---|---|---|---|---|---|---|
| Played balls (n) | Rho | 0.350 | 0.150 | 0.183 | 0.133 | 0.317 | -0.733* |
| | *p* | 0.356 | 0.700 | 0.637 | 0.732 | 0.406 | **0.025** |
| Successful passes (n) | Rho | -0.150 | -0.267 | -0.367 | -0.350 | 0.367 | -0.817** |
| | *p* | 0.700 | 0.488 | 0.332 | 0.356 | 0.332 | **0.007** |
| Successful playing patterns (n) | Rho | 0.517 | 0.267 | 0.233 | 0.233 | 0.150 | -0.500 |
| | *p* | 0.154 | 0.488 | 0.546 | 0.546 | 0.700 | 0.170 |
| Lost balls (n) | Rho | 0.733* | 0.500 | 0.600 | 0.600 | 0.033 | -0.200 |
| | *p* | **0.025** | 0.170 | 0.088 | 0.088 | 0.932 | 0.606 |
| Fouls committed (n) | Rho | -0.133 | -0.183 | -0.317 | -0.100 | 0.350 | -0.233 |
| | *p* | 0.732 | 0.637 | 0.406 | 0.798 | 0.356 | 0.546 |
| Fouls received (n) | Rho | 0.217 | 0.000 | 0.000 | -0.017 | -0.133 | -0.233 |
| | *p* | 0.576 | 1.000 | 1.000 | 0.966 | 0.732 | 0.546 |
| Successful dribbling (n) | Rho | 0.831** | 0.627 | 0.661 | 0.610 | -0.034 | -0.220 |
| | *p* | **0.006** | 0.071 | 0.053 | 0.081 | 0.931 | 0.569 |
| Total dribbling (n) | Rho | 0.862** | 0.678* | 0.686* | 0.661 | -0.033 | -0.151 |
| | *p* | **0.003** | **0.045** | **0.041** | 0.053 | 0.932 | 0.699 |
| Successful/total dribbling (n) | Rho | 0.630 | 0.341 | 0.289 | 0.077 | -0.060 | -0.281 |
| | *p* | 0.069 | 0.370 | 0.450 | 0.845 | 0.879 | 0.464 |
| Successful crosses (n) | Rho | 0.836** | 0.679* | 0.714* | 0.531 | 0.165 | -0.435 |
| | *p* | **0.005** | **0.044** | **0.031** | 0.141 | 0.671 | 0.242 |
| Total crosses (n) | Rho | 0.485 | 0.527 | 0.343 | 0.159 | 0.033 | -0.243 |
| | *p* | 0.185 | 0.145 | 0.366 | 0.683 | 0.932 | 0.529 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Successful/total crosses (n) | Rho | 0.621 | 0.456 | 0.511 | 0.201 | -0.183 | -0.128 |
| | *p* | 0.074 | 0.217 | 0.160 | 0.604 | 0.638 | 0.743 |
| Successful assists (n) | Rho | 0.548 | 0.456 | 0.548 | 0.342 | -0.068 | 0.068 |
| | *p* | 0.127 | 0.217 | 0.127 | 0.367 | 0.861 | 0.861 |
| Total assists (n) | Rho | 0.683* | 0.650 | 0.583 | 0.533 | -0.183 | -0.283 |
| | *p* | **0.042** | 0.058 | 0.099 | 0.139 | 0.637 | 0.460 |
| Successful/total assists (n) | Rho | 0.548 | 0.456 | 0.548 | 0.342 | -0.068 | 0.068 |
| | *p* | 0.127 | 0.217 | 0.127 | 0.367 | 0.861 | 0.861 |
| Shots towards goal (n) | Rho | 0.837** | 0.611 | 0.644 | 0.469 | 0.092 | -0.293 |
| | *p* | **0.005** | 0.081 | 0.061 | 0.203 | 0.814 | 0.444 |
| Total shots (n) | Rho | 0.837** | 0.611 | 0.678* | 0.552 | 0.209 | -0.360 |
| | *p* | **0.005** | 0.081 | **0.045** | 0.123 | 0.589 | 0.342 |
| Shots towards goal/total shots (n) | Rho | 0.378 | 0.042 | 0.101 | -0.143 | 0.244 | -0.395 |
| | p | 0.316 | 0.915 | 0.796 | 0.714 | 0.527 | 0.293 |
| Ball possession (sec) | Rho | -0.300 | -0.533 | -0.617 | -0.367 | 0.567 | -0.650 |
| | *p* | 0.433 | 0.139 | 0.077 | 0.332 | 0.112 | 0.058 |

*(p≤0.05),**(p≤0.01) significant correlations.

### V. 6.1. COMPARISON OF TECHNICAL AND TACTICAL PERFORMANCE INDICATORS IN RELATION TO GAME LOCATION: FORWARD PLAYERS.

In this analysis (table 5), match location is linked to an effect for played balls, time of ball possession, successful passes, successful playing patterns, lost balls, even approaching significance for successful dribbling indicator.

**Table 5.**

*Significance (Mann-Whitney-U test) for matched location (home and away matches) for FWs in relation to observed technical and tactical, and TMA indicators.*

| # | INDICATORS | *P* VALUE |
|---|---|---|
| 1 | Played_balls | ,027 |
| 2 | Time_ball_possession | ,018 |
| 3 | Successful_passes | ,032 |
| 4 | Successful_playing_patterns | ,049 |
| 5 | Lost_balls | ,033 |
| 6 | Successful_dribbling | ,058 |
| 7 | Total_dribbling | ,204 |
| 8 | Successful_over_total_dribbling | ,594 |
| 9 | Successful_crosses | 1,000 |
| 10 | Total_crosses | ,781 |
| 11 | Successful_over_total_crosses | ,297 |
| 12 | Successful_assists | ,878 |
| 13 | Total_assists | ,114 |
| 14 | Successful_over_total_assists | ,651 |
| 15 | Shots_towards_goal | ,248 |
| 16 | Total_shots | ,127 |
| 17 | Towards_goal_over_total_shots | ,658 |
| 18 | TD | ,798 |

| | | |
|---|---|---|
| 19 | Z2 | ,443 |
| 20 | Z3 | ,339 |
| 21 | Z4 | ,219 |
| 22 | MPE_rec | ,314 |
| 23 | Bursts | ,759 |

From this analysis, and considering the emerged significance, it can be considered difference as actual home advantage (i.e., higher values for home than away match) for played balls (home: 31±8, away: 25±6; ES=0.41), time ball possession (home: 72±26 s, 47±13 s; ES=0.52), successful passes (home: 15±7, away: 11±2; ES=0.36), successful playing patterns (home: 3.2±1.3, away: 1.6±0.3; ES=0.65), and lost balls (home: 11.7±1.9, away: 10.9±1.8; ES=0.21).

### V. 6.2. COMPARISON OF TECHNICAL AND TACTICAL PERFORMANCE INDICATORS IN RELATION TO GAME LOCATION: MIDFIELDER PLAYERS.

In this analysis (table 6), match location is not linked to any effect, determining the absence of home advantage for this particular tactical role.

**Table 6.**

*Significance (Mann-Whitney-U test) for matched location (home and away matches) for MDs in relation to observe technical and tactical, and TMA indicators.*

| # | INDICATORS | *P* VALUE |
|---|---|---|
| 1 | Played_balls | ,684 |
| 2 | Time_ball_possession | ,820 |
| 3 | Successful_passes | ,577 |
| 4 | Successful_playing_patterns | ,911 |
| 5 | Lost_balls | ,933 |
| 6 | Successful_dribbling | ,619 |
| 7 | Total_dribbling | ,136 |
| 8 | Successful_over_total_dribbling | ,511 |
| 9 | Successful_crosses | ,929 |
| 10 | Total_crosses | ,603 |
| 11 | Successful_over_total_crosses | ,293 |
| 12 | Successful_assists | ,303 |
| 13 | Total_assists | ,917 |
| 14 | Successful_over_total_assists | ,291 |
| 15 | Shots_towards_goal | ,203 |
| 16 | Total_shots | ,135 |
| 17 | Towards_goal_over_total_shots | ,506 |
| 18 | TD | ,967 |
| 19 | Z2 | ,254 |
| 20 | Z3 | ,907 |
| 21 | Z4 | ,149 |

| | | |
|---|---|---|
| 22 | MPE_rec | ,555 |
| 23 | Bursts | ,219 |

### V. 6.3. COMPARISON OF TECHNICAL AND TACTICAL PERFORMANCE INDICATORS IN RELATION TO GAME LOCATION: DEFENDER PLAYERS.

In this analysis (table 7), likely for MDs, match location is not linked to any effect, determining the absence of home advantage for DFs.

**Table 7**.

*Significance (Mann-Whitney-U test) for matched location (home and away matches) for MDs in relation to observed technical and tactical, and TMA indicators.*

| # | INDICATORS | *P* VALUE |
|---|---|---|
| 1 | Played_balls | ,442 |
| 2 | Time_ball_possession | ,390 |
| 3 | Successful_passes | ,529 |
| 4 | Successful_playing_patterns | ,710 |
| 5 | Lost_balls | ,205 |
| 6 | Successful_dribbling | ,196 |
| 7 | Total_dribbling | ,219 |
| 8 | Successful_over_total_dribbling | ,287 |
| 9 | Successful_crosses | ,543 |
| 10 | Total_crosses | ,930 |
| 11 | Successful_over_total_crosses | ,767 |
| 12 | Successful_assists | ,777 |
| 13 | Total_assists | ,230 |
| 14 | Successful_over_total_assists | 1,000 |
| 15 | Shots_towards_goal | ,480 |
| 16 | Total_shots | ,650 |
| 17 | Towards_goal_over_total_shots | ,833 |
| 18 | TD | ,901 |

| | | |
|---|---|---|
| 19 | Z2 | ,630 |
| 20 | Z3 | ,314 |
| 21 | Z4 | ,223 |
| 22 | MPE_rec | ,678 |
| 23 | Bursts | ,740 |

### V. 7.1. COMPARISON OF TECHNICAL AND TACTICAL PERFORMANCE INDICATORS IN RELATION TO *SERIE A* TEAM RANKING: FORWARD PLAYERS.

For Serie A ranking categories, and FWs category (table 8), effects emerged only in shots towards goal and ratio between shots towards goal and total shots.

**Table 8.**

*Significance (Kruskal–Wallis test) for Serie A ranking categories (top level, from 1st to 6th place; higher level, from 7th to 13th places; lower level, from 15th to 20th place) for FWs, in relation to observed technical and tactical, and TMA indicators.*

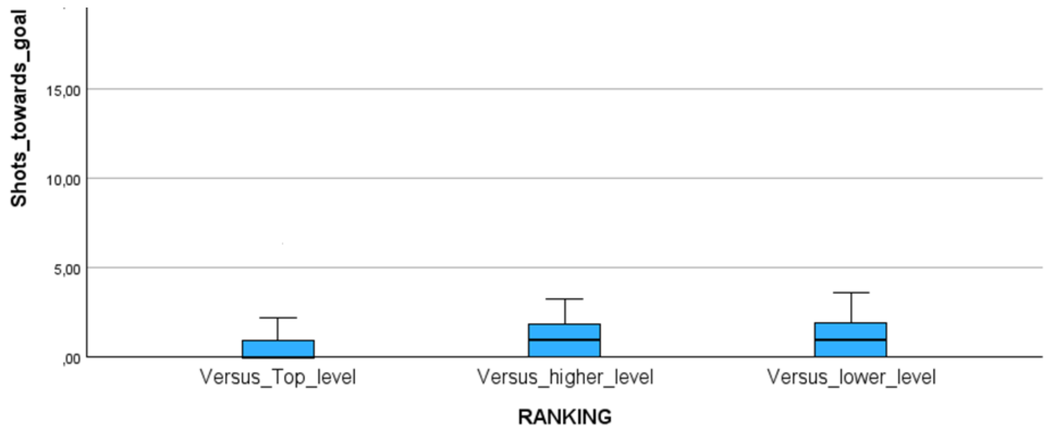
| # | INDICATORS | *P* VALUE |
|---|---|---|
| 1 | Played_balls | ,122 |
| 2 | Time_ball_possession | ,904 |
| 3 | Successful_passes | ,111 |
| 4 | Successful_playing_patterns | ,896 |
| 5 | Lost_balls | ,112 |
| 6 | Successful_dribbling | ,445 |
| 7 | Total_dribbling | ,426 |
| 8 | Successful_over_total_dribbling | ,818 |
| 9 | Successful_crosses | ,262 |
| 10 | Total_crosses | ,742 |
| 11 | Successful_over_total_crosses | ,246 |
| 12 | Successful_assists | ,491 |
| 13 | Total_assists | ,757 |
| 14 | Successful_over_total_assists | ,344 |
| 15 | Shots_towards_goal | ,031 |
| 16 | Total_shots | ,153 |
| 17 | Towards_goal_over_total_shots | ,038 |
| 18 | TD | ,102 |
| 19 | Z2 | ,088 |
| 20 | Z3 | ,278 |

| | | |
|---|---|---|
| 21 | Z4 | ,166 |
| 22 | MPE_rec | ,843 |
| 23 | Bursts | ,692 |

Further analyses, comparing ranking paired categories, reported that Empoli FC players' performed more shots towards goal (figure 4) when playing against higher ranking teams (mean ± standard deviation, M±SD=1.6±3.9, range=0-22.5) than against top level ranking teams (M±SD=0.5±1.3, range=0-6.3; p=0.023, ES=0.19), as well as when playing against lower ranking teams (M±SD=1±1.2, range=0-3.6) than against top level ranking teams (p=0.021, ES=0.21).

**Figure 4.**

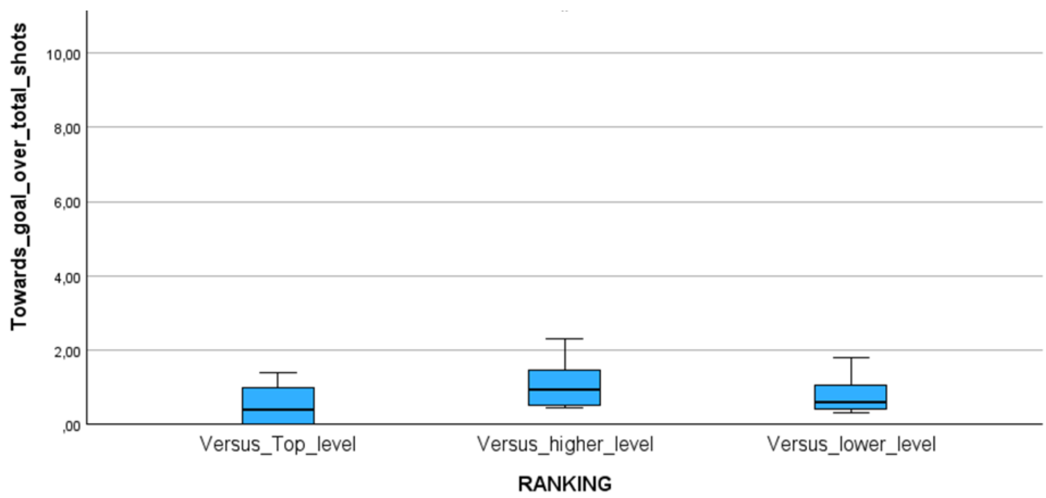
*Shots towards goal performed by FW, in relation to matches played against different Serie A team category ranking.*



In addition, for the ratio between shots towards goal and total shots (figure 5) recruited players reported a higher value when playing against higher ranking teams (M±SD=1.6±2.5, range=0.5-11.2) than against top level ranking teams (M±SD=0.9±1.7, range=0-6.3; p=0.015, ES=0.16).

**Figure 5.**

*Ratio between shots towards goal and total shots performed by FW, in relation to matches played against different Serie A team category ranking.*



### V. 7.2. COMPARISON OF TECHNICAL AND TACTICAL PERFORMANCE INDICATORS IN RELATION TO *SERIE A* TEAM RANKING: MIDFIELDER PLAYERS.

For Serie A ranking categories, and MDs category (table 9), effects emerged only for successful passes, while an approach to significance (p range= 0.051-0.065) emerged for time ball possession, lost balls, and total crosses.

**Table 9.**

*Significance (Kruskal–Wallis test) for Serie A ranking categories (top level, from 1st to 6th place; higher level, from 7th to 13th places; lower level, from 15th to 20th place) for MDs, in relation to observed technical and tactical, and TMA indicators.*

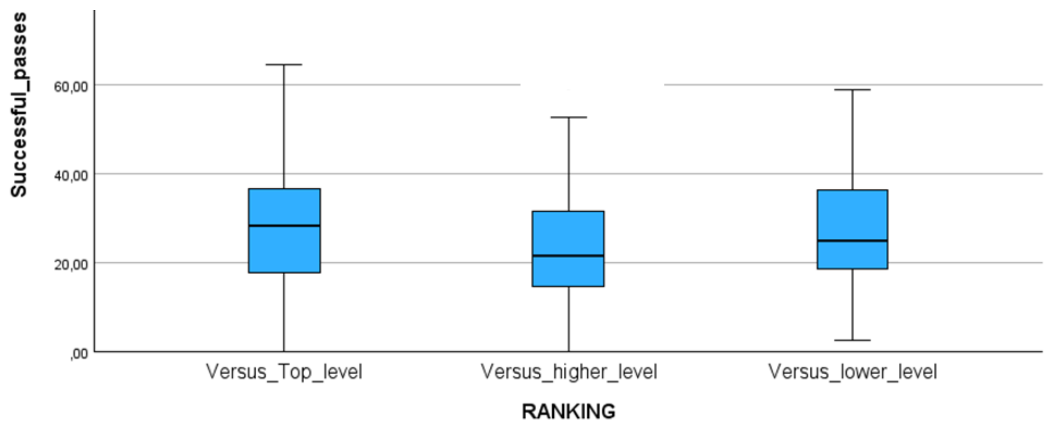
| # | INDICATORS | *P* VALUE |
|---|---|---|
| 1 | Played_balls | ,079 |
| 2 | Time_ball_possession | ,051 |
| 3 | Successful_passes | ,023 |
| 4 | Successful_playing_patterns | ,843 |
| 5 | Lost_balls | ,053 |
| 6 | Successful_dribbling | ,446 |
| 7 | Total_dribbling | ,753 |
| 8 | Successful_over_total_dribbling | ,453 |
| 9 | Successful_crosses | ,076 |
| 10 | Total_crosses | ,060 |
| 11 | Successful_over_total_crosses | ,150 |
| 12 | Successful_assists | ,692 |
| 13 | Total_assists | ,544 |
| 14 | Successful_over_total_assists | ,745 |
| 15 | Shots_towards_goal | ,408 |
| 16 | Total_shots | ,148 |
| 17 | Towards_goal_over_total_shots | ,765 |
| 18 | TD | ,068 |

| | | |
|---|---|---|
| 19 | Z2 | ,535 |
| 20 | Z3 | ,111 |
| 21 | Z4 | ,518 |
| 22 | MPE_rec | ,610 |
| 23 | Bursts | ,436 |

In particular, comparing ranking paired categories (figure 6), reported that Empoli FC players' performed more successful possesses when playing against top level ranking teams (M±SD=28.6±14.7, range=0-85) than higher ranking teams (M±SD=23.6±13, range=0-60.3; p=0.017, ES=0.18), as well as when playing against lower ranking teams (M±SD=28.7±14.6, range=2.5-74.1) than against higher ranking teams (p=0.018, ES=0.18).

**Figure 6.**

*Successful possesses performed by MD, in relation to matches played against different Serie A team category ranking.*



### V. 7.3. COMPARISON OF TECHNICAL AND TACTICAL PERFORMANCE INDICATORS IN RELATION TO *SERIE A* TEAM RANKING: DEFENDER PLAYERS.

For Serie A ranking categories, and DFs category (table 10), effects emerged only for played balls, successful passes, and successful playing patterns.

**Table 10.**

*Significance (Kruskal–Wallis test) for Serie A ranking categories (top level, from 1st to 6th place; higher level, from 7th to 13th places; lower level, from 15th to 20th place) for DFs, in relation to observed technical and tactical, and TMA indicators.*

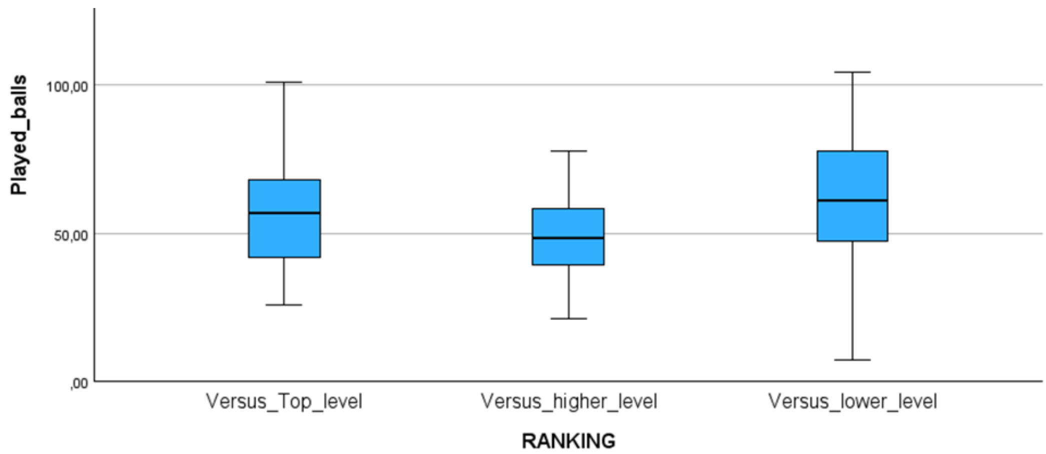
| # | INDICATORS | *P* VALUE |
|---|---|---|
| 1 | Played_balls | ,021 |
| 2 | Time_ball_possession | ,084 |
| 3 | Successful_passes | ,018 |
| 4 | Successful_playing_patterns | ,034 |
| 5 | Lost_balls | ,337 |
| 6 | Successful_dribbling | ,443 |
| 7 | Total_dribbling | ,548 |
| 8 | Successful_over_total_dribbling | ,421 |
| 9 | Successful_crosses | ,959 |
| 10 | Total_crosses | ,913 |
| 11 | Successful_over_total_crosses | ,685 |
| 12 | Successful_assists | ,985 |
| 13 | Total_assists | ,274 |
| 14 | Successful_over_total_assists | ,857 |
| 15 | Shots_towards_goal | ,273 |
| 16 | Total_shots | ,310 |
| 17 | Towards_goal_over_total_shots | ,956 |
| 18 | TD | ,316 |
| 19 | Z2 | ,939 |
| 20 | Z3 | ,819 |

| | | |
|---|---|---|
| 21 | Z4 | ,101 |
| 22 | MPE_rec | ,359 |
| 23 | Bursts | ,236 |

Further analyses, comparing ranking paired categories (figure 7), reported that Empoli FC players performed more played balls when performing against lower-level ranking teams (M±SD=60.2±28.9) than against higher ranking teams (M±SD=51.1±20.6; p=0.006, ES=0.18).

**Figure 7.**

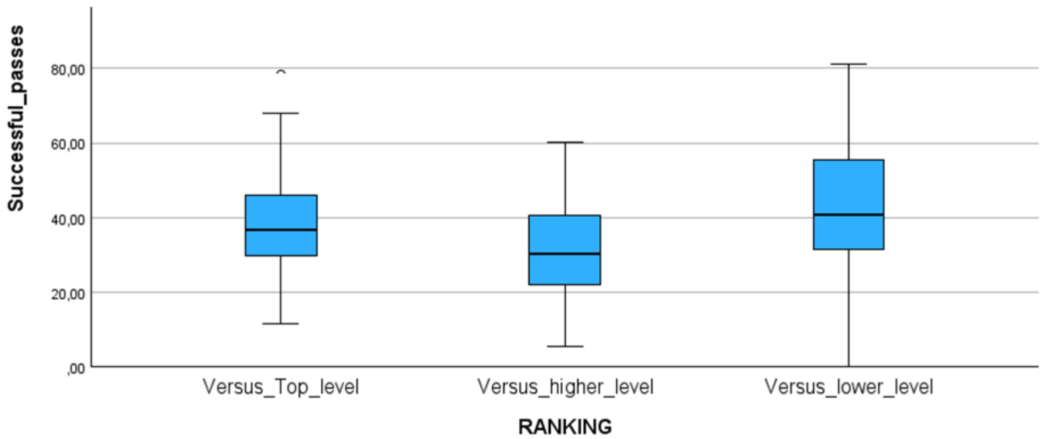
*Played balls performed by DF, in relation to matches played against different Serie A team category ranking.*



In addition, comparing ranking paired categories (figure 8), reported that Empoli FC players performed more successful passes when performing against lower-level ranking teams (M±SD=42.8±19.1) than against higher ranking teams (M±SD=34.3±18.7; p=0.005, ES=0.22).

**Figure 8.**

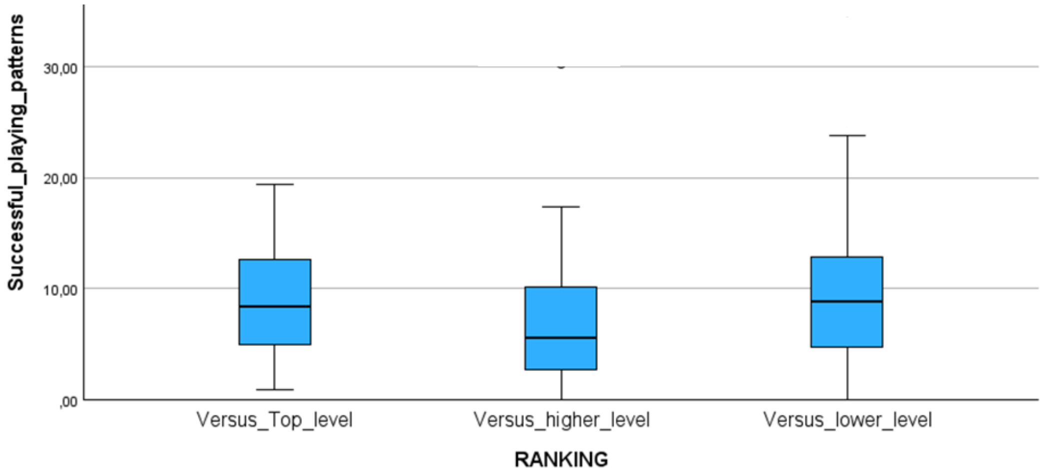
*Successful passes performed by DF, in relation to matches played against different Serie A team category ranking.*




Finally, comparing ranking paired categories (figure 9), reported that Empoli FC players performed less successful playing patterns when performing against higher level ranking teams (M±SD=6.9±5.8) than against lower ranking teams (M±SD=9.1±5.4; p=0.016, ES=0.19) and to top level ranking teams (M±SD=9.9±7.4; p=0.04, ES=0.22).

**Figure 9.**

*Successful playing patterns performed by DF, in relation to matches played against different Serie A team category ranking.*



### V. 8.1. COMPARISON OF TECHNICAL AND TACTICAL PERFORMANCE INDICATORS IN RELATION TO MARGIN OF VICTORY: FORWARD PLAYERS.

Players' data analysed in relation to margin of victory (winning and losing match with >1 or only 1 goal of difference, and draw matches) are as follows. In table 11, main effects between different margins of victory regarding FW category have been reported for shots towards goal and total shots, as well as for time-motion Z3 indicator. Differently, TD only approached significance.

**Table 11.**

*Significance (Kruskal–Wallis test) for margin of victory for FWs, in relation to each technical and tactical, and TMA indicators.*

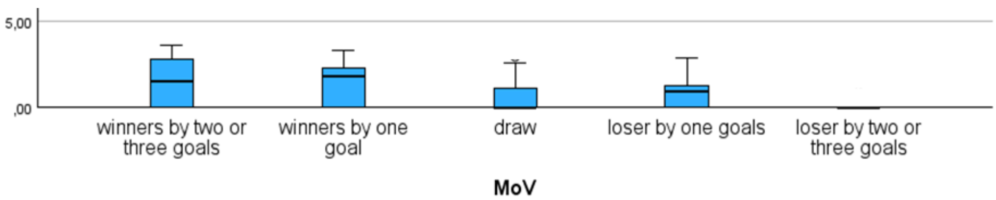
| # | INDICATORS | *P* VALUE |
|---|---|---|
| 1 | Played_balls | ,792 |
| 2 | Time_ball_possession | ,750 |
| 3 | Successful_passes | ,430 |
| 4 | Successful_playing_patterns | ,448 |
| 5 | Lost_balls | ,087 |
| 6 | Successful_dribbling | ,124 |
| 7 | Total_dribbling | ,284 |
| 8 | Successful_over_total_dribbling | ,523 |
| 9 | Successful_crosses | ,501 |
| 10 | Total_crosses | ,909 |
| 11 | Successful_over_total_crosses | ,304 |
| 12 | Successful_assists | ,537 |
| 13 | Total_assists | ,169 |
| 14 | Successful_over_total_assists | ,137 |
| 15 | Shots_towards_goal | ,022 |
| 16 | Total_shots | ,009 |
| 17 | Towards_goal_over_total_shots | ,507 |

| | | |
|---|---|---|
| 18 | TD | ,058 |
| 19 | Z2 | ,297 |
| 20 | Z3 | ,047 |
| 21 | Z4 | ,616 |
| 22 | MPE_rec | ,560 |
| 23 | Bursts | ,857 |

In the further analyses (Mann–Whitney-U test), comparing values for paired margin of victory categories (figure 10), the observed Serie A players' performed less shots towards goal when lost a match with two or three goals (mean±dev.st=0.5±1.5, range=0-6.3) than when won with two or three goals of difference (mean±dev.st=3.9±7.6, range=0-22.5; p=0.019, ES=0.31), and won with one goal (mean±dev.st=1.4±1.2, range=0-3.3; p=0.004, ES=0.32). In addition, a difference emerged also comparing the case in which they perform a draw match (mean±dev.st=0.7±0.9, range=0-3.2) with respect to the case of winning with one goal (p=0.031, ES=0.31).

**Figure 10.**

*Shots towards goal performed by FW, in relation to Serie A matches ended with different margins of victory.*

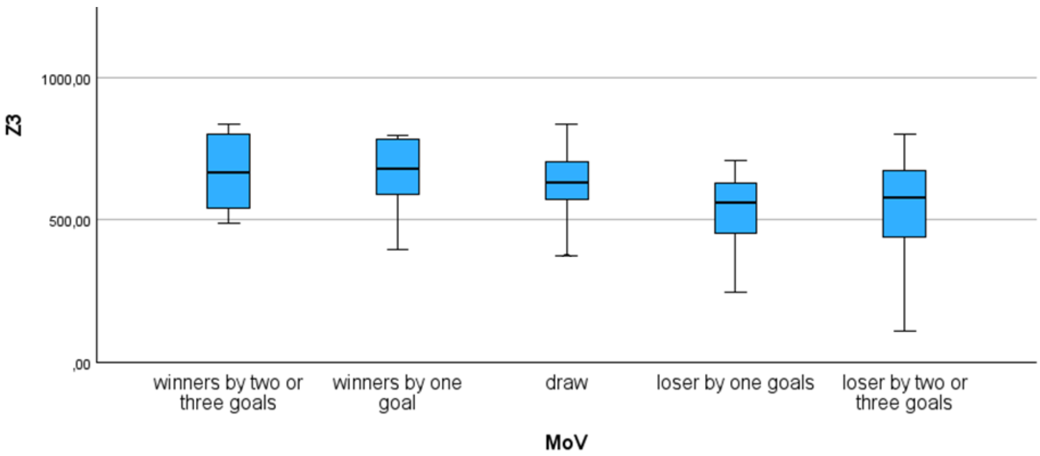


In line to shots towards goal, total shots reported the same trends. In fact, comparing values for paired margin of victory categories, the observed players performed fewer total shots when they lost a match with two or three goals than when won with two or three goals of difference (p=0.044), and won with one goal (p=0.002); as well as comparing the case in which they perform a draw match with respect to the case of winning with one goal (p=0.005).

For the Z3 indicator (figure 11), margin of victory reports an almost linear and positive incremental trend passing from losing to winning margins of victory. In particular, the observed Serie A players' performed more Z3 running when won a match with two or three goals of difference (mean±dev.st=742±302) than when lost with one goal of difference (mean±dev.st=560±198; p=0.049, ES=0.34); when won a match with one goal of difference (mean±dev.st=694±228) than when lost with two or three goals of difference (mean±dev.st=562±165; p=0.048, ES=0.31); and when won a match with one goal of difference (p=0.013, ES=0.30) or for draw matches (mean±dev.st=614±173; p=0.044, ES=0.14) than when lost with one goal of difference.

**Figure 11.**

*Z3 time-motion indicator performed by FW, in relation to Serie A matches ended with different margins of victory.*




### V. 8.2. COMPARISON OF TECHNICAL AND TACTICAL PERFORMANCE INDICATORS IN RELATION TO MARGIN OF VICTORY: MIDFIELDER PLAYERS.

In table 12, main effects between different margins of victory regarding MD category have been reported for played balls, time ball possession, successful passes, lost balls, total crosses, and successful over total assists.

**Table 12.**

*Significance (Kruskal–Wallis test) for margin of victory (winning and losing match with >1 or only 1 goal of difference, and draw matches) for MDs, in relation to each technical and tactical, and TMA indicators.*

| # | INDICATORS | *P* VALUE |
|---|---|---|

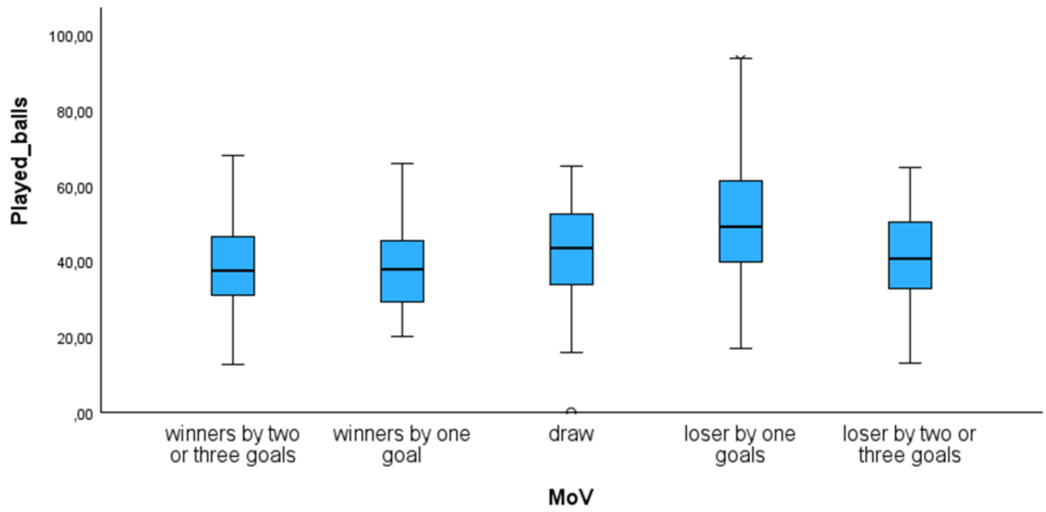
| | | |
|---|---|---|
| 1 | Played_balls | ,002 |
| 2 | Time_ball_possession | ,020 |
| 3 | Successful_passes | ,003 |
| 4 | Successful_playing_patterns | ,112 |
| 5 | Lost_balls | ,049 |
| 6 | Successful_dribbling | ,357 |
| 7 | Total_dribbling | ,114 |
| 8 | Successful_over_total_dribbling | ,808 |
| 9 | Successful_crosses | ,732 |
| 10 | Total_crosses | ,046 |
| 11 | Successful_over_total_crosses | ,096 |
| 12 | Successful_assists | ,090 |
| 13 | Total_assists | ,087 |
| 14 | Successful_over_total_assists | ,016 |
| 15 | Shots_towards_goal | ,865 |
| 16 | Total_shots | ,681 |
| 17 | Towards_goal_over_total_shots | ,870 |
| 18 | TD | ,102 |
| 19 | Z2 | ,855 |
| 20 | Z3 | ,870 |
| 21 | Z4 | ,356 |
| 22 | MPE_rec | ,608 |
| 23 | Bursts | ,629 |

In the further analyses (Mann–Whitney-U test), comparing values for paired margin of victory categories (figure 12), the observed Serie A players' performed more played balls when lost with one goal of difference (mean±dev.st=52±19) than in the other four cases: win a match with two or three goals (mean±dev.st=39±15; $p=0.001$, ES=0.36), or win with one goal (mean±dev.st=39±12; $p<0.001$, ES=0.38); drawn matches (mean±dev.st=45±18;

p=0.032, ES=0.19); and losing match with two or three goals of difference (mean±dev.st=42±15; p=0.004, ES=0.28).

**Figure 12.**

*Played balls performed by MD, in relation to Serie A matches ended with different margins of victory.*



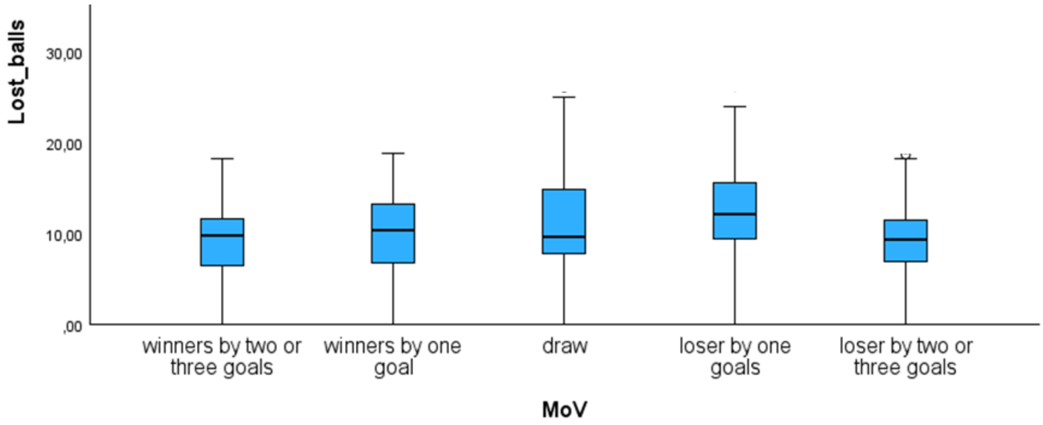

For time ball possessions, a similar trend to balls played emerged. In particular, the observed Serie A players' performed more time ball possession when lost with one goal of difference (mean±dev.st=131±61) than the cases in which players: win a match with two or three goals (mean±dev.st=97±40; p=0.015, ES=0.31), or win with one goal (mean±dev.st=93±34; p=0.003, ES=0.36); and losing match with two or three goals of difference (mean±dev.st=102±53; p=0.04, ES=0.25).

Successful passes reported similar paired effects of time ball possession. In fact, more successful passes were performed when players lost matches with one goal of difference (mean±dev.st=33±15) than the cases in which players: win a match with two or three goals (mean±dev.st=24±14; p=0.001, ES=0.31), or win with one goal (mean±dev.st=22±10; p<0.001, ES=0.41); and after a drawn match (mean±dev.st=27±14; p=0.021, ES=0.21).

Coherently to the above effects, MD also reported higher frequency of lost balls (figure 13) at the end of matches lost with one goal (mean±dev.st=13±8) than that at the end of matches ended as winners with two or three goals (mean±dev.st=9±4; p=0.009, ES=0.31), and losers with two or three goals (mean±dev.st=10±5; p=0.01, ES=0.22).

**Figure 13.**

*Lost balls performed by MD, in relation to Serie A matches ended with different margins of victory.*




Also total crosses reported higher values for lost matches with one goal of differences (mean±dev.st=3.9±2.6) with respect to those lost with two or three goals (mean±dev.st=2.1±1; p=0.015, ES=0.42) and won with one goal (mean±dev.st=2.9±2.2; p=0.049, ES=0.21). Moreover, higher total crosses were performed at the end of drawn matches (mean±dev.st=4±3.1) with respect to matches lost with two or three goals (p=0.016, ES=0.38).

For the ratio between successful assists and total assist, higher values emerged for winning matches with two or three goals (mean±dev.st=0.37±0.59, range=0-2); which reported differences compared to the following margin of victory categories: lost matches with two or three goals (mean±dev.st=0.01±0.11, range=0-1; p=0.005, ES=0.39), lost matches with one goal (mean±dev.st=0.01±0.08, range=0-1; p=0.003, ES=0.39), and won matches with one goal (mean±dev.st=0.02±0.07, range=0-1; p=0.012, ES=0.38).

### V. 8.3. COMPARISON OF TECHNICAL AND TACTICAL PERFORMANCE INDICATORS IN RELATION TO MARGIN OF VICTORY: DEFENDER PLAYERS.

In table 13, main effects between different margins of victory regarding DF category have been reported for played balls, successful passes, and total crosses; In addition, differences emerged also for Z4 time-motion indicators. For bursts, an approach to significance was reported.

**Table 13.**

*Significance (Kruskal–Wallis test) for margin of victory (winning and losing match with >1 or only 1 goal of difference, and draw matches) for DFs, in relation to each technical and tactical, and TMA indicators.*

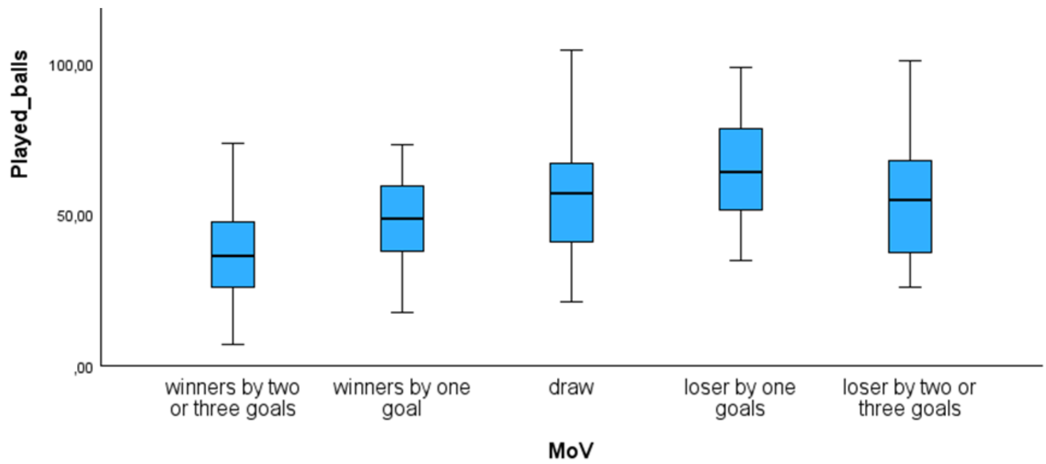
| # | INDICATORS | *P* VALUE |
|---|---|---|
| 1 | Played_balls | <,001 |
| 2 | Time_ball_possession | ,103 |
| 3 | Successful_passes | <,001 |
| 4 | Successful_playing_patterns | ,182 |
| 5 | Lost_balls | ,181 |
| 6 | Successful_dribbling | ,685 |
| 7 | Total_dribbling | ,784 |
| 8 | Successful_over_total_dribbling | ,578 |
| 9 | Successful_crosses | ,368 |
| 10 | Total_crosses | ,004 |
| 11 | Successful_over_total_crosses | ,915 |
| 12 | Successful_assists | ,838 |
| 13 | Total_assists | ,790 |
| 14 | Successful_over_total_assists | ,850 |
| 15 | Shots_towards_goal | ,981 |
| 16 | Total_shots | ,981 |
| 17 | Towards_goal_over_total_shots | ,719 |

| | | |
|---|---|---|
| 18 | TD | ,230 |
| 19 | Z2 | ,453 |
| 20 | Z3 | ,362 |
| 21 | Z4 | ,026 |
| 22 | MPE_rec | ,118 |
| 23 | Bursts | ,051 |

Likely for MDs, the further Mann–Whitney-U analyses, comparing values for paired margin of victory categories (figure 14), reported that observed players performed more played balls when lost with one goal of difference (mean±dev.st=66±18) than in the other four cases: win a match with two or three goals (mean±dev.st=38±17; $p<0.001$, ES=0.62), or win with one goal (mean±dev.st=50±23; $p<0.001$, ES=0.36); drawn matches (mean±dev.st=57±20; $p=0.049$, ES=0.23); and losing match with two or three goals of difference (mean±dev.st=56±26; $p=0.041$, ES=0.22). In addition, played balls were less performed by DFs at the end of winning matches with two or three goals with respect to drawn matches ($p=0.003$, ES=0.46) and lost matches with two or three goals ($p=0.01$, ES=0.36)

**Figure 14.**

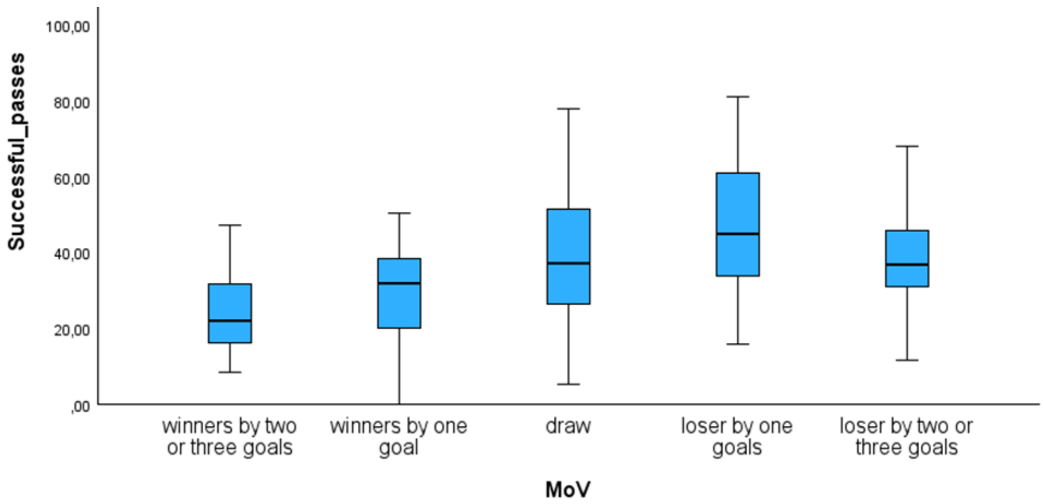
*Played balls performed by DF, in relation to Serie A matches ended with different margins of victory.*




Successful passes (figure 15) reported a similar scenario of played balls for MDs. In fact, more successful passes were performed when players lost matches with one goal of difference (M±SD=46±17) than at the end of winning matches with two or three goals (mean±dev.st=25±11; $p<0.001$, ES=0.59) and one goal (mean±dev.st=33±21; $p=0.001$, ES=0.32). In addition, lower values emerged for winning matches with two or three goals with respect to drawn matches (mean±dev.st=40±18; $p=0.004$, ES=0.45) and losing matches with two or three goals (mean±dev.st=39±18; $p=0.01$, ES=0.42).

**Figure 15.**

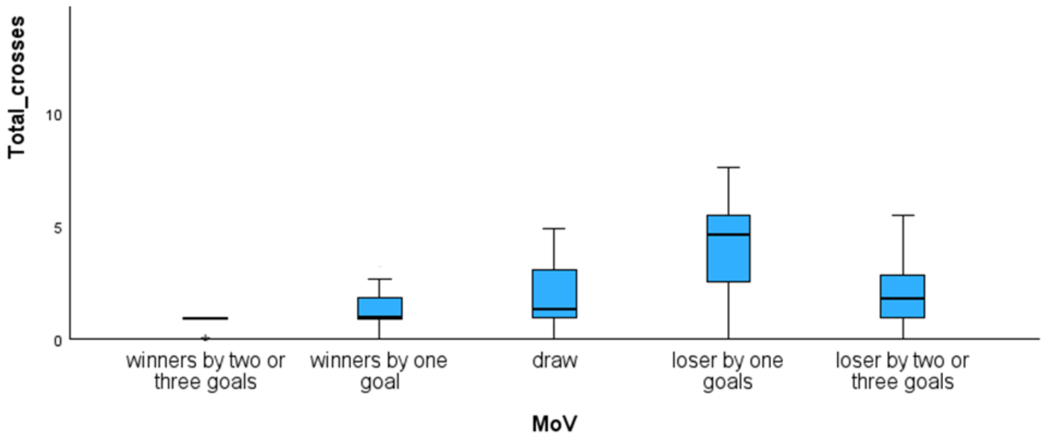
*Successful passes performed by DF, in relation to Serie A matches ended with different margins of victory.*




Similarly to successful passes, total crosses (figure 16) showed higher values at the end of lost matches with one goal of difference (M±SD=4.5±3.3) than in the other four cases: win a match with two or three goals (M±SD=0.9±0.6; p=0.001, ES=0.61), or win with one goal (M±SD=1.4±1.1; p=0.003, ES=0.53); drawn matches (mean±dev.st=2.2±2.6, range=0-10; p=0.015, ES=0.36); and losing match with two or three goals of difference (mean±dev.st=2±1.5; p=0.047, ES=0.44).

**Figure 16.**

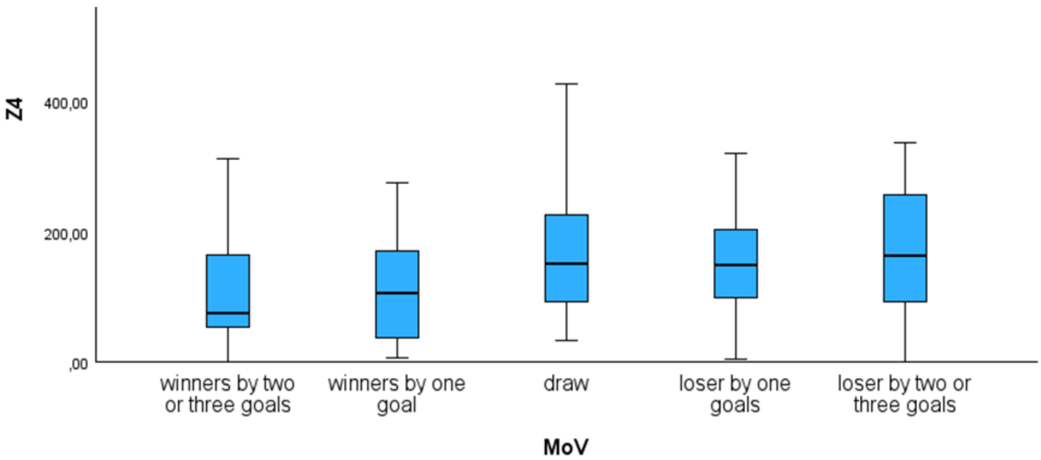
*Total crosses performed by DF, in relation to Serie A matches ended with different margins of victory.*




Coherently with the main trend reported for technical and tactical results, the Z4 time-motion indicator reported that DFs (figure 17) showed higher values for drawn and losing matches. In particular, higher values emerged for drawn matches (M±SD=170±94) with respect to winning matches with two or three goals (M±SD=118±93; p=0.038, ES=0.27), and won with one goal of difference (M±SD=111±75; p=0.012, ES=0.33). In addition, matches lost with one (M±SD=175±125; p=0.023, ES=0.29), and lost with two or three goals (M±SD=166±91; p=0.024, ES=0.31) reported higher values than for matches won with one goal.

**Figure 17.**

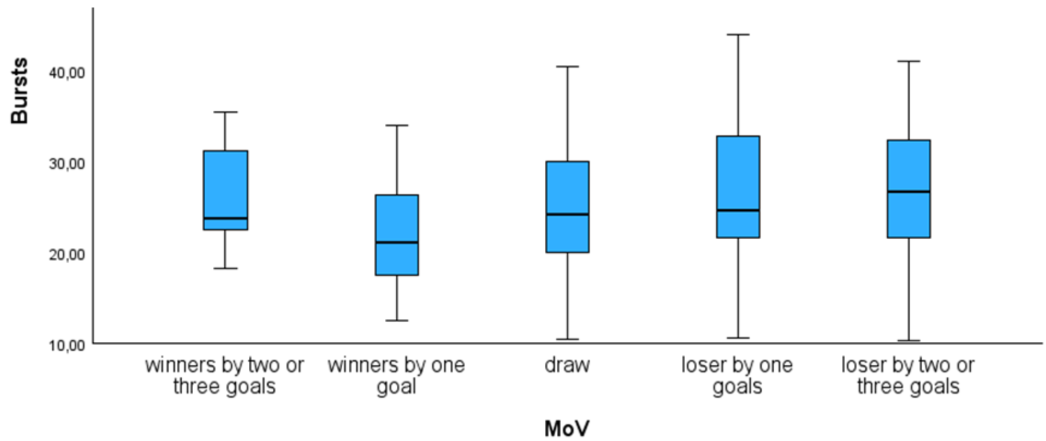
*Z4 performed by DF, in relation to Serie A matches ended with different margins of victory.*




Even though bursts performed by DFs only approach a main significance in terms of margin of victory, in the following graphic (figure 18), losing matches (both with one goal, and two-three goals categories; both=28±10) reported a higher level with respect to other margin of victory categories (winning with two or three goals: 27±8; winning with one goal: 23±8; drawn matches: 25±8), thus reporting a coherent scenario with the previous one about Z4.

**Figure 18.**

*Bursts performed by DF, in relation to Serie A matches ended with different margins of victory.*



## V.9. SUMMARY OF MAIN FINDINGS

This chapter presented the empirical results of the study using a structured, role-specific, and context-driven approach. Findings were organised according to the methodological plan and analytical framework described in Chapters III and IV. Below is a concise synthesis of the main outcomes.

### V.9.1. Time-Motion Findings

Across the entire season:

- Midfielders generally covered the greatest total distance, reflecting their transitional role between defensive and offensive phases.
- Forwards demonstrated the highest volumes of sprinting and high-speed running, consistent with attacking penetration behaviours.
- Defenders exhibited lower sprint outputs but higher engagement in short, high-intensity decelerations, associated with defensive positioning, blocking, and recovery actions.
- Maximal speed values were typically highest for forwards.

These patterns align with role-specific TMA expectations observed in elite football research (Bradley, 2024; Modric, Malone, et al., 2022).

### V.9.2. Technical–Tactical Findings

Role-specific technical behaviour revealed:

- Midfielders performed the highest number of passes, progressive actions, and overall involvement in ball circulation.

- Defenders displayed the highest pass accuracy and dominated interceptions and clearances, indicating strong engagement in build-up and defensive stability actions.

- Forwards led all attacking indicators, including shots, dribbles, and offensive duels.

Indicators highlight a clear tactical differentiation across roles, consistent with the specialised responsibilities identified in modern football literature (Mayhew et al., 2015; Savoia et al., 2024).

**V.9.3. Contextual Findings**

Context significantly modulated performance:

Match Location

Home matches were characterised by:

- higher volumes of high-speed running,

- greater progressive passing,

- more advanced recoveries.

Opponent Strength

Matches against top-tier opponents elicited:

- increased defensive running demands,

- reduced technical efficiency,

- greater duel involvement.

Margin of Victory

Tightly contested matches produced:

- higher physical intensity (especially HSR and accelerations),
- lower progressive-play indicators,
- more duel-oriented behaviours.

These findings emphasise the situational dependency of elite performance (Gómez et al., 2018; Lago-Peñas & Gómez-López, 2014).

### V.9.4. Integrated Correlation Findings

Integrated correlation matrices revealed:

- For defenders:

  strong coupling between accelerations/decelerations and defensive duels/interceptions.

- For midfielders:

  moderate-to-large correlations between time-motion volume and passing involvement, reflecting their bridging function across phases.

- For forwards:

  large correlations between sprint-based indicators and attacking outcomes (shots, dribbles, xG involvement), highlighting the central role of speed in offensive penetration.

The integrated relationships confirm the ecological principle that physical, tactical, and technical behaviours are interdependent rather than isolated (Gonçalves et al., 2017; Mayhew et al., 2015).

**V.9.5. Overall Summary**

In summary:

1. Playing role was a major determinant of both time-motion and technical–tactical indicators.

2. Match context further modulated these indicators, often amplifying or reducing role-specific demands.

3. Integrated performance relationships were clearly identified within each role, supporting the thesis hypothesis that technical–tactical and physical actions emerge as co-dependent behaviours.

4. These findings provide the empirical foundation for the interpretive and theoretical discussion presented in Chapter VI.

# VI – DISCUSSION

# VI - DISCUSSION

The purpose of this chapter is to interpret and critically appraise the empirical findings presented in Chapter V in light of the conceptual, methodological, and applied framework developed throughout the thesis. In particular, the discussion reconnects the results with the theoretical perspectives introduced in Chapter I—ecological dynamics, constraints-led approaches, and complex systems theory—as well as with the justification for the study (Chapter II) and the objectives and hypotheses formulated in Chapter III (Davids et al., 2013). Rather than treating the results as isolated statistical outcomes, this chapter adopts a holistic perspective, considering how role-specific time–motion demands, technical–tactical behaviours, and contextual variables interact to produce emergent patterns of performance in elite Italian Serie A football.

Where appropriate, the findings are contrasted with recent literature (particularly from 2010–2025), with convergences and divergences explicitly highlighted (Bradley et al., 2016). The chapter concludes by outlining theoretical and practical implications, specific contributions, limitations, and directions for future work, thereby positioning the thesis within the broader scientific and applied landscape of high-performance football.

Therefore, the purpose of this chapter is to interpret the empirical findings presented in Chapter V through a theoretical, methodological, and applied lens. The discussion integrates:

- the conceptual framework defined in Chapter I,
- the rationale and objectives outlined in Chapter II,
- the hypotheses established in Chapter III, and

- the results obtained from the analyses in Chapter V.
- Interpretation is grounded in contemporary sport-science theory, particularly:
- ecological dynamics,
- constraints-led approach,
- complex systems theory,
- integrated technical–tactical–physical performance models,
- contextual dependency frameworks (Bradley, 2024; Gonçalves et al., 2017; Mayhew et al., 2015; Sampaio & Maçãs, 2012).

## VI.1. Summary of the Study Purpose and Framework

The overarching aim of this doctoral thesis was to design and implement an **integrated performance model** for elite Serie A players, based on a full competitive season of a top-flight professional club. This model combined three main domains:

1. **Time–motion indicators**, derived from validated electronic performance and tracking systems (EPTS).
2. **Technical–tactical behaviours**, obtained from notational/event-based analysis.
3. **Key contextual variables**, including match location, opponent strength, and match outcome/margin of victory.

A fourth transversal dimension—the interdependent relationships across playing roles (defenders, midfielders, forwards)—served as the central axis for interpreting the data, consistent with the notion of role-specific performance ecologies (Bradley, 2024; Modric, Malone, et al., 2022; Savoia et al., 2024).

This design was explicitly conceived to overcome several limitations identified in the literature. First, many previous studies have analysed physical and technical–tactical variables separately, leading to partial understandings that lack ecological validity (Sarmento et al., 2024). Second, a substantial body of work has relied on **single-match** or **short-term samples**, which may not capture the variability and stability of performance across an entire season (Gregson et al., 2010). Third, a considerable proportion of the existing literature is based on outdated locomotor thresholds or non-integrated datasets, limiting comparability with current elite demands (Bradley et al., 2016).

By adopting a **longitudinal, full-season design** and by employing updated operational definitions aligned with recent methodological proposals (Bradley, 2024; Modric, Malone, et al., 2022), the present study aimed to construct a performance model that is simultaneously **methodologically rigorous**,

**ecologically realistic**, and **theoretically grounded**. The empirical results presented in Chapter V must therefore be interpreted not merely as descriptive statistics, but as manifestations of how football performance emerges from multi-layered constraints acting on defenders, midfielders, and forwards in a highly tactical environment such as Serie A (Savoia et al., 2024).

The aim of this doctoral thesis was to develop an integrated performance model for Serie A players by examining:

1. time-motion indicators,
2. technical–tactical behaviours,
3. contextual variables, and
4. interdependent relationships across roles.

The study addressed major gaps identified in previous research:

- lack of integration between physical and technical-tactical data;
- insufficient ecological validity;
- limited understanding of role-specific behaviour in Serie A;
- scarce use of full-season longitudinal designs;
- outdated thresholds and methodological standards in older studies.

By addressing these gaps, this thesis contributes a modern, role-specific, contextually grounded, and ecologically realistic model of elite performance.

## VI.2. Interpretation of Role-Specific Time-Motion Behaviour

A central finding is the differentiation of TMA outputs across roles, confirming H1 and aligning with contemporary literature (Bradley, 2024; Modric, Malone, et al., 2022; Savoia et al., 2024).

### VI.2.1. Midfielders: High Volume, High Versatility

Midfielders consistently covered the greatest total distances and displayed substantial involvement in all game phases. This profile is compatible with earlier evidence demonstrating that central and wide midfielders typically accumulate the largest volumes of running, serving as continuous links between defensive and attacking lines (Bradley, 2024; Vigne et al., 2010). Within the present study, midfielders' locomotor profiles were characterised by:

- high total distance,
- considerable low-to-moderate intensity movement,
- substantial exposure to high-speed running,
- frequent accelerations and decelerations.

Crucially, these locomotor features cannot be reduced to generic "work rate." When examined alongside technical–tactical data, they reveal a **functional integration** between movement and ball circulation. The moderate-to-large associations observed between total distance and passing involvement suggest that movement is not merely supportive but **structurally linked** to central control of possession and tempo regulation (Rampinini et al., 2009).

In ecological-dynamics terms, midfielders operate in an environment of **high informational density**, continuously adjusting their positioning to afford passing lanes, receive under pressure, and stabilise team structure (Davids et al., 2013). Their physical profile thus reflects a continuous negotiation between maintaining compactness, offering support, and managing transitions—confirming the particularly complex demands of this role in modern football.

The consistently higher total distance among midfielders reflects:

- their role as connectors between defensive and offensive units;
- frequent transitions between zones;
- participation in both pressing and covering actions;
- responsibility for maintaining team structure.

This pattern is well supported by recent evidence showing that modern midfielders experience multidirectional, continuous movement patterns with high time-motion density (Tierney et al., 2016).

Furthermore, midfielders' moderate-to-large correlations between distance and passing volume (Chapter V) reinforce the idea that their physical and technical demands are tightly interdependent.

### VI.2.2. Forwards: High-Intensity Specialists

Forwards demonstrated the highest values for sprint distance, high-speed running exposure, and maximal speed. This finding is consistent with work from the UEFA Champions League, domestic European leagues, and World Cup competition, which identifies forwards and wide attacking players as the roles with the greatest proportion of explosive, depth-oriented runs (Castellano et al., 2014; Di Salvo et al., 2007).

The present data show that forwards' locomotor output is **less continuous but more peak-oriented**, with many high-intensity actions linked to:

- penetrative runs behind the defensive line,
- counterattacking sequences,
- pressing actions in advanced areas,

- explosive movements during finishing opportunities.

The strong associations between sprinting metrics and attacking actions (shots, offensive duels, dribbles) reinforce the notion that high-intensity running is not a marginal component but a **central determinant of forwards' effectiveness**, particularly in the final third (Savoia et al., 2024; Yi et al., 2018). From an integrated perspective, speed should be conceptualised not only as a physical capacity but as a **tactical affordance** that reshapes defensive spacing, constrains opponent behaviour, and increases the probability of high-xG opportunities (Modric, Versic, et al., 2022).

### VI.2.3. Defenders: High Neuromuscular Load, Lower time-motion values

Defenders covered less distance at high speed than other positional groups, but exhibited the highest frequencies of **accelerations, decelerations, defensive duels, clearances, and interceptions**. These data align with prior studies indicating that central and wide defenders operate in **spatially constrained zones**, requiring repeated short bursts, positional corrections, and reactive movements rather than frequent long sprints (Rampinini et al., 2009).

In the context of Serie A—traditionally associated with compact, tactically organised blocks—the defensive role is heavily shaped by:

- maintaining line integrity,
- managing depth and space behind the line,
- engaging in duels in central and lateral defensive zones,
- executing rapid adjustments in response to opponent movements (Savoia et al., 2024).

The strong link between acceleration/deceleration metrics and defensive actions observed in this thesis supports the idea that defender performance relies on **high**

**neuromuscular loads concentrated in micro-spaces**, where anticipation and timing are crucial (Castellano et al., 2014) (Torres-Ronda et al., 2022). Defenders thus exemplify a role in which **positional stability** and **micro-intensity actions** co-exist as core performance demands.

Defenders covered less high-speed running but performed:

- more decelerations,
- more defensive duels,
- more interceptions,
- more clearances.

These behaviours suggest:

- frequent short-distance reactive movements,
- repeated re-positioning actions,
- anticipatory defensive adjustments,
- tactical compactness roles,
- protection of central corridors.

This aligns with models showing that defensive behaviour relies more on rapid changes of direction and structured movement patterns, rather than continuous high-speed displacement (Sarmento et al., 2024). The strong acceleration–duel correlations in defenders indicate that defensive actions are inherently neuromuscular intensive, supporting literature on positional energetics.

### VI.3. Interpretation of Technical–Tactical Behaviour Across Roles

The technical–tactical findings also revealed **pronounced differences between positional roles**, supporting Hypothesis 2 and reinforcing the picture drawn by the time–motion data. These differences are consistent with classic and contemporary notational studies, but the present work extends them by integrating role-specific technical indicators with locomotor and contextual dimensions (Amatria et al., 2019; Bradley, 2024; Modric, Malone, et al., 2022; Sarmento et al., 2014, 2024).

Midfielders recorded the highest number of passes, including progressive passes and involvement in build-up and consolidation phases. This confirms their central role in possession management, rhythm control, and transitions between defensive and attacking structures (H. Liu et al., 2016; Modric, Malone, et al., 2022). A large proportion of these actions occurred in central zones and under moderate-to-high opponent pressure, emphasising the cognitive and perceptual loads associated with this role (Davids et al., 2013; Ric et al., 2016; Sampaio & Maçãs, 2012).

Defenders dominated **interceptions, clearances, defensive duels, and first-phase build-up** involvement, aligning with literature on modern possession-based systems where defenders are simultaneously required to ensure defensive stability and initiate structured build-up under pressure (Carling, 2011; Gómez et al., 2018). High pass accuracy in deep zones reflects controlled risk management, whereas strong engagement in duels and interceptions reflects the **reactive and anticipatory dimensions** of defensive play (Di Salvo et al., 2007).

Forwards were unsurprisingly the most involved in **shots, offensive duels, dribbles, and advanced recoveries**, echoing work on attacking profiles in top European competitions (H. Liu et al., 2016; Modric, Malone, et al., 2022). The concentration of their technical actions in the final third, often under intense opposition pressure and limited time–space windows, highlights the dependence of forward performance on **individual decision-making under constraint**, creative exploitation of space, and synergy with team tactical structures (Sarmento et al., 2024).

Collectively, these patterns reinforce the idea that **technical–tactical behaviour is strongly role-dependent**, and that training, evaluation, and recruitment must be anchored in role-specific benchmarks (Sarmento et al., 2024).

### VI.3.1. Midfielders: Centrality to Possession and Game Flow

Midfielders displayed:

- the highest pass volume,
- strong progressive-play involvement,
- consistent presence in ball circulation.

These findings reflect their tactical responsibility for controlling tempo, linking defensive and attacking phases, managing transitions, and structuring team shape. Practically, this means that midfielders must repeatedly offer passing options, receive under pressure, and redistribute the ball in ways that preserve or enhance positional superiority.

The strong technical load is consistent with research showing midfielders as the main stabilisers of collective information flow (Gonçalves et al., 2017). In midfielders, the coupling between **total distance and passing involvement**, and between **accelerations and duels**, indicates that ball-related actions are embedded in continuous movement and frequent micro-intensifications. Midfielders function as dynamic hubs through which physical load, technical execution, and positional responsibility converge into a unified behavioural profile (Rampinini et al., 2009).

### VI.3.2. Defenders: Defensive Control and Build-Up Stability

Defenders showed:

- the highest pass accuracy,
- greater involvement in the first phase of build-up,
- dominance in interceptions, clearances, defensive duels.

These behaviours reflect a dual responsibility: on one side, defenders must ensure secure, low-risk circulation under limited pressure during build-up; on the other, they must be ready to engage in decisive defensive interventions whenever the block is threatened.

The technical stability observed among defenders supports the modern trend of positional play where defenders must combine defensive reliability with constructive build-up capacity (Bradley et al., 2016). Their high pass accuracy in deeper zones indicates careful risk management when circulating the ball, particularly against high-pressing opponents. At the same time, frequent interceptions and clearances show that defenders must anticipate attacking patterns, occupy critical zones, and intervene to stop penetration (Castellano et al., 2014).

In this context, the strong associations between **accelerations, decelerations, defensive duels, and interceptions** highlight the role's dependence on short, explosive reactions synchronised with tactical positioning. Defensive performance involves **maintaining passing stability under pressure** while simultaneously executing rapid micro-adjustments in response to changing threats reinforcing the image of defenders as "anchors" of both stability and reactivity (Castellano et al., 2014).

### VI.3.3. Forwards: Technical Actions Oriented Toward Penetration

Forwards dominated:

- shots,
- offensive duels,
- dribbles,
- attacking-third recoveries.

These actions indicate direct involvement in chance creation, exploitation of 1v1 situations, and responsibility for destabilising defensive lines.

This aligns with modern tactical analysis showing that attacking behaviours depend heavily on individual initiative combined with speed-based actions (Savoia et al., 2024). In forwards, strong correlations between **sprinting metrics and attacking outputs** suggest that key offensive behaviors (shots, dribbles, dangerous off-the-ball runs) typically occur at high speeds and under intense temporal constraints (Savoia et al., 2024; Yi et al., 2018). From a practical standpoint, this emphasizes that technical coaching for forwards cannot be separated from high-intensity, high-pressure contexts; finishing and dribbling must be trained within the **intensity envelopes** observed in match play.

### VI.4. Integrated Interpretation of Physical and Technical–Tactical Behaviour

One of the most significant contributions of this thesis is the demonstration that **time-motion and technical–tactical behaviours do not operate as independent constructs**, but emerge through integrated and interdependent processes. This finding aligns with modern ecological dynamics, which conceptualises football performance as the result of continuous interactions between:

- player attributes,
- tactical constraints,
- environmental opportunities,
- contextual demands (Mayhew et al., 2015; Sampaio & Maçãs, 2012).

By examining correlations and joint patterns between locomotor and technical variables across roles, the present study provides evidence that physical and technical profiles are functionally coupled. Performance does not appear to be organised as "physical load plus technical actions," but rather around role-specific couplings such as distance–passing, sprinting–shooting, or accelerations–duels. These couplings help explain how different roles contribute to team functioning in complementary yet distinct ways, further reinforcing the complexity-based view of football proposed in Chapter I.

#### VI.4.1. Integrated Demands in Midfielders

The parameters indicators studied in the present thesis can indicate a strong coupling between:

- total distance ↔ passing volume,
- accelerations ↔ duel engagement,
- HSR distance ↔ progressive passes.

. These integrated patterns reflect the hybrid nature of midfield roles, in which physical, technical, and tactical demands are tightly interwoven.

The association between total distance and passing volume indicates that midfielders' extensive movement is not random but functionally oriented towards creating and maintaining passing options. Their continuous locomotor activity allows them to support teammates across zones, provide additional angles for circulation, and ensure that the team can adapt to the shifting geometry of play. Similarly, the link between accelerations and duel engagement suggests that many contests for the ball are preceded by short bursts of speed to arrive first to the ball, close down opponents, or gain positional advantage.

The coupling between high-speed running distance and progressive passes further reinforces the idea that midfielders are actively involved in driving the team forward, both by moving with the ball and by advancing into spaces that enable line-breaking passes. From this perspective, midfielders represent a link between defenders and forwards in both physical and informational terms, as their actions help propagate and transform the flow of play. This integrated profile confirms that midfielders represent the most complex and cognitively demanding role, requiring simultaneous physical, tactical, and technical engagement (Sarmento et al., 2024).

### VI.4.2. Integrated Demands in Forwards

For forwards, correlations revealed:

- sprint distance ↔ shots (large effect)
- HSR efforts ↔ dribbles
- accelerations ↔ offensive duels
- max speed ↔ xG involvement (when available)

These results suggest that forward performance effectiveness emerges through a tight **speed–technique coupling**.
High-intensity time–motion actions appear to create and expand opportunities for technical execution. For example, a successful sprint in behind the defence can destabilise the back line, alter defensive spacing, and force rapid adjustments that open passing or shooting lanes. Dribbling actions at high speed further compound these effects, obliging defenders to make decisions under pressure and increasing the likelihood of winning offensive duels.
In this context, offensive duels and finishing actions are strongly influenced by the forward's ability to generate and sustain speed. Physical explosiveness allows forwards to create separation, arrive first to the ball, or maintain advantage in 1v1 situations. Conversely, limitations in speed may restrict the effective use of technical skills, particularly in leagues such as Serie A where time–space constraints are severe. The present findings therefore support literature emphasising speed as a decisive affordance for attacking penetration (Gonçalves et al., 2017) and highlight the need to train technical skills under speed and fatigue conditions that resemble match realities.

### VI.4.3. Integrated Demands in Defenders

Defenders displayed:

- massive neuromuscular loads (accelerations, decelerations),
- strong interaction with defensive duels and interceptions,
- stable technical behaviour (high pass accuracy),
- lower high-speed running volume.

. This combination suggests that defensive performance is shaped less by global displacement and more by micro-adjustments of positioning, anticipatory reading of the game, repeated short-distance actions, and situational decision-making under pressure.

The integration between physical and technical–tactical demands in defenders is particularly evident in the coupling of accelerations and decelerations with defensive duels and interceptions. Before engaging in a duel or executing an interception, defenders often perform short, explosive adjustments to align body position, control the distance to opponents, or attack the ball. These micro-intensifications are essential for success in 1v1 situations and for preventing dangerous progressions.

At the same time, high pass accuracy indicates that defenders must manage the ball reliably under pressure, often initiating build-up play from deep areas. This places them at the intersection of risk and control: they must circulate the ball safely enough to avoid turnovers while still making constructive passes that enable progression. The necessity to maintain composure and precision while simultaneously being ready to execute rapid defensive actions encapsulates the integrated nature of their role.

This integrated profile confirms that defenders rely on **tactical intelligence and neuromuscular readiness** rather than time-motion volume alone (Savoia et al., 2024).

Their effectiveness depends on their capacity to anticipate opponent behaviour, position themselves advantageously, and coordinate rapid physical responses with accurate technical execution.

### VI.5. Contextual Modulation of Performance

Contextual variables proved to be **major determinants** of performance outcomes, confirming H3 and supporting the idea that performance is situational and shaped by evolving game dynamics.

### VI.5.1. Match Location Effects

Contextual variables—match location, opponent strength, and match outcome/margin of victory—emerged as **powerful modulators** of both physical and technical–tactical behaviours, confirming Hypotheses 3–5 and echoing the growing literature on contextual influences in football (Castellano et al., 2014).

**Match location** influenced intensity and tactical orientation. In home matches, the team displayed higher high-speed running, more progressive play, and increased advanced recoveries, aligning with classic and recent work on home advantage and its impact on playing style and physical output (Lago-Peñas & Gómez-López, 2014). These findings suggest that **home environments favour more assertive tactical behaviours** and greater risk-taking, with implications for load management and game-plan design.

Findings showed:

- higher HSR and sprinting at home,
- more progressive play,
- more advanced recoveries.

These results are consistent with:

- home-field advantage theory (crowd influence, familiarity)
- increased tactical assertiveness at home
- higher pressing and territorial control
  (Lago-Peñas & Gómez-López, 2014).

Home teams often adopt higher defensive blocks, generating more opportunities for:

- forward runs,
- progressive passes,
- final-third recoveries.

This reinforces the idea that **performance must be understood within environmental affordances**.

### VI.5.2. Opponent-Strength Effects

Opponent strength also exerted a clear influence on performance patterns.

Against top-tier opponents:

- physical demands increased (higher HSR, more duels),
- technical efficiency decreased,
- duel involvement intensified.

This pattern reflects:

- forced defensive behaviours,
- longer defensive sequences,
- reduced ability to maintain stable possession,
- increased chaotic transitions.

These dynamics align with studies showing that **strong opponents impose constraints that alter both technical and physical behaviours** (Bradley et al., 2016). **Opponent strength** also exerted a clear effect. Matches against top-tier teams were characterized by increased defensive workloads, higher duel intensities, and a tendency towards reduced technical efficiency. This observation is consistent with studies reporting that stronger opponents compress time–space windows and impose more severe tactical and physical constraints (Savoia et al., 2024). In such contexts, the ability to preserve technical quality under pressure and to efficiently manage transitions becomes critical.

### VI.5.3. Impact of Margin of Victory

Match outcome and margin of victory added further nuance to the contextual analysis**.** Tight matches were associated with elevated high-speed and sprint requirements, increased accelerations, and reduced progressive passing—indicative of **high tactical volatility, frequent transitions, and intense covering behaviours** (Vigne et al., 2010). Conversely, larger-margin victories were associated with greater possession control and somewhat redistributed physical demands. These results support the importance of viewing performance through the lens of **match status and scoreline**, rather than only final outcome (Gómez et al., 2018).

Overall, the contextual analyses underscore that performance cannot be treated as context-free and that integrated models must necessarily incorporate match location, opponent level, and score dynamics to attain full ecological validity (Castellano et al., 2014).

In tightly contested matches:

- HSR and sprint demands were higher,
- accelerations increased,
- progressive passing decreased.

This suggests that close matches create:

- tactical volatility,
- faster transitions,
- more defensive covering actions,
- reduced time for stable possession play.

- In contrast, comfortable wins allow teams to:
- manage tempo,
- develop more structured possession,
- produce more attacking actions.

This aligns with modern analyses showing that **match status directly shapes intensity and tactical choices** (Gómez et al., 2018).

### VI.6. Interpretation of Correlation Structures

The correlation matrices presented in Chapter V highlight systematic, role-specific relationships that reflect deeper theoretical principles of football as a complex system.

The correlation matrices reported in Chapter V provide insight into the **organizational logic** of performance as a complex system. Rather than random or independent associations, the data revealed **coherent, role-specific interaction patterns** between physical and technical–tactical variables.

For defenders, links between **decelerations, defensive duels, and recoveries** support models emphasizing anticipation, positioning, and repeated micro-intensity responses in constrained spaces (Castellano et al., 2014). Defensive behavior appears structured around a recurrent pattern of short, intense interactions embedded in stable spatial structures.

For midfielders, the combined effects of **distance, passing, and high-speed progressive actions** indicate that they function as **central nodes within the team's information and movement network**, consistent with previous work on positional importance and centrality (H. Liu et al., 2016; Modric, Malone, et al., 2022).

For forwards, strong associations between **sprinting metrics and attacking outputs** confirm that offensive penetration depends heavily on the capability to exploit space at speed, reinforcing proposed models linking speed and penetration with success in elite competitions (Savoia et al., 2024; Yi et al., 2018).

These structures lend empirical support to the conceptualisation of football as a **complex adaptive system**, in which each role exhibits specific, recurrent interaction patterns shaped by its functional constraints and the wider tactical environment (Davids et al., 2013; Ric et al., 2016; Sampaio & Maçãs, 2012).

### VI.6.1. Defenders: Anticipation and Micro-Intensity Patterns

In defenders, strong correlations between:

- decelerations ↔ defensive actions,
- accelerations ↔ duels,
- position-based actions ↔ recoveries,
- indicate that defenders' performance is shaped by **short, explosive, reactive behaviours** rather than sustained running.

These relationships suggest that successful defensive interventions depend on the ability to adjust speed quickly and repeatedly in tight spaces, responding to changes in opponent movement and ball location.

This supports conceptual models of defensive play emphasising:

- anticipation,
- small-space interactions,
- decision-making in constrained contexts.

Defenders must anticipate passes, anticipate runs, and time their interventions precisely, all while managing their neuromuscular load over the course of the match. The correlation structure observed in this thesis provides quantitative support for these qualitative descriptions.

### VI.6.2. Midfielders: Coupling of Technical Stability and Physical Output

For midfielders, the moderate-to-large correlations between:

- total distance ↔ passes,
- HSR ↔ progressive play,
- accelerations ↔ duels,

These implications suggest that midfielders operate within a **highly integrated behavioural zone**, where physical and technical actions co-emerge. These relationships reinforce the idea that midfielders act as **central hubs of collective organisation**, generating and responding to informational opportunities (Gonçalves et al., 2017).

Their role is not simply to "connect lines" in a static sense, but to adaptively regulate the flow of play through continuous adjustments in movement and technical decisions. The correlation patterns observed provide a statistical fingerprint of this integrative function.

### VI.6.3. Forwards: High-Intensity Affordances and Attacking Effectiveness

For forwards, offensive penetration emerges through the interplay of:

- speed,
- duels,
- finishing actions,
- space exploitation.

Large correlations between sprint indicators and attacking outputs confirm that **physical explosiveness directly underpins technical effectiveness** in the final third. Recent studies support this interpretation, emphasising that speed is increasingly crucial in scoring opportunities at elite level.

The present results are consistent with this view, suggesting that high-intensity time–motion profiles are not only characteristic but functionally necessary for forwards operating in competitive Serie A contexts.

### VI.7. Comparison with previous literature (2020–2025)

The results of this thesis can be interpreted in relation to the evolution of performance-science research over the last five years. Between 2020 and 2025, the literature has shifted towards:

- integrated model approaches,
- contextualised analysis,
- role-specific benchmarks,
- machine-learning enhanced performance profiling,
- high-resolution optical tracking validation,
- ecological-dynamics-based interpretations.

The findings of this thesis align with, extend, and in several cases challenge or refine current knowledge.

#### VI.7.1. Time-Motion Behaviour

A. These studies show that:

- midfielders exhibit the highest total distance,
- forwards dominate sprinting and HSR metrics,
- defenders engage in lower macro-time-motion volume but greater micro-intensity actions.

B. Extension of previous findings

This thesis extends the literature by:

- using updated 2024–2025 speed thresholds,
- applying full-season longitudinal data in a Serie A context,
- incorporating neuromuscular load indicators (accelerations & decelerations) as primary variables.

These elements are still emerging in current publications and make this thesis methodologically contemporary

When compared with sport-science research from the last decade, the present findings demonstrate substantial continuity with established trends while introducing important refinements.

In the **time–motion domain**, the role hierarchy observed here (midfielders > total distance; forwards > HSR and sprints; defenders > accelerations/decelerations) broadly matches evidence from English, Spanish, Portuguese, and international competitions (Bradley et al., 2016; Hands & Janse de Jonge, 2020; Modric, Malone, et al., 2022). The innovations of this thesis lie in:

- the use of **updated speed thresholds** (Modric, Versic, et al., 2022),
- the explicit inclusion of **acceleration/deceleration** as primary indicators (Akenhead & Nassis, 2016; Buchheit et al., 2014),
- the focus on a full **Serie A** season.

The results of this thesis can be interpreted in relation to the evolution of performance-science research over the last five years. Between 2020 and 2025, the literature has progressively shifted towards integrated model approaches, contextualised analyses, role-specific benchmarks, machine-learning enhanced performance profiling, high-resolution optical tracking validation, and ecological-dynamics-based interpretations. The findings of this thesis align with, extend, and in several cases refine current knowledge.

### VI.7.2. Technical–Tactical Behaviour

In the **technical–tactical domain**, the results align with systematic reviews and empirical analyses describing role-specific technical patterns (Modric, Malone, et al., 2022; Sarmento et al., 2024; Yi et al., 2018). However, the present work extends this literature by combining classic indicators (passes, shots, duels) with more nuanced measures such as progressive passing and recovery zones, specifically within the tactical culture of Serie A (Savoia et al., 2024; Yi et al., 2018; Perrotta et al., 2025).

Key consistencies with prior work:

- high passing involvement of midfielders (Mayhew et al., 2015)
- defenders leading in interceptions and clearances (Sampaio & Maçãs, 2012)
- forwards dominating attacking actions and offensive duels (Gonçalves et al., 2017)

This thesis reinforces these trends but provides a **more granular view**, particularly in:

- progressive passing,
- recovery zones,
- directionality of actions,
- duel typology.

Such nuances are largely absent from pre-2023 studies and provide a more detailed understanding of role-specific tactical functions.

### VI.7.3. Contextual Effects

Regarding **contextual modulation**, the findings are coherent with existing studies on match location, opponent quality, and scoreline effects (Castellano et al., 2014). The thesis adds value by demonstrating how these contextual factors reshape **integrated physical–technical relationships** within each role, rather than simply altering overall volume or intensity.

Most importantly, in the field of **integrated analysis**, the present study advances beyond much of the existing literature, which has often examined physical and technical domains separately or without robust contextual segmentation (Castellano et al., 2014; Rein & Memmert, 2016). By providing **role-specific, context-aware correlation matrices** based on a full season in a tactically demanding league, this thesis contributes one of the most comprehensive integrated analyses currently available.

The contextual findings corroborate and refine:

- home advantage dynamics (Lago-Peñas & Gómez-López, 2014)
- opponent-tier impact on physical load (Carling, 2011; Gómez et al., 2018)
- match-status modulation of technical behaviour (Gómez et al., 2018)

This thesis adds new insights by separating context × role interactions, analysing margin-of-victory categories with appropriate statistical robustness, and integrating contextual modulation within a combined model of physical and technical performance.

### VI.7.4. Integrated Physical–Technical Relationships

In contrast, this thesis offers a cleaner, more robust, and more comprehensive integrated analysis, drawing on a full season in a tactically demanding league and providing role-specific, context-aware correlation matrices. In doing so, it makes an original contribution to the literature on integrated performance analysis and sets a methodological precedent for future work.

This is where this thesis truly **advances the field**.

Previous research has rarely examined correlations between technical–tactical and time-motion indicators in a unified framework. Recent attempts (2023–2025) include:

- Gonçalves et al. (2017): integrated tactical clusters
- (Mayhew et al., 2015): xThreat reconstruction with time-motion coupling
- (Bradley et al., 2016): multi-domain load profiling

However:

- correlations were often restricted to small datasets,
- lacked contextual segmentation,
- did not separate role-specific matrices,
- used heterogeneous thresholds.

In contrast, this thesis offers a cleaner, more robust, and more comprehensive integrated analysis, drawing on a full season in a tactically demanding league and providing role-specific, context-aware correlation matrices. In doing so, it makes an original contribution to the literature on integrated performance analysis and sets a methodological precedent for future work.

### VI.8. Theoretical and Practical Implications

The results of this thesis carry implications at multiple levels.

**Theoretically**, the findings:

- reinforce conceptualisations of football as a **complex adaptive system**,
- empirically support the idea that performance emerges from **constraint interactions** across physical, technical, tactical, and contextual domains (Davids et al., 2013),
- refine the understanding of **role-specific ecologies**, illustrating how each position operates within distinct constraint landscapes (Sarmento et al., 2024).

**Practically**, the integrated profiles can inform:

- **tactical periodisation**, by designing training tasks that reproduce the specific physical–technical couplings and contextual intensities identified for each role (Akenhead & Nassis, 2016; Gregson et al., 2010). For example, drills for defenders can integrate high frequencies of accelerations and decelerations with duels and interceptions in small spaces, while tasks for forwards can couple sprints and bursts with shooting and 1v1 actions in the final third.

- **player recruitment and profiling**, using integrated benchmarks to evaluate alignment between an individual's characteristics and the tactical model of the team (Lago-Ballesteros & Lago-Peñas, 2010). Coaches and performance staff can use these benchmarks to identify players whose integrated time–motion and technical–tactical profiles match desired role specifications
- **load management and injury prevention**, particularly through understanding neuromuscular loads in defenders and high-speed exposures in forwards (Buchheit et al., 2014). Tailoring recovery strategies

and conditioning programmes to these role-specific patterns may reduce injury risk and optimise performance.

**Methodologically**, the study demonstrates the feasibility and value of integrating tracking data, event logs, and contextual metadata within a coherent framework, respecting current standards in statistics, reliability, and reporting (Will G Hopkins, 2016; Wobbrock et al., 2011). This integration constitutes an important step towards more comprehensive performance models in elite football.

### VI.9. Specific Contributions of This Thesis

This thesis makes **five major contributions** to contemporary sport science:

1. **A full-season integrated performance model** for a Serie A team, combining time–motion, technical–tactical, and contextual domains in a single framework.
2. **Use of updated locomotor thresholds and operational definitions** consistent with current elite standards (Bradley et al., 2016).
3. **Role-specific correlation matrices** describing how physical and technical indicators co-emerge within defenders, midfielders, and forwards.
4. **Explicit contextual modulation**, demonstrating how match location, opponent strength, and margin of victory reshape integrated performance patterns.
5. **Methodological transparency and APA 7–aligned reporting**, providing a replicable structure for future studies (Torres-Ronda et al., 2022).

### VI.10. Limitations of the Study

Several limitations must be acknowledged to contextualise the scope of the conclusions:

- The **single-club design** increases internal consistency but limits generalisability to other teams, tactical models, and leagues.
- Reliance on **optical tracking and event-based platforms** introduces technical constraints related to tracking errors, occasional data gaps, and the inherent subjectivity of human coding (Buchheit et al., 2014).
- The absence of **internal-load metrics** prevents a complete bioenergetic profiling of match demands (Akenhead & Nassis, 2016; Buchheit et al., 2014).
- Contextual variables, although substantial, did not include **environmental conditions, travel, or psychological factors** such as momentum and perceived pressure (Lago-Peñas & Gómez-López, 2014).
- More advanced measures of **collective behaviour** (synchronisation indices, network analysis, spatial entropy) were not fully operationalised, primarily due to feasibility constraints (Rein & Memmert, 2016).

These limitations do not invalidate the results, but rather delineate the boundaries of inference and identify areas for future research.

#### VI.10.1. Single-Club Sample

The study analysed data from a single Serie A club. While this ensures methodological consistency and data reliability, it may limit generalisability to:

- other tactical systems,
- different leagues,
- alternative playing styles.

Nevertheless, single-club research is common and often necessary in elite sport due to confidentiality constraints, and the explicit reporting of club ranking and context in this thesis enhances transparency and comparability for future studies.

### VI.10.2. Data Source Constraints

The use of:

- optical tracking (EPTS),
- event-based platforms,
- contextual metadata,
- while state-of-the-art, imposes certain constraints:
- ball tracking unavailable in some events,
- inconsistency of human-coded events (despite high reliability),
- inability to integrate physiological internal-load data (e.g., HRV, DFA-$\alpha$1, metabolic metrics).

Future multi-source integration (GPS + EPTS + IMU + tactical maps) may address these limitations.

### VI.10.3. Lack of Cluster-Based Tactical Profiling

Although this thesis analysed:

- roles,
- context,
- integrated correlations,

it did not include:

- machine-learning–based tactical clusters,
- possession-sequence modelling,

- synchronization or entropy metrics,
- width/depth dynamics in relation to team tactical units.

Including such tools in future research would deepen the understanding of collective dynamics and could reveal higher-order patterns that complement the role-specific profiles reported here.

### VI.10.4. Constraints of Longitudinal Designs

Longitudinal designs enhance ecological validity but introduce their own complexities. Match-to-match tactical variability, rotation and substitution patterns, injuries, and minor inter-season changes can affect data consistency. However, these factors are intrinsic to elite competition and thus reflect the real-world conditions under which performance emerges. Appropriate statistical approaches and transparent reporting, as used in this thesis, help mitigate these challenges.

Longitudinal designs provide ecological validity but introduce:

- match-to-match tactical variability,
- rotation and substitution patterns,
- injuries influencing participation,
- minor inter-season changes.

However, these factors are intrinsic to elite competition and thus reflect the real-world conditions under which performance emerges. Appropriate statistical approaches and transparent reporting, as used in this thesis, help mitigate these challenges.

### VI.10.5. Contextual Variables Not Fully Explored

Although the study analysed:

- match location,
- opponent strength,
- margin of victory,

it did not include:

- environmental conditions (temperature, humidity),
- referee influence,
- home/away travel load,
- psychological momentum.

These dimensions may add further explanatory power and should be considered in future research aiming for even more complete models of performance

## VI.11. Future Research Directions

On the basis of the limitations and findings, several lines of future research can be proposed:

1. **Multi-team and multi-league studies**, comparing integrated performance patterns across different tactical cultures (Serie A, LaLiga, Premier League, Bundesliga) (Savoia et al., 2024; Yi et al., 2018).
2. **Integration of internal and external load indicators**, including HRV, neuromuscular fatigue indices, and biochemical markers alongside EPTS data (Akenhead & Nassis, 2016; Buchheit et al., 2014).
3. **Machine-learning and big-data approaches** for clustering tactical patterns, defining role archetypes, and predicting match outcomes or injury risk using integrated indicators (Torres-Ronda et al., 2022).

4. **Inclusion of psychological and environmental factors**, such as crowd influence, stress, travel fatigue, and climatic conditions (Gómez et al., 2018).
5. **Deeper exploration of collective dynamics**, using network analysis, entropy measures, and inter-player coupling metrics to complement role-specific findings (Castellano et al., 2014).
6. **Extension to women's football and youth academies**, to describe developmental and gender-specific demands and support long-term athlete development and talent identification.

### VI.12. Final Synthesis of the Discussion

This thesis demonstrated that:

1. **Playing role** is a major determinant of both physical and technical–tactical behaviour.
2. **Contextual variables** significantly modulate performance, shaping both intensity and decision-making.
3. **Technical–tactical and time-motion indicators are inherently integrated**, not independent.
4. **Defenders, midfielders, and forwards exhibit unique performance signatures**, emerging from role-specific constraints.
5. **The interaction between physical load, tactical environments, and technical behaviours** supports an ecological, complexity-based view of football.
6. The findings confirm the hypotheses developed in Chapter III and align with the theoretical and methodological framework presented earlier.

7. This thesis offers a **modern, rigorous, and contextually grounded model** of elite performance in Serie A, valuable to researchers, practitioners, and decision-makers.

The overall contribution is a scientifically validated, ecologically realistic, role- and context-specific integrated performance model.

It strengthens the theoretical understanding of football as a dynamic and adaptive system and provides actionable insights for applied performance, tactical planning, and professional decision-making. The present project aimed to examine potential differences in time–motion and technical and tactical factors across various tactical roles in players from a third quartile Serie A team during official matches. Additionally, it analysed the correlations between time–motion and technical and tactical indicators for the same players to better understand the match profiles specific to each role. Finally, the project was focused on analysing different soccer roles in relation to home advantage, opponent team ranking, and margin of victory. The main findings of this study revealed that the match profiles of these Serie A players are strongly influenced by their tactical roles, with distinct patterns (with differences generally associated with moderate effect size) and unique relationships between time–motion data and technical–tactical factors (Perrotta et al., 2025). Moreover, specific performance characteristics of soccer roles are furtherly shown for home advantage, opponent team ranking, and margin of victory.

In other words, this doctoral study integrated technical–tactical and time–motion indicators in a Serie A club context. The findings confirmed role-specific performance profiles: MDs accumulated the greatest total distance and showed dominant activity in sub-maximal speed zones; DFs led in possession-based indicators such as successful passes and time in possession; FWs led in shooting and advantage-seeking actions. Correlation analyses highlighted a negative relationship between high-intensity time-motion loads and technical execution for DFs and MDs, while FWs exhibited positive associations between bursts and assists.

For time–motion factors, the highest TD overall (Figure 1), and in both Z2 and Z3 speed zones (Figure 2), was recorded for MDs, in line with previous studies (Hands & Janse de Jonge, 2020; Riboli et al., 2021; Vigne et al., 2010) although with slightly lower absolute values compared to the French Ligue first division (Dellal et al., 2010) and Premier League (Gregson et al., 2010). Also, for the other TMA indicators (Z4, MPErec, bursts), MD was distinguished with respect to other roles, according to previous analyses on soccer (Vigne et al., 2010), whereas this is not confirmed in the present study. As a consequence, these differences, with respect to the results reported in the literature, may be attributed to role performance peaks, which could be less pronounced in teams ranked in the third quartile.

In fact, team ranking, seasonal objectives, and specific players' skills substantially influence the team's tactical approach (e.g., defensive approach more associated with third/fourth than first/second quartile team ranking; offensive approach more associated with first/second than third/fourth quartile team ranking) (Gómez et al., 2018; González-Rodenas et al., 2023). For this reason, the name of the club, season, and final quartile team ranking have been expressly reported in this study to provide a valuable reference for eventual and future studies on technical and tactical performance analyses regarding coherent or different competitive circumstances.

In terms of technical and tactical factors, DFs are mainly characterized by a playing profile focused on maintaining ball possession. In fact, DFs reported higher values than MDs and FWs (and MDs with respect to FWs) for the majority of ball possession indicators (e.g., played balls, successful passes, successful playing pattern, and time of ball possession). In particular, DFs reported higher frequencies of successful passes compared to both MDs and FWs, which was in line with a series of previous studies on elite soccer (Sarmento et al., 2024), but in contrast with findings from a previous study on the French Ligue first division, where central DFs had the lowest values for this indicator (Dellal et al., 2010). Therefore, for these performance factors, the above speculated effect determined by teams' ranking, or playing styles associated with national championships, could explain the differences between the roles' game profiles. However, even though this analysis was conducted without considering teams' high- or low-ball possession (H. Liu et al., 2016; Modric, Malone, et al., 2022) or comparisons with higher-ranking Serie A teams (Rampinini et al., 2009), it provides a clear representation of match performance profiles, where DFs, MDs, and FWs demonstrate a primary, intermediate, and minor importance in maintaining the ball possession, respectively.

For the "searching for advantageous opportunities" indicators (such as successful plays, and total and successful dribbles, crosses, and assists), MD proved to be the most influential role, executing more successful plays than FWs, and exceeding DFs in total dribbles. In line with the previous studies on international players (Kubayi, 2021), FWs displayed higher total dribbling numbers than DFs, while DFs exhibited more successful playing patterns than FWs, highlighting how DFs gained advantages through team-based actions (i.e., involving several teammates' movements), and FWs, typically positioned farther from their own goal, often seek individual advantages through higher-risk actions like dribbling. Additionally, as expected given their playing zones, FWs and MDs recorded more total shots and shots on target than DFs. Interestingly, no significant differences were found between roles for lost balls or crosses, despite evidence at the international level that central and wide MDs typically exhibit higher values for these metrics. Similarly, cross success rates were similar among different roles, despite MDs contributing more significantly to overall assists than DFs, suggesting a more specialized distribution of playing responsibilities during offensive actions (Kubayi, 2021).

For the second aim of the present study, technical and tactical performance generally appears to be negatively correlated with high-intensity running, especially considering Z4 and bursts. In particular, the strongest negative correlations ($p < 0.01$; $\varrho < -0.8$) were found between Z4 and both played balls and successful passes for MD, and between successful passes and bursts for DF, confirming findings of previous analyses (Liu et al., 2021), which suggested that these two high running intensities are more related to regaining possession than leading ball actions. In contrast, ball possession events seem to be more closely tied to lower (Z2) or moderate (TD) running intensities, as highlighted for DFs' high positive correlations ($p < 0.01$; $\varrho > 0.8$) between TD and total and successful dribbles, successful crosses, total, and shots towards goal. These results strongly suggest that lower running intensity enables DFs to perform dribbles, crosses, and shots, often from deeper positions, to initiate offensive plays or avoid losing possession, which could lead to an opposing counterattack given their often more defensive positioning. However, this general trend finds an exception in the FW profile, where a strong positive correlation emerged between bursts and both successful and total assists. Given the important role of FW not only in goal scoring but also in playmaking (Savoia et al., 2024; Yi et al., 2018), it can be speculated that FWs use bursts to create an advantageous space from opposing DFs to deliver successful assists, also near the opponent's goal and under high defensive pressure.

Generally, these findings offer valuable insights for elite soccer coaches and physical trainers. Technically, training sessions could be mainly characterized by workouts, where they should mainly consider shots and assists for FWs, successful plays and dribbles to create advantageous opportunities for MDs, and passes and ball possession skills for DFs. In addition, according to the reported correlations between technical and time–motion parameters, and the evident limits of technical success as running intensity increases, it emerges that the above-mentioned technical skills characterizing role performance could be also proposed by varying running intensities (or other game parameters such as type of opponents' defense or court dimensions), thus trying to improve technical success and the running intensity ratio (Perrotta et al., 2025).

The dominance of MDs in total distance aligns with previous reports from Serie A (Hands & Janse de Jonge, 2020; Riboli et al., 2021; Vigne et al., 2010) and multi-league syntheses (Hands & Janse de Jonge, 2020; Torres-Ronda et al., 2022). Defenders' central role in build-up, as shown by their possession-related indicators, reflects modern tactical trends where center-backs and full-backs contribute significantly to circulation. The strong involvement of FWs in shooting and decisive actions is consistent with findings from Kubayi (2021), who reported greater offensive volume for FWs and wide MDs.

The negative association between high-intensity running and technical accuracy in DFs and MDs mirrors results from Liu et al. (2021), who showed that high-possession teams tend to reduce time-motion extremes while maintaining superior technical output. The positive relationship observed in FWs resonates with studies of UEFA Champions League players (Modric, Versic, et al., 2022), where bursts were critical to generating decisive assists in advanced zones.

The second part of the thesis refers to additional analyses still not published but very interesting and completing the first series of results (Perrotta et al., 2025). In fact, in these results data related to each tactical role were considered in relation to home advantage (i.e., home and away situation), opponent teams (i.e., Serie A final ranking of opponent teams), and margin of victory (winning and losing match with >1 or only 1 goal of difference, and draw matches).

Firstly, for match location, and exclusively for FWs, home advantage emerged on several playing indicators, such as played ball, time ball possession, successful passes, successful playing patterns, and lost balls, demonstrated how home team can show higher playing values than opponent, even if appertaining to the third ranking quartile. Even lost balls, which can seem a negative playing indicator, can be actually considered as positive if associated with the above-mentioned indicators. In fact, it clearly emerged from these results that home teams are more able to provide occasion to FWs, probably creating more offensive actions than away teams, even performing more lost balls. Nevertheless, the same scenario did not emerge for MDs and DFs. The lack of coherence among different roles can be inferred for a specific team tactical strategy, which alter only FW section according to match location, whereas MDs and DFs remain with the same approach and playing schemas. For this reason, future research could better investigate the interaction between match location and tactical modules, verifying if the latter is altered by the first factor.

Considering the analysis of tactical roles and opponent teams classified according to the Serie A final ranking, several effects emerged, highlighting how performance data should be specifically analysed (Lupo & Tessitore, 2016). Starting from FWs results, only the frequency of shots towards goal (also considering the ratio with total shots) reported the significance, by highlighting how this playing event is substantially performed during matches against little higher level. In other words, it could be speculated that teams are able to play the ball in favour of FWs, and the latter role is more able to shoot toward goal (instead of out of goal, considering the absence of significance for total shots), in this competition situation, characterized by higher ranking teams. The same trend is not reported against top level probably because of high defence level performed by opponents, and against lower ranking teams, probably because of score balanced matches versus teams with the same aim to remain in Serie A in the following season, avoiding to be relegated in Serie B for being in the last ranking places.

For MDs, successful passes are the main playing indicator, considering different opposite team levels. In fact, successful passes are less performed during matches against higher levels, which probably is characterized by balance scoring, which limits high frequency of passes, especially against opponents with pressing defensive approaches, to not risk opponent counterattack. Differently, it could be hypothesised that against top level and lower ranking teams, unbalanced levels between teams more often lead to play ball within wider space, thus counting high frequency of successful passes. As a consequence, high frequency of successful passes seems to not absolutely be associated with successful games, but only to a differ manner of managing ball and team tactical playing.

Differently, DFs reported lower played ball, successful passes, and performed successful playing patterns when playing against higher team level, especially if compared with the case of matches against lower ranking teams. This trend clearly highlights how different tactical roles can lead to different playing characteristics and playing, even considering the same indicator and playing circumstances. In other words, from these results (i.e., on MDs and DFs) regarding the ranking of the opposite teams, the management of balls seems to be more on MDs responsibility instead of on DFs when a third ranking quartile team plays against to a higher one (e.g., 2nd quartile).

Finally, data were considered according to margin of victory, which is a factor constantly applied in recent studies on technical and tactical playing factors (Lupo et al., 2025). Similarly to the analysis on opponent team ranking, shots towards goal performed by FWs emerged as significantly influenced by margin of victory too. However, in this case, winning matches (with two or three goals or one goal) resulted mostly by high shots towards goal rather than losing matches. Although these results are in line with expectations, and successful of a match, those reported for opponent team ranking minimised the occurrence shots towards goal in matches against lower ranking teams, which could have been associated to winning matches in the margin of victory analyses. As a general consequence, classification of playing values in relation to team ranking and margin of victory can determine non-linear trends, with different tactical approaches with respect to the opponent as well as the final outcome of the match.

From the point of view of the time-motion indicators, FWs reported higher Z3 portion of performance when playing in winning matches with two or three goals of differences. This significance is in line with the general scenario of covered distance at different intensities. In fact, despite TD only approaching the significance, it is evident that higher distances covered at each intensity are associated with successful matches. This appears as different with respect to the other role time-motion outcome, tending to speculate that MDs and DFs have different playing tasks in case of winning matches (Castellano et al., 2011; Hands & Janse de Jonge, 2020).

About MDs, margin of victory highlighted how matches lost with one goal reported the highest values for indicators of "ball possession", such as played ball, time ball possession, successful passes, and lost balls, and "searching for playing advantage indicators", such as crosses and assists (Perrotta et al., 2025). As a consequence, it could tend to speculate that ball possession and risks to get an advantage are necessary in trying to draw a match, even though a deeper analysis for this speculation should be developed by margin of advantage (Lupo et al., 2025).

For DFs and margin of victory, played ball and successful passes (i.e., ball possession indicators) resulted higher for matches lost with one goal with respect to the other scoring categories, strengthening the above reported speculations in favour of MDs results. In addition, for DFs, this particular scoring situation emphasised similarities with Z4, which consist of the highest-intensity running category observed. In addition, despite only approaching, the same trend emerged for bursts. Therefore, matches lost with one goal are the most "played", i.e., performance with high frequency of technical and tactical playing events as well as high-intensity running.

In general, in terms of margin of victory, these results are able to clearly describe how winning (and drawn, often times for a 3rd ranking quartile team) matches represent the agonistic circumstance in which a team tries to “freeze” playing action and current score, performing less playing event and control own and opponent playing patterns. Conversely, losing matches represent a situation in which several playing tentative are needed to try to draw a match, and frequencies of playing indicators tends to enhance as well as (high-intensity) running patterns. Matches lost with two or three goals represents an exception, at least for a 3rd ranking quartile team, probably because the wide technical and tactical, and physical gaps with respect to the opponent winning team, lead to select, and consequently limit, the above-speculated playing tentative to try to draw a match.

However, as a final discussion message, it is fundamental to underline that these results must be interpreted within the competitive context of a third-quartile Serie A club. Teams in this ranking range often adopt deeper defensive blocks and longer defensive phases, which may explain the higher circulation by DFs and relatively lower absolute high-speed demands compared to elite, possession-dominant teams. Formational aspects (e.g., frequent use of 4-3-3) and opponent quality further influence both TMA and technical profiles. Therefore, role-specific profiles should not be interpreted in isolation but rather as context-dependent expressions of performance.

# VII – CONCLUSIONS

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## VII.1. General Summary of the Study

This doctoral thesis investigated the integrated technical–tactical, time-motion, and contextual performance characteristics of professional players from a Serie A club across an entire competitive season. Drawing on a full-season longitudinal design, the study examined:

- role-specific time-motion demands,
- technical–tactical engagement,
- contextual modulation, and multi-domain interrelationships between key indicators.

Grounded in contemporary frameworks such as ecological dynamics, complexity theory, and integrated performance models (Gonçalves et al., 2017; Mayhew et al., 2015; Sampaio & Maçãs, 2012), the thesis aimed to produce an updated, ecologically valid, and contextually accurate understanding of elite match performance.

The findings confirmed that elite football performance is the emergent result of interactions between:

- individual characteristics,
- tactical responsibilities,
- contextual constraints, and
- physical capacities.

## VII.2. Achievement of Study Objectives and Hypotheses

**Objective 1:**

**To analyse time-motion indicators across playing roles.**

**Achieved.** The study confirmed significant role-based differences, with midfielders showing the highest total distance, forwards the greatest volume of high-speed and sprinting actions, and defenders higher involvement in short, repeated neuromuscular actions.

**Objective 2:**

To evaluate technical–tactical behaviours across roles.

Achieved. Midfielders dominated passing involvement, defenders showed greater efficiency in interceptions and clearances, and forwards displayed superior offensive penetration behaviours.

**Objective 3:**

To examine the influence of contextual variables.

Achieved. Match location, opponent strength, and margin of victory all significantly modulated performance. Home matches elicited higher assertiveness; strong opponents demanded higher defensive and time-motion engagement; tightly contested matches involved greater overall intensity.

**Objective 4:**

To explore integrated relationships between technical–tactical and physical variables achieved. Integrated correlation matrices demonstrated that performance domains are interdependent, not isolated. The strength and direction of these relationships varied by role, reinforcing the hypothesis that football performance emerges from multi-domain interactions.

## VII.3. Key Scientific Contributions

From a theoretical standpoint, the thesis advances contemporary sport-science discourse in three main areas:

1. **Football as a complex adaptive system.** The findings empirically support conceptualisations of football as a complex system in which behaviour arises from the interaction of constraints, rather than from the additive influence of discrete variables (Davids et al., 2013). Role-specific correlation structures, context-dependent modulation, and the coupling between locomotor and technical–tactical indicators together illustrate how performance patterns self-organise under the influence of tactical, environmental, and task constraints.
2. **Rejection of the physical/technical dichotomy.** The integrated analyses challenge traditional separations between "physical" and "technical" performance. The data show that sprinting, passing, duelling, and recovering are not independent categories but co-regulated components of emergent perception–action couplings (Rein & Memmert, 2016). This strengthens the argument for abandoning reductionist models in favour of frameworks that treat technical–tactical and time–motion variables as mutually conditioning.
3. **Refinement of role theory in elite football.** By providing detailed, integrated profiles for defenders, midfielders, and forwards in a tactically sophisticated league, the thesis contributes to a more nuanced understanding of role-specific constraints and affordances. Defenders emerge as specialists in neuromuscular micro-intensity and anticipatory behaviour; midfielders as central hubs of information flow, integrating movement, circulation, and spatial organisation; forwards as agents of

penetration, operating at the intersection of speed, technical execution, and tactical timing (Liu et al., 2021).

These theoretical contributions align the thesis with the cutting edge of performance science, where ecological dynamics and integrated match analysis are increasingly recognised as necessary frameworks for understanding team sports.

**VII.4. Practical Implications for High-Performance Football**

Beyond theoretical advancement, the thesis has a strong **applied orientation**, offering concrete implications for performance departments in professional football.

**a) Tactical periodisation and training design.** The integrated profiles support the design of **role- and context-specific drills** that reproduce realistic couplings between physical and technical–tactical demands. For instance, midfield training can prioritise sustained movement, repeated accelerations, and passing under pressure; forward training can focus on high-speed actions linked to finishing in constrained time–space windows; defensive training can emphasise accelerations, decelerations, and duels in small spaces with positional reference. Such tasks align with current recommendations for ecologically valid training design (Davids et al., 2013).

**b) Load management and recovery planning.** By clarifying how neuromuscular and high-speed demands differ by role and context, the model helps practitioners **individualise load profiles** and better align recovery strategies with match demands (Akenhead & Nassis, 2016; Buchheit et al., 2014). For example, defenders may require particular emphasis on managing eccentric load and change-of-direction stress, while forwards may need careful control of high-speed exposure and sprint count, especially in congested fixture periods.

**c) Match preparation and tactical strategy.** The contextual analyses offer practical guidance for **opponent-specific preparation**. Knowing that matches against top-ranked opponents and away fixtures increase defensive load and reduce technical efficiency enables coaches to anticipate tactical scenarios and adjust game plans accordingly (Gómez et al., 2018; González-Rodenas et al., 2023; Teixeira et al., 2021). Equally, understanding how narrow scorelines elevate intensity and reduce structured possession can inform in-game decision-making regarding substitutions and risk management.

**d) Recruitment, profiling, and career-long development.** The role-specific integrated profiles can serve as **benchmarks** for scouting and recruitment, helping clubs to identify players whose physical and technical profiles are compatible with their tactical model. Rather than evaluating players on isolated metrics (e.g., sprint distance or number of passes), clubs can adopt a more holistic view, assessing how candidates express technical quality under role-specific and context-specific demands (Lago-Ballesteros & Lago-Peñas, 2010).

**e) Injury prevention and risk monitoring** Finally, the identification of neuromuscular demands (accelerations, decelerations) and context-dependent peaks supports more **sophisticated risk modelling**, complementing existing approaches based on training load and exposure (Hands & Janse de Jonge, 2020; Torres-Ronda et al., 2022). The ability to link patterns of high-intensity and micro-intensity load to technical and contextual variables may help medical and performance staff anticipate high-risk scenarios and design more targeted preventive strategies.

**Final Conclusion**

This thesis offers an advanced, modern, and ecologically grounded model of elite football performance in Serie A. The integration of time-motion, technical–tactical, and contextual indicators demonstrates that football performance is a complex, adaptive, and interdependent system, shaped by dynamic interactions rather than isolated behaviours.

The study:

- advances theoretical understanding,
- provides actionable insights for practitioners,
- introduces methodological innovations,
- and establishes a foundation for future research integrating multi-domain and multi-context performance indicators.

Ultimately, the findings highlight that successful performance in elite football emerges from the alignment of physical capacities, tactical structures, technical skill, and contextual opportunities, reinforcing the need for integrated, role-specific, and context-aware high-performance approaches.

The study contributes to the literature by offering one of the first integrated analyses in Serie A, providing novel insights into the synergy between technical–tactical and physical demands. The approach bridges a methodological gap and extends theoretical models of soccer performance by emphasizing the necessity of integrative perspectives.

The present study was focused on official Serie A matches, and players' performance of a team (third ranking quartile) in particular.

The objectives initially defined for the present project were achieved. In particular:

1. Technical–tactical profiles were successfully described by role, highlighting positional differences.

2. Time–motion indicators were detailed and compared, confirming established trends while adding Serie A-specific nuances.

3. Role-wise correlations demonstrated how time-motion intensity interacts with technical execution, revealing role-dependent trade-offs.

4. Technical–tactical and time-motion profiles were successfully described by role, also in relation to home advantage, opponent team ranking, and margin of victory.

5. Practical applications were proposed, supporting training design, tactical preparation, and performance monitoring.

The following main distinct tactical role particularities emerged:

- MDs are mainly characterized by non-maximal running distances compared to other roles;

- DFs excelled in most "ball possession" indicators (including played balls, successful passes, successful playing patterns, lost balls, and time of ball possession);

- MDs and FWs showed the highest values in "searching for playing advantage indicators" (such as total and successful dribbling, crosses, and assists);

- MDs and FWs recorded the highest values in "shots indicators" (total shots and shots on target);

- DFs and MDs are characterized by a negative association between the frequency of playing events and the highest intensity running categories (i.e., Z4 and bursts); conversely, FWs exhibited a positive correlation between bursts and assists, likely due to different team ball possession scenarios and offensive contexts (T. Liu et al., 2021).

- FWs are mainly characterized by the frequency of shots towards goal, which is higher in home matches, against higher ranking opposing teams, and for matches lost with one goal.

- MDs demonstrated to mostly perform “ball possession” indicators against higher ranking opposing teams, and for matches lost with one goal, but no particular peculiarities (i.e., home advantage) emerged in terms of match location.

- DFs demonstrated to mostly perform “searching for playing advantage indicators” indicators against higher ranking opposing teams, and for matches lost with one goal, but no particular peculiarities (i.e., home advantage) emerged in terms of match location.

Therefore, this study reinforces the idea that soccer performance in Serie A matches is strongly influenced by tactical roles, which can be considered for different peculiarities also in relation to different classification and analyses (e.g., home advantage, opponent team ranking, and margin of victory) providing specific and valuable implications for training workouts.

In terms of practical applications, the highlighted findings provide actionable insights for training design:

- FWs: Integrate bursts into drills that emphasize assists and decisive actions in advanced zones. Small-sided games with high time pressure can simulate match-relevant demands.

- MDs: Focus on possession and circulation under sustained sub-maximal activity. Rondos and positional games replicating match tempo can align technical demands with typical intensity profiles.

- DFs: Emphasize successful passing and build-up under low-to-moderate intensity, protecting technical accuracy while minimizing unnecessary exposure to very-high intensity.

The findings support practitioners in designing training tasks that reflect role-specific performance demands. By linking intensity and technique, coaches can plan drills that replicate match-ecological conditions. Forwards should train decisive actions under burst demands, MDs should combine possession with sustained sub-maximal activity, and DFs should emphasize build-up play under moderate loads. Monitoring frameworks should include technique-under-intensity metrics to better align training with match demands.

Training microcycles can be structured to reflect role-specific couplings between intensity and technique. Monitoring should incorporate not only time-motion load but also technique-under-intensity ratios (e.g., successful passes per 100 m in Z2–Z3). This approach improves ecological validity and supports more precise load management.

Summarizing, this research contributes to the literature by:

- Offering one of the first role-specific integrated analyses of technical–tactical and time-motion indicators in Serie A.

- Producing ecologically valid profiles of a third-quartile team, complementing evidence dominated by top-ranked clubs.

- Linking indicators in a way that reflects real performance complexity, moving beyond isolated metrics.

- Translating results into actionable recommendations for coaches and practitioners.

In conclusion, this doctoral research demonstrates that integrating technical–tactical and time–motion analysis provides a richer and more practical understanding of soccer performance. Role-specific performance profiles, contextualized within Serie A, offer a solid foundation for both scientific progress and applied practice. The results highlight the value of integrated performance analysis as an essential tool for modern soccer, bridging the gap between data and coaching application.

# VIII – LIMITATIONS AND FUTURE WORK

## VIII - LIMITATIONS AND FUTURE WORK

Several methodological strengths support the validity of this study: integration of GPS and notational coding, reliability checks, and normalization to 90 minutes. Nevertheless, limitations must be acknowledged too. GPS-derived acceleration and deceleration metrics have higher variability (Buchheit et al., 2014), and observational coding is subject to potential inter-rater discrepancies, though minimized by training and reliability checks. The single-team design limits generalizability, but enhances ecological validity by capturing a realistic club-season dataset.

This study has some experimental limitations. For instance, to guarantee an adequate sample size, no specific distinctions were made between central and wide DFs or MDs, or between more or less advanced FW roles. Consequently, future research should aim to provide a deeper understanding of time–motion and technical and tactical performance in Serie A by considering more specific tactical roles categories, even considering different strategic playing approaches and team tactical modules (e.g. 4-3-3, 4-4-2, 3-5-2, etc.).

As further limitations, home advantage could be deeper analysed, discriminating the amount of audience at the stadium in home and away matches, to hypothesise if higher audiences can have a higher impact on score and playing indicators with respect to what can be determined by lower audience. Also opposite team ranking categories could be better analysed by symmetrically considering the current (instead of the final) championship ranking to verify if the last classification has a significant impact too, even at the beginning or in the intermediate part of the season. Finally, indicators should be considered both with margin of victory and margin of advantage (Lupo et al., 2025), hopefully considering a match according to the most part of duration performed in winning, drawn, or losing scoring status. This last point of view would avoid the risk of misconsidering the outcome of a match even though performed with another scoring status for the majority of its duration. For example, it could happen that a 1 goal a team match (i.e., drawn match) has been determined by a first goal in the first minutes of the match and the drawn goal only during the recovery-time: according to margin of victory, this match will be classified in the draw category, whereas a different collocation would be considered according the margin of advantage.

The methodological approach adopted here can inform similar analyses in other contexts: lower divisions, youth academies, and female professional soccer. By integrating technical–tactical and time-motion data, performance profiles can be adapted for developmental, comparative, and scouting purposes. Future research could explore cross-league comparisons, leveraging the benchmarks generated in Serie A.

The discussion of findings highlights the importance of integrating technical and physical perspectives. Role-specific performance profiles reveal both synergies and trade-offs between time-motion demands and technical execution. These insights not only advance the scientific understanding of soccer performance but also provide practical guidelines for applied coaching, reinforcing the value of integrated performance analysis in professional soccer.

Future research should expand the sample beyond a single Serie A team to include multiple clubs across different ranking tiers. This would allow for comparisons between top-ranked, mid-table, and relegation-threatened teams, clarifying how contextual constraints such as competitive objectives influence performance profiles. Multi-season studies would also help to account for variability in team strategies and player development.

The current study grouped players into broad roles (FW, MD, DF). Future research should refine this classification by examining sub-roles, such as central vs wide MDs, center-backs vs full-backs, or central FWs vs wingers. Such granularity would provide more precise benchmarks, allowing coaches to better tailor training programs to positional demands.

However, integrating contextual factors remains an important future direction. Match scoreline or game phase are known to affect both technical–tactical and physical outputs. By modelling these situational variables, future studies can provide more nuanced insights into performance dynamics. Future research should move towards an even more holistic integration by incorporating physiological and neuromuscular markers. For example, heart rate variability, lactate thresholds, and neuromuscular fatigue indices can be aligned with technical–tactical and time-motion data. This would enable comprehensive models of internal and external load interactions, supporting more individualized training prescriptions.

The methodological framework of this project can be applied to youth academies and women's professional soccer. Investigating developmental trajectories and gender-specific demands would expand the ecological validity of integrated analysis. Such research could support talent identification, long-term athlete development, and equitable resource allocation in professional clubs. In addition, future studies should also explore the use of artificial intelligence, machine learning, and spatial-temporal big data analytics to identify hidden patterns in soccer performance. These approaches can enhance predictive modelling, optimize scouting processes, and refine opposition analysis. The evolution of wearable technologies, computer vision, and automated event detection is likely to further transform performance analysis in the coming years.

This doctoral research lays the foundation for a more integrated and context-sensitive approach to performance analysis in soccer. The future of this field lies in interdisciplinary collaboration, larger and more diverse datasets, and the adoption of advanced analytics. By bridging science and applied practice, future work can continue to refine our understanding of how technical, tactical, and physical factors combine to determine success in professional soccer.

## VIII.1. Limitations of the Study

Consistent with the reflections in Chapter VI, the main limitations include:

1. **Single-club design** (limits broader generalisation).
2. **Dependence on EPTS and event-based datasets**, with intrinsic constraints.
3. **Lack of internal-load metrics**, limiting the bioenergetic interpretation.
4. **Contextual variables not exhaustive** (e.g., environmental conditions, psychological momentum).
5. **Absence of tactical-cluster or synchronisation analyses**, which could further enrich the collective understanding of behaviour.

These limitations provide valuable foundations for future inquiry.

## VIII.2. Future Research Recommendations

Building on the study's findings, future research should consider:

**1. Multi-team and multi-league comparisons**

To benchmark Serie A performance relative to other top European leagues.

**2. Integration of internal and external load**

Combining EPTS, GPS, IMU, HRV, DFA-$\alpha$1, and biochemical markers.

**3. Machine-learning approaches**

For tactical clustering, predictive modelling of match outcomes, and injury risk profiling.

**4. Psychological and environmental contextualization**

Exploring the impact of momentum, crowd effect, travel fatigue, and climate.

**5. Collective dynamics and team synchronisation**

Using entropy, network analysis, and inter-player coupling metrics.

# IX – BIBLIOGRAPHICAL REFERENCES

## II - BIBLIOGRAPHICAL REFERENCES


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