The Beautiful Game Unveiled – The Influence of Tactical Factors on Soccer Match Performance

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The Beautiful Game Unveiled

–

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Summary

Soccer generates great interest from spectators and the media, cementing its place as one of the most riveting and influential cultural phenomena of our time. Similarly, professional soccer has also generated scientific interest in the recent past. Through the systematization of data collection in professional soccer, the quantity of available data has increased considerably in recent years. This development has led to a better quantification of the individual aspects of performance and thus to deeper insights into the performance structure of soccer.

When describing the match performance of professional soccer players, it becomes evident that a variety of contextual factors have an impact on their performance. Examples of such contextual factors are the current scoreline or the quality of the opponent. Furthermore, also the tactical context (i.e. tactical factors) influences the match performance of professional players. These tactical factors include, for example, the position of a player or the tactical formation of a team. Studies analyzing the playing position or the tactical formation already indicate that tactical factors influence match performance. However, the current state of the literature does not cover all relevant questions on the influence of tactical factors on match performance. In detail, research questions that have not yet been sufficiently addressed concern changes in tactical formation during the match or the magnitude of the influence of tactical factors on match performance. Therefore, the aim of this thesis is the tactical contextualization of the match performance in professional soccer using the German Bundesliga as an example.

To gain an overview of the multitude of factors influencing match performance, a model of the individual complex match performance in professional soccer was developed. In detail, this model features the components of match performance (e.g. physical, technical, tactical-cognitive, and psychological) and factors influencing the match performance (e.g. Organism [Internal Factors] and Environment [External Factors]). Based on this model approach, questions and hypotheses were derived and investigated in *Papers I* to *VI*. First, a systematic review was conducted (*Paper I*), which summarized the existing literature on the influence of tactical formations on match performance in soccer. Based on this, three major research gaps were identified (*Identified Research Gaps I* to *III*), which subsequently were addressed by five original studies (*Papers II* to *VI*). All original studies were conducted using data from the German Bundesliga. Match performance was mainly investigated in technical (e.g. number of

passes) and physical (e.g. sprint distance) aspects. Additionally, variables linked to success were examined (e.g. goals). Tactical contextualization was conducted via the use of various tactical factors, such as playing position (e.g. central defender), tactical formation (e.g. 3-5-2), and offensive playing style (e.g. ball-possession style).

The results of the systematic review (*Paper I*) revealed that tactical formation influences match performance in soccer. At a team level, physical performance was lower in formations with a back four (e.g. 4-4-2) than in formations with a back three (e.g. 3-5-2). At an individual level, the physical match performance of all positions was influenced to a similar extent by tactical formation. Furthermore, aspects concerning the methodological approaches of existing literature were identified. Firstly, formation changes occurring during matches were not considered by the included studies. Consequently, this methodological aspect was investigated in the original studies in *Identified Research Gap I – In-game Formation Changes*. Secondly, the studies included in the review used only small samples (i.e. 16 to 61 matches) and mostly distinguished only two or three different tactical formations. Therefore, the original studies in *Identified Research Gap II – Influence of Formation/Individual* are dedicated to this issue. Finally, the influence of tactical factors on match performance in soccer was substantiated by the results of the systematic review. On this basis, the original study in *Identified Research Gap III – Influence of Playing Style* examined another tactical factor, namely offensive playing style, and its influence on match performance.

The studies in *Identified Research Gap I – In-game Formation Changes* (*Paper II* and *Paper III*) were able to reveal that in 30-43% of the games investigated, a change of formation took place during the match. Furthermore, most formation changes occurred in the second half (85-95%). However, the situations in which a formation change during a match was observed differed depending on the coach.

The studies in *Identified Research Gap II – Influence of Formation/Individual* (*Paper IV* and *Paper V*) identified major differences in match performance between different tactical formations for central defenders, wide defenders, and wide midfielders. For example, central defenders in formations with a back three (e.g. 3-4-3 or 3-5-2) were more physically demanded than in other formations (e.g. sprinting distance). However, the differences in match performance between formations were smaller for central midfielders and forwards. Moreover, there were large interindividual differences in the way the tactical factors (i.e. tactical formation and playing position) influenced the match performance of a player.

Finally, the study in *Identified Research Gap III – Influence of Playing Style* (*Paper VI*) revealed that the offensive playing style (i.e. ball-possession or counter-attacking style) significantly influenced technical and physical match performance. For example, teams emphasizing a ball-possession style (i.e. compared to a counter-attacking style) played more horizontal passes and revealed a better passing success rate. However, variables linked to success (e.g. goals) were only influenced to a small extent by the offensive playing style.

In summary, the results of the studies included in this thesis highlighted the marked influence of tactical factors (e.g. playing position, tactical formation, playing style) on match performance in professional soccer. Accordingly, the consideration of tactical factors is important regarding the description and evaluation of match performance. Furthermore, the included investigations also generated relevant information for future research (e.g. consideration of formation changes during the game). With the implementation of the newly generated information, future studies can produce research results that are more robust and comparable, thereby contributing to important scientific progress. Concluding, this thesis provided information leading to a more differentiated view of the match performance in professional soccer and, therefore, comprised crucial information for researchers and practitioners. Nevertheless, one should consider match performance in soccer as a highly complex construct. Hence, due to the diversity of different influencing factors, it is hardly possible to explain match performance to the fullest extent. Therefore, this thesis is intended to be a module of the research work aiming to explain match performance in professional soccer to an increasing extent.

Zusammenfassung

Fußball stößt auf großes Interesse bei Zuschauern und Medien und ist deshalb eines der fesselndsten und einflussreichsten kulturellen Phänomene unserer Zeit. Gleichermaßen hat der Profifußball in der jüngsten Vergangenheit auch wissenschaftliches Interesse geweckt. Durch die Systematisierung der Datenerhebung im professionellen Fußball, konnte die Quantität an verfügbaren Daten in den zurückliegenden Jahren erheblich gesteigert werden. Aufgrund dieser Entwicklung konnte die Spielleistung im professionellen Fußball in verschiedenen Aspekten besser quantifiziert werden und dadurch tiefere Einblicke in die Leistungsstruktur ermöglicht werden.

Bei der Beschreibung der Spielleistung im professionellen Fußball fällt auf, dass diese Leistung von einer Vielfalt an kontextuellen Faktoren beeinflusst wird. Beispiele für derartige kontextuelle Faktoren sind der aktuelle Spielstand oder die Qualität des Gegners. Darüber hinaus beeinflussen auch taktische Faktoren die Spielleistung. Zu diesen taktischen Faktoren gehören beispielsweise die Position eines Spielers oder die taktische Formation einer Mannschaft. Studien, die die Position oder die Formation untersuchen, weisen bereits darauf hin, dass taktische Faktoren die Spielleistung beeinflussen. Allerdings deckt der aktuelle Forschungsstand nicht alle relevanten Fragestellungen zum Einfluss von taktischen Faktoren auf die Spielleistung ab. Bei den noch nicht ausreichend erforschten Fragestellungen geht es beispielsweise um Wechsel der taktischen Formation während des Spiels oder das Ausmaß des Einflusses taktischer Faktoren auf die Spielleistung. Deshalb besteht das Ziel der vorliegenden Arbeit in der taktischen Kontextualisierung der Spielleistung im professionellen Fußball anhand der Deutschen Bundesliga.

Um einen Überblick über die Fülle an Faktoren zu erhalten, die die Spielleistung beeinflussen, wurde ein Modell zur individuellen komplexen Spielleistung im professionellen Fußball entwickelt. Dieses Modell umfasst die Komponenten der Spielleistung (z. B. physisch, technisch, taktisch-kognitiv und psychologisch) und die Faktoren, die die Spielleistung beeinflussen (z. B. Organismus [Interne Faktoren] und Umwelt [Externe Faktoren]). Auf Basis dieses Modellansatzes wurden Fragestellungen und Hypothesen abgeleitet, die in den *Papern I* bis *VI* bearbeitet wurden. Zunächst wurde ein systematisches Review erstellt (*Paper I*), welches die bestehende Literatur zum Einfluss von taktischen Formationen auf die Spielleistung im Fußball zusammenfasst. Darauf aufbauend wurden drei wesentliche Forschungslücken identifiziert (*Identified Research Gaps I* bis *III*), die durch fünf

Originalstudien (*Paper II* bis *VI*) adressiert wurden. Alle originalen Studien wurden mit Daten aus der Deutschen Fußball-Bundesliga durchgeführt. Die Spielleistung wurde dabei hauptsächlich in technischen (z.B. Anzahl der Pässe) und physischen (z.B. Sprintdistanz) Aspekten untersucht. Darüber hinaus wurden ebenfalls mit Erfolg verknüpfte Variablen untersucht (z.B. Tore). Die taktische Kontextualisierung wurde durch vielfältige taktische Faktoren wie Spielposition (z.B. Innenverteidiger), taktische Formation (z.B. 3-5-2) und offensiver Spielstil (z.B. Ballbesitzstil) umgesetzt.

Die Ergebnisse des systematischen Reviews (*Paper I*) zeigten, dass die taktische Formation die Spielleistung im Fußball beeinflusst. Auf Teamebene legten die Ergebnisse nahe, dass die physische Spielleistung in Formationen mit Viererkette (z.B. 4-4-2) niedriger ist, als in Formationen mit Dreierkette (z.B. 3-5-2). Auf individueller Ebene zeigte sich, dass die physische Spielleistung aller Positionen in ähnlichem Ausmaß von der taktischen Formation beeinflusst wird. Weiterführend wurden methodische Aspekte in der bestehenden Literatur identifiziert, die in der Folge Beachtung finden sollen. Zum einen wurden Formationswechsel, die während des Spiels stattfanden, nicht berücksichtigt. Diesen Aspekt untersuchen die Originalstudien in *Identified Research Gap I – In-game Formation Changes*. Zum anderen nutzten die im systematischen Review inkludierten Studien nur kleine Stichproben (d.h. 16 bis 61 Spiele) und unterschieden zumeist nur zwei oder drei taktische Formationen. Diesem Thema widmen sich die Originalstudien in *Identified Research Gap II – Influence of Formation/Individual*. Abschließend wurde durch Ergebnisse des systematischen Reviews der Einfluss von taktischen Faktoren auf die Spielleistung im Fußball untermauert. Auf dieser Basis untersucht die Originalstudie in *Identified Research Gap III – Influence of Playing Style* einen weiteren taktischen Faktor, namentlich den offensiven Spielstil, auf dessen Einfluss auf die Spielleistung.

Die Untersuchungen in *Identified Research Gap I – In-game Formation Changes* (*Paper II* und *Paper III*) konnten zeigen, dass in 30-43% der untersuchten Spiele ein Formationswechsel während des Spiels stattfand. Dabei wurden die meisten Formationswechsel in der zweiten Halbzeit beobachtet (85-95%). Darüber hinaus unterschieden sich die Situationen, in denen ein Formationswechsel während des Spiels stattfand, je nach Trainer.

Die Studien in *Identified Research Gap II – Influence of Formation/Individual* (*Paper IV* und *Paper V*) identifizierten große Unterschiede in der Spielleistung zwischen verschiedenen taktischen Formationen für Innenverteidiger, Außenverteidiger und äußere Mittelfeldspieler.

Beispielsweise waren Außen- und Innenverteidiger in Formationen in einer Dreierkette (z.B. 3-4-3 oder 3-5-2) körperlich stärker gefordert als in anderen Formationen (z.B. Sprintdistanz). Die Unterschiede in der Spielleistung zwischen Formationen waren dagegen für zentrale Mittelfeldspieler und Stürmer geringer. Zusätzlich wurden große interindividuelle Unterschiede hinsichtlich der Art und Weise, wie die taktischen Faktoren Formation und Position die individuelle Spielleistung beeinflusste, beobachtet.

Zuletzt konnte die Studie in *Identified Research Gap III – Influence of Playing Style* (*Paper VI*) zeigen, dass der offensive Spielstil (d.h. Ballbesitz- oder Konterstil) die technische und physische Spielleistung deutlich beeinflusst. Beispielsweise spielten Mannschaften, die einen Ballbesitzstil akzentuieren (d.h. im Vergleich zu Mannschaften, die einen Konterstil spielen), mehr horizontale Pässe und weisen eine bessere Passquote auf. Mit Erfolg verknüpfte Variablen (z.B. Tore) wurden dahingegen nur zu einem geringen Ausmaß vom offensiven Spielstil beeinflusst.

Zusammenfassend heben die Ergebnisse der in dieser Thesis inkludierten Studien hervor, dass taktische Faktoren (z.B. Position, Formation, Spielstil) die Spielleistung im professionellen Fußball erheblich beeinflussen. Demnach ist die Berücksichtigung von taktischen Faktoren bei der Beschreibung und Bewertung von Spielleistungen bedeutsam. Darüber hinaus konnten die inkludierten Studien auch für zukünftige Forschung wichtige Informationen generieren (z.B. Berücksichtigungen von Formationswechseln während des Spiels). Mit der Implementierung der neu generierten Informationen können zukünftige Studien Forschungsergebnisse hervorbringen, die belastbarer und vergleichbarer sind und dadurch zu wichtigem wissenschaftlichem Fortschritt beitragen können. Abschließend liefert diese Thesis wichtige Informationen für Wissenschaftler und Praktiker, die zu einem differenzierteren Blick auf die Spielleistung im professionellen Fußball führen. Es sollte dennoch berücksichtigt werden, dass die Spielleistung im Fußball sehr komplex ist und es, durch die Vielzahl an unterschiedlichen Einflussfaktoren, kaum möglich ist diese in vollem Umfang zu erklären. Diese Thesis soll deshalb ein Baustein der Forschungsarbeit sein, die das Ziel verfolgt die Spielleistung zu einem größtmöglichen Anteil erklären zu können.

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1 General Introduction

1.1 Preface

In addition to its popularity as a leisure activity and sporting event, soccer has become one of the most studied subjects in science (Kirkendall, 2020). Similarly, soccer is undergoing an evolutionary process of professionalization. In detail, due to scientific interest and increasing digitization over the past years, the availability of data in soccer has steadily increased. In scientific research, soccer is being analyzed in increasing depth to unveil the secrets of the beautiful game. For example, in 2016, the Deutsche Fußball Liga [DFL] launched an initiative to improve the availability of high-quality data in professional soccer in Germany. The DFL is the organization taking care of the operational business of the first and second divisions of German soccer. In cooperation with Deltatre (Deltatre, Turin, Italy) the DFL has launched the company Sportec Solutions (Sportec Solutions AG, Unterföhring, Germany), which aims to improve the availability of data in German soccer (Sportec Solutions, 2023). Through such ventures, the availability and accessibility of data on sports have increased, especially in professional soccer.

As mentioned the developments in terms of data availability have made soccer match performance more quantifiable in all aspects. These aspects include physical (i.e. physical demands), technical (i.e. on-ball actions), tactical-cognitive (i.e. decisions and resulting movements of the players), and psychological (i.e. player experience and behavior) parts of the match performance. In detail, concerning physical match performance, professionals cover up to 13 km per match while sprinting 2-3 % of this distance (Dolci et al., 2020; Sarmento et al., 2014; Stølen et al., 2005). Regarding technical match performance, players play 38 passes, head the ball four times, but shoot only once per match on average (Dellal et al., 2011; Liu et al., 2015). From a tactical-cognitive match performance perspective, passes inducing higher disruption in the organization of the opposing team lead to more dangerous attacks (Forcher et al., 2021). However, there are currently no studies on the psychological aspect of the match performance in soccer. In addition to the plain description of the match performance in its various components (e.g. physical, technical, tactical-cognitive, and psychological), there are other facets of the soccer match performance that have already been investigated.

One aspect of the abovementioned facets is different factors that possibly influence the match performance of players. An example of variables affecting match performance is external factors. These external factors include for example the quality of the opponent (e.g. top third of the table vs. bottom third of the table), the match venue (e.g. away vs. home), and the current score (e.g. leading vs. trailing). In detail, playing against weaker teams is associated with a higher percentage of ball possession and, hence, more played passes (i.e. influence on technical match performance) (Lago & Martín, 2007; Lago-Peñas & Dellal, 2010). Furthermore, teams playing at home cover more running distance than those playing away (i.e. influence on physical match performance) (Castellano et al., 2011; Lago et al., 2010; Lago-Peñas et al., 2011). Moreover, players perform less high-intensity actions (e.g. accelerations) when winning compared to when losing (i.e. influence on physical match performance) (Lago et al., 2010; Lago-Peñas et al., 2011). Concluding, external factors influence match performance in soccer.

Besides the mentioned aspects (e.g. quality of the opponent, match venue, and current score), another external factor influencing the match performance of professional soccer players is tactical factors. In detail, tactical factors are predetermined tactical variables (e.g. playing position), that include various classifications (e.g. central defender, wide defender, etc.). Tactical factors impact the frequency and modality of match situations a player faces during a match. For example, forwards tend to find themselves in match situations where they can score goals, whereas defenders are more likely to face match situations where they need to protect their own team's goal. Therefore, tactical factors do not only influence the match situations a player faces but also the decisions and behavior of a player to solve these situations. To sum up, these classifications help to define the tasks that differ according to the tactical factors. To be more specific, for example, depending on their playing position (i.e. classification), players repeatedly encounter similar situations or problems in the match (e.g. central defender faces aerial duels more frequently vs. wide midfielder faces dribbling opportunities more frequently). It is important to highlight the difference between the above-defined tactical factors and the tactical-cognitive aspect of match performance. In contrast to the tactical factors, which affect the frequency and nature of the situations a player is facing during a match, tactical-cognitive aspects of match performance describe the tactical-cognitive decisions of players (e.g. where to run or where to pass) (Escher, 2020).

The most frequently studied tactical factors are the playing position and the tactical formation. On the one hand, the playing position is a tactical factor at an individual level. The playing position describes the tactical role of a player within his team, mainly defined by the vertical and horizontal distribution of all ten outfield players on the pitch. Concerning a vertical classification defenders, midfielders, and forwards can be distinguished (Bauer et al., 2023; Bialkowski et al., 2014). If the horizontal distribution is also considered, a distinction can also be made between central and wide players (e.g. central vs. wide midfielder, central vs. wide defender). Regarding the influence of playing positions on match performance, wide playing positions (= wide defenders and wide midfielders) for example cover greater high-intensity and sprinting distances than other playing positions (Altmann et al., 2021; Bush, Barnes, et al., 2015; Sarmento et al., 2014). In addition, forwards reveal the smallest amount of ball possessions and still shoot most frequently of all playing positions (Liu et al., 2015). On the other hand, tactical formation is a tactical factor at a team level and is defined by the number of players playing in each positional group, respecting only the vertical distribution of the players on the pitch (e.g. defenders, midfielders, and forwards) (Bauer et al., 2023; Bialkowski et al., 2014). In detail, the number of defenders, midfielders, and forwards is then used to define the tactical formation. For example, a 4-5-1 formation consists of four defenders, five midfielders, and only one forward. Regarding the influence of tactical formations on match performance, players reveal more high-intensity runs in a 4-3-3 formation, compared to a 4-4-2 formation (Aquino, Palucci Vieira, et al., 2017). Furthermore, players play more passes in a 4-4-2 formation compared to other formations (e.g. 4-3-3 or 4-5-1) (Arjol-Serrano et al., 2021; Bradley et al., 2011). Concluding, tactical factors like the playing position or the tactical formation have been shown to influence the match performance of soccer players.

However, to date, there is still much to be discovered about tactical factors and their influence on match performance in soccer. Unexplored research topics are effects of changes in tactical formation within a match [in-game] or the combination of various tactical factors (e.g. playing position and tactical formation). Furthermore, the influence of other tactical factors on match performance needs to be investigated in the future. For instance, the playing style is a tactical factor whose influence on match performance has received little attention so far. In detail, the playing style is a tactical factor at a team level and describes the characteristic behavioral features (e.g. high pressing) a team is repeatedly displaying over a long period (Fernandez-Navarro et al., 2016). In summary, there is still a great need for research on the influence of tactical factors on match performance in soccer.

Therefore, the aim of this dissertation is the tactical contextualization of match performance in professional soccer, using the German Bundesliga as an example. The included studies aim to summarize and extend the state of research in the research field of tactical factors and match performance in soccer. In detail, the objectives of this dissertation are to explore in-game formation changes, investigate the influence of the combination of playing position and tactical formation on match performance, and analyze the influence of the playing style on match performance. The results could potentially help to better assess and interpret the match performance of professional soccer players. Furthermore, when scouting and recruiting players the assessment of the match performance of the players in question is essential. In this context, the importance of respecting tactical factors when assessing match performance could be substantiated. In addition, the insights provided by this thesis could be used to design training regimes (e.g. technical and physical performance demands of the respective drill) suitable for an appropriate tactical context (e.g. playing position, tactical formation, and playing style). Finally, this dissertation could help to provide information for coaches on how to increase the probability of success with the use of in-game formation changes.

1.2 Outline

This dissertation starts with general content about soccer match performance being covered in the introduction and theoretical background. The main section continues with the treatment of specific research questions. At the end of this thesis, a comprehensive discussion and a conclusion are intended to broaden the scope of this work. Therefore, *Figure 1.1* illustrates the structure of this dissertation in the shape of an hourglass.

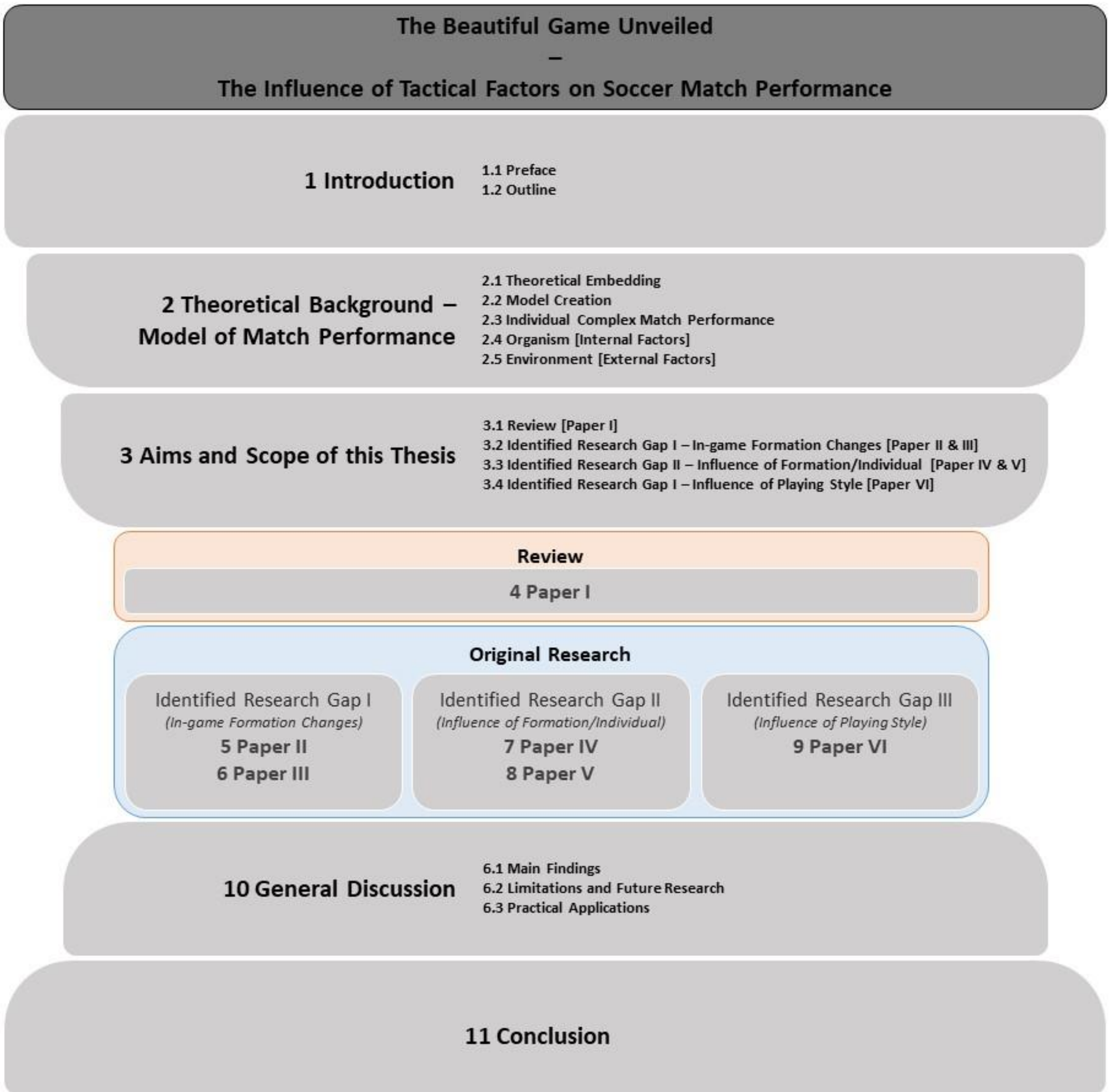

Figure 1.1: Structure of the dissertation.

In ***1 Introduction***, the topic of tactical factors in soccer and their influence on match performance is introduced. In addition, the structure of the dissertation is described at this point.

In ***2 Theoretical Embedding***, the dissertation is embedded in the theoretical background of sports science. This section is followed by the development and the detailed presentation of a model approach dealing with the individual complex match performance in soccer.

3 Aims and Scope of this Thesis deals more specifically with the aims of the main section of this dissertation. In detail, the structure and research questions of the individual scientific papers are outlined. Furthermore, the research questions and hypotheses of the following studies are derived from the model of the individual complex match performance, that was introduced earlier.

Chapters 4 to 9 build the main part of this thesis. The scientific studies, that have been published in international peer-reviewed scientific journals (*Paper I* to *V*) or are currently under review (*Paper VI*), aim to contextualize match performance in professional soccer, using the German Bundesliga as an example. First, a systematic review gives an overview of the state of research on the influence of tactical formation on match performance. Subsequently, three research gaps are identified and addressed in the following chapters.

- *Review*

4 Paper I

Forcher, L., Forcher, L., Wäsche, H., Jekauc, D., Woll, A., & Altmann, S. (2022). The influence of tactical formation on physical and technical match performance in male soccer: A systematic review. International Journal of Sports Science & Coaching, 1-30. https://doi.org/10.1177/17479541221101363

- *Identified Research Gap I – In-game Formation Changes*

5 Paper II

Forcher, L., Preine, L., Forcher, L., Wäsche, H., Jekauc, D., Woll, A., Gross, T., & Altmann, S. (2022). Shedding some light on in-game formation changes in the German Bundesliga - Frequency, contextual factors, and differences between offensive and defensive formations. International Journal of Sports Science & Coaching, 1-10. https://doi.org/10.1177/17479541221130054

6 Paper III

Forcher, L., Forcher, L., Jekauc, D., Wäsche, H., Woll, A., Gross, T., & Altmann, S. (2022). How Coaches can Improve their Teams' Match Performance - The Influence of in-game Changes of Tactical Formation in Professional Soccer. Frontiers in Psychology, 13, 1-11. https://doi.org/10.3389/fpsyg.2022.914915

- *Identified Research Gap II – Influence of Formation/Individual*

7 Paper IV

Forcher, L., Forcher, L., Jekauc, D., Woll, A., Gross, T., & Altmann, S. (2022). Center backs work hardest when playing in a back three: The influence of tactical formation on physical and technical match performance in professional soccer. PLoS ONE, 17(3), 1-17. https://doi.org/10.1371/journal.pone.0265501

8 Paper V

Forcher, L., Forcher, L., Härtel, S., Jekauc, D., Wäsche, H., Woll, A., Gross, T., & Altmann, S. (2022). Does Technical Match Performance in Professional Soccer Depend on the Positional Role or the Individuality of the Player? Frontiers in Psychology, 13, 1-13. https://doi.org/10.3389/fpsyg.2022.813206

- *Identified Research Gap III – Influence of Playing Style*

9 Paper VI

Forcher, L., Forcher, L., Wäsche, H., Jekauc, D., Woll, A., Gross, T., & Altmann, S. (under review). Is ball-possession style more physically demanding than counter-attacking? – The influence of playing style on match performance in professional soccer. 1-20.

In ***10 Discussion***, the results of the papers are summarized and critically discussed based on the current state of the literature.

In ***11 Conclusion***, the thesis ends with a summary and future perspectives.

2 Theoretical Background – Model: Individual Complex Soccer Performance

In the following chapter, this dissertation will be embedded in the large context of sports science to give the thesis a theoretical framework. Furthermore, already existing models in the soccer context are described and critically reviewed. Based on this, the model of the individual complex match performance in professional male soccer, which was developed to eliminate the shortcomings of the existing models, is implemented. The individual components of the developed model are then outlined in further detail in the following sections.

2.1 Theoretical Embedding

In order to give the contents of this dissertation a broader context, the following chapter will contemplate the contents of this thesis in light of sports science. At the beginning the scientific orientation of this dissertation will be outlined, followed by the implemented research methodology. Furthermore, the theoretical position of critical rationalism will be delineated. Lastly, the basic idea of falsification is explained.

According to Schröder and Dose, there are various scientific orientations in sports science (2010). In addition to other tendencies such as social-behavioral or economic-political-judicial orientations, the contents of the present thesis can be assigned to the medical-natural scientific orientation of sports science. At a scientific level, the research work of this dissertation can be attributed to the field of applied and interdisciplinary research. In essence, the aim of the research presented in the following chapters is to derive applied research questions based on a theory or model as a foundation. In this case, the underlying model will be presented in *2.2.2 Model of the Individual Complex Match Performance in Professional Male Soccer*. On this basis, the research questions of the original studies are derived. Important in this context is the theory-practice relationship in sports science, which declares sports should always be at the center of research to operate as a functional carrier of sports science. Referring to Schröder and Dose (2010), research is a scientific procedure aimed at gaining new knowledge. This essential research interest is at the center of this thesis. Concluding, this thesis aims to gain new knowledge in the area of medical-natural scientific sports science using an applied and interdisciplinary research methodology.

Moreover, besides the applied and interdisciplinary research methodology approach used in this thesis, the research methodology can be further classified in detail. Therefore, on the continuum of epistemological positions from empirical to phenomenological to hermeneutic, from a methodological point of view, this dissertation can be located in empirical research. In detail, empirical research is based on perceptual properties which lead to accurate perceptions of a person, that are also comprehensible by other people (Haag & Mess, 2010). In this thesis, the visible match performance in soccer (see *2.3 Individual Complex Match Performance*) is the main research interest and, therefore, is investigated in the studies of this dissertation (i.e. *Paper I* to *VI*).

In addition, according to Haag and Mess, the scientific theoretical position of critical rationalism is pursued throughout this thesis (Haag & Mess, 2010). The basis of this theoretical position is the assumption there is nothing absolutely certain. Accordingly, no verification of statements or hypotheses can occur through observations. Therefore, instead of verifying statements or hypotheses, critical rationalism relies on falsification. The basic idea of falsification is that observations can only be used to refute scientific statements, but can never confirm them. A more detailed description of falsificationism will be outlined in the following paragraph.

Falsificationism is based on the ‘all or nothing’ principle (Haag & Mess, 2010). In detail, the basis is formed by theories or models, which indeed are speculative and provisional assumptions. On this fundament of theories or models, research questions and hypotheses are to be derived which are very specific and thus highly falsifiable. From a falsificationist perspective, good models make comprehensive statements about the environment and, therefore, are characterized by a high degree of falsifiability. In addition, existing models should always withstand falsification attempts (i.e. they should not have been disproved so far). Falsificationists agree with the opinion, the more theories or models there are and the more speculative they are, the greater the chance of decisive progress in science is. Accordingly, falsificationists understand scientific progress as the creation of new speculative theories which are ‘better’ (i.e. from a falsicationistic point of view, e.g. higher specificity and falsifiability) than existing models. These new speculative theories or models are then to be subjected to constant falsification attempts by deriving research questions and hypotheses.

This falsicationistic approach also represents the main focus of this thesis. In detail, first, a new model is evolved (see *2.2 Model creation*). According to Chalmers, this model approach is advantageous compared to existing models because it is more specific and, thus, allows for more highly falsifiable questions and hypotheses (Chalmers, 2006). Therefore, from a falsificationist point of view, the presented *model of the individual complex match performance in professional male soccer* is more developed compared to already existing models in this context. Based on this model, questions and hypotheses are derived, which are subjected to a falsification test using empirical research methods. Finally, the discussion will examine whether the hypotheses have withstood the falsification attempts and whether the model can remain valid to this point in time. Therefore, the contents of this thesis can probably lead to decisive scientific progress.

The following section will review already existing models of soccer match performance, based on which the new *model of the individual complex match performance in professional male soccer* evolved.

2.2 Model Creation

In sports science, several models try to describe and explain performance in sports. Similarly, in soccer, some models currently exist that attempt to contextualize the performance of a player. Therefore, exemplary two of the most frequently used models will be presented and discussed in the following. Both models are well-known in German-speaking countries.

2.2.1 Other Models

First, the model of Weineck will be presented (2007). This approach focuses on athletic performance and its components. This modeling approach puts the contextual factors on the same level as the performance and describes the relation between these contextual factors and performance.

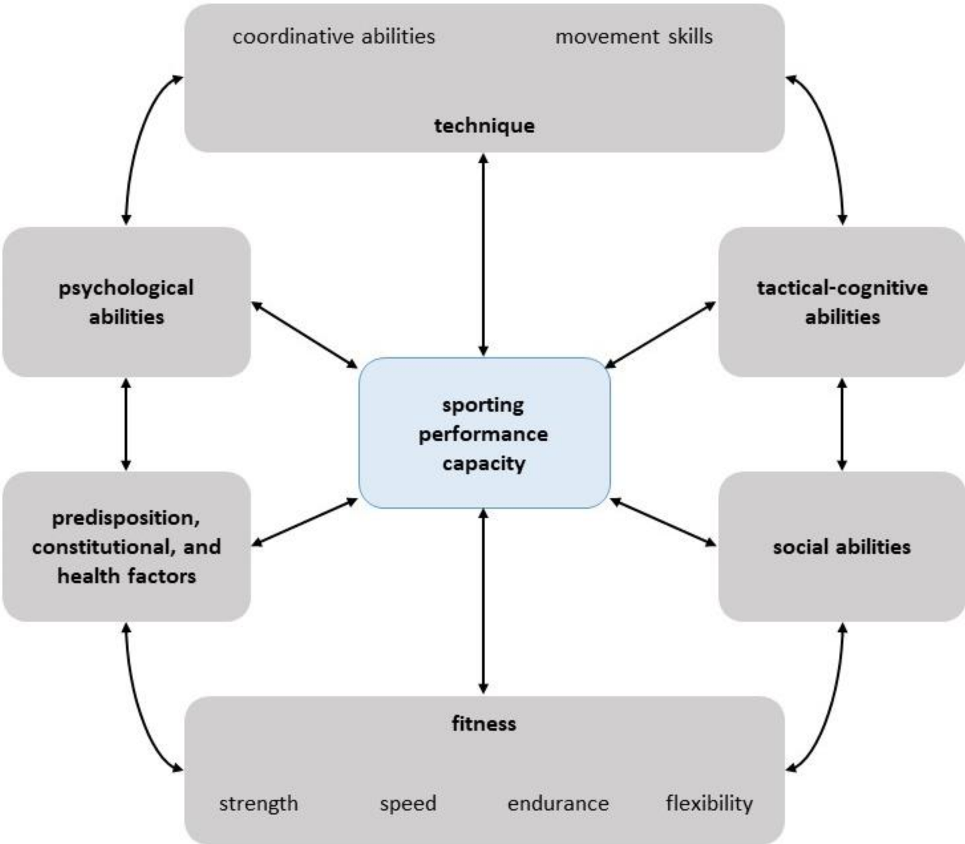

Figure 2.1: Model of the components of athletic performance (according to Weineck, 2007). The center of the model by Weineck consists of the sporting performance capacity of an athlete. The performance capacity of the athlete is surrounded by various components which on the one hand influence the performance and on the other hand also interact with each other. These components include psychological, social, and tactical-cognitive abilities. Furthermore, predisposition, constitutional, and health factors moderate performance according to Weinecks' approach. In addition, technique plays an important role in the context of performance capacity. In detail, coordinative abilities and movement skills are of central importance when looking at technique. Finally, according to Weineck, fitness is a moderator of athletic performance capacity. In this model, physical fitness includes the abilities of strength, speed, endurance, and flexibility.

A major strength of this model approach is the consideration of four sub-areas of complex sports performance. As considered in the model, this complex performance can be differentiated into technical, tactical-cognitive, physical, and psychological components.

However, athletic performance, representing the center of Weineck's model, is a theoretical construct that cannot be measured directly. Therefore, a specific hypothesis derivation based on this model approach is only possible to a limited extent (see *2.1 Theoretical Embedding*).

Furthermore, the model is missing external contextual factors, that possibly influence a player's performance. Since various contextual factors have already been proven to influence performance in soccer, the lack of influence of external factors limits the application of the model by Weineck.

Secondly, the model of Hohmann and Brack will be considered in the following (1983). This approach deals with the individual complex game performance in sports games. This pyramidal modeling approach illustrates the underlying factors of individual complex sports performance.

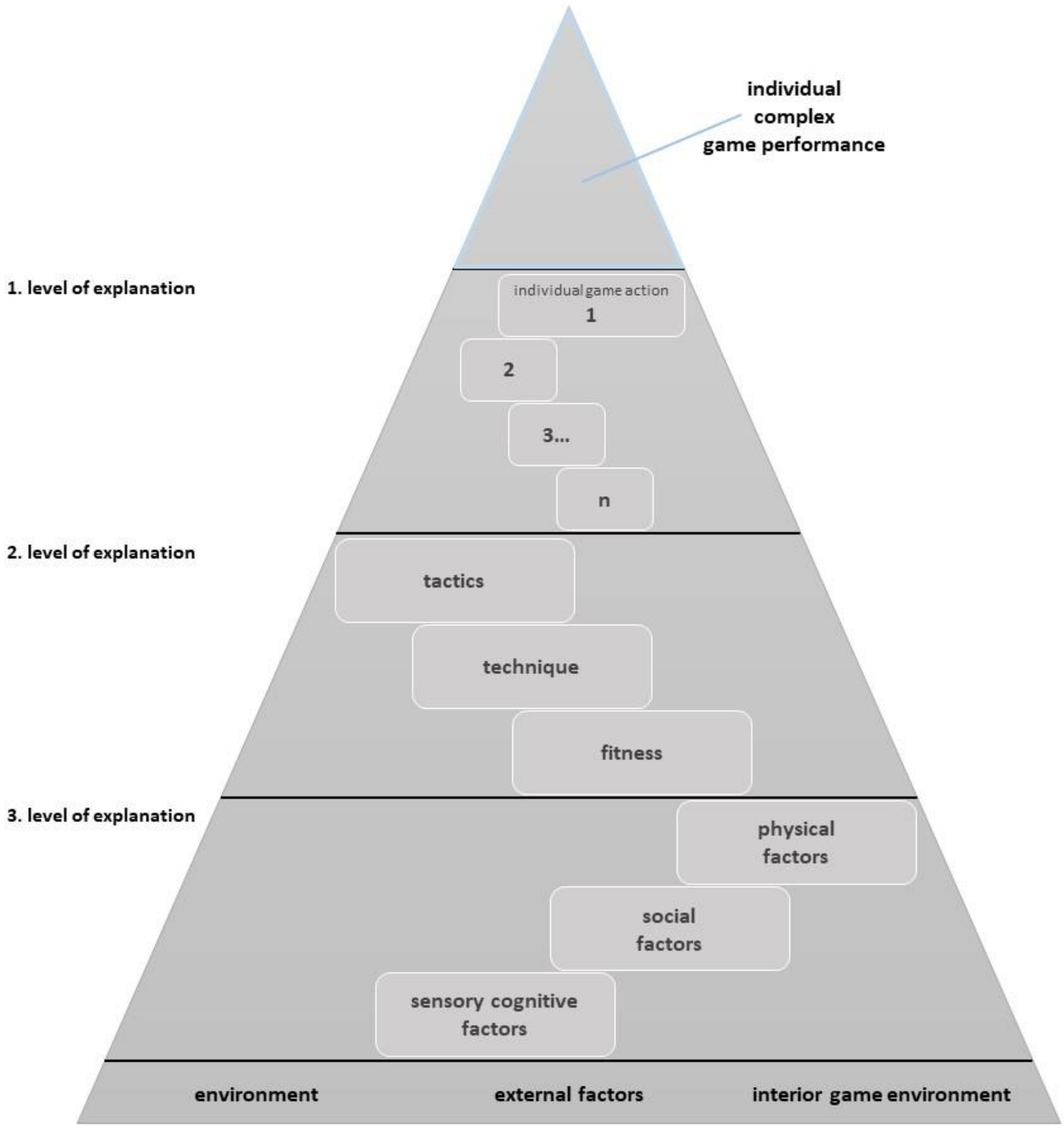

Figure 2.2: Model of the individual complex match performance in sports games (according to Hohmann & Brack, 1983).

The model by Hohmann and Brack is ordered hierarchically and, thus, is divided into three different levels of explanation. According to Hohmann and Brack, the basis of any complex game performance is the game environment, external factors, and the interior game environment. The third and lowest level of the explanation involves physical, social, and sensory cognitive factors which fundamentally influence a player's performance. The second and middle level of explanation includes tactics, technique, and physical fitness. Therefore, the second level serves as the foundation of game performance. The first and highest level of explanation includes each game action, the player is performing during the current game. These single actions add up and end at the top of the cone, which represents the individual complex game performance. Since the individual complex game performance consists of single actions of a player it can be measured.

In contrast to Weineck's model approach, Hohmann and Brack's model does not deal with a theoretical construct but with real measurable game performance. The game performance is based on individual factors (e.g. technique or physical fitness) and results in single observable game actions. These game actions add up and result in an individual complex game performance that actually can be measured. In addition, the performance is influenced by external factors which are independent of the player (e.g. external factors).

However, the model by Hohmann and Brack features some limitations. First of all, there is no division of the game performance into four essential components (i.e. physical, tactical-cognitive, technical, and psychological). Furthermore, the second level of explanation lacks psychological factors moderating performance in addition to the included tactics, technique, and condition. Furthermore, the cone-shaped arrangement of the model gives the impression the individual complex game performance is partly based on external influencing factors (e.g. game environment). Contrary, it can be assumed, although performance is influenced by external factors, performance does not build on them. Moreover, no mutual interactions can be identified among the factors moderating performance. In this context, an example can clarify a possible interaction between factors included in the model by Hohmann and Brack: assuming the score changes from leading to trailing, the current score can influence the tactics used to a significant extent (i.e. leading: preventing a goal to secure the lead with low defensive risk vs. trailing: maximizing attacking effort to level the score with greater defensive risk).

In summary, both models presented have merits but simultaneously feature some limitations. On this basis, a new model is developed working with the strengths of the presented models and balancing the limitations mentioned above. This newly evolved model aims to reveal match performance and it’s context more clearly. As outlined in *2.1 Theoretical Embedding*, the new model should be more specific than the presented models of Weineck and Hohmann and Brack. Therefore, one should be able to derive more highly falsifiable hypotheses. This new model will be examined in more detail in the following chapter.

2.2.2 Individual Complex Match Performance in Professional Male Soccer

In this section, the novel model entitled '*model of the individual complex match performance in professional male soccer*' is introduced and its structure and components are explained in detail. The model covers the match performance of professional male soccer players. In detail, the model features the components of the match performance and factors influencing the match performance.

The basic structure of the developed model on individual complex match performance is based on Newell's model of constraints. The approach by Newell identifies the constraints that determine the best coordination and control of human movements.

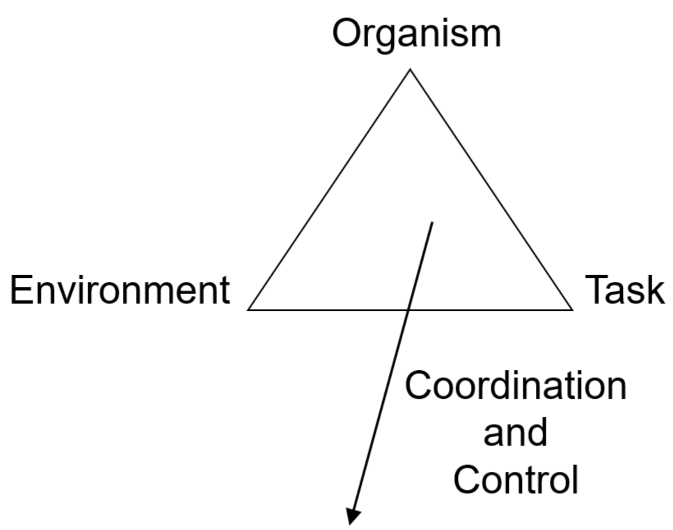

Figure 2.3: Model of constraints (according to Newell, 1986).

The approach of Newell schematically presents which categories of constraints specify optimal coordination and control of human movements. In the new model approach, as with Newell, the aim is to depict the influence of the organism and the environment on the specific task in the current moment of the match. This interaction of organism, environment, and movement task then results in the coordination and control of a movement. This visible movement is referred to as the individual complex match performance in the newly implemented model. This basic composition after Newell results in the *model of the individual complex match performance in professional male soccer*.

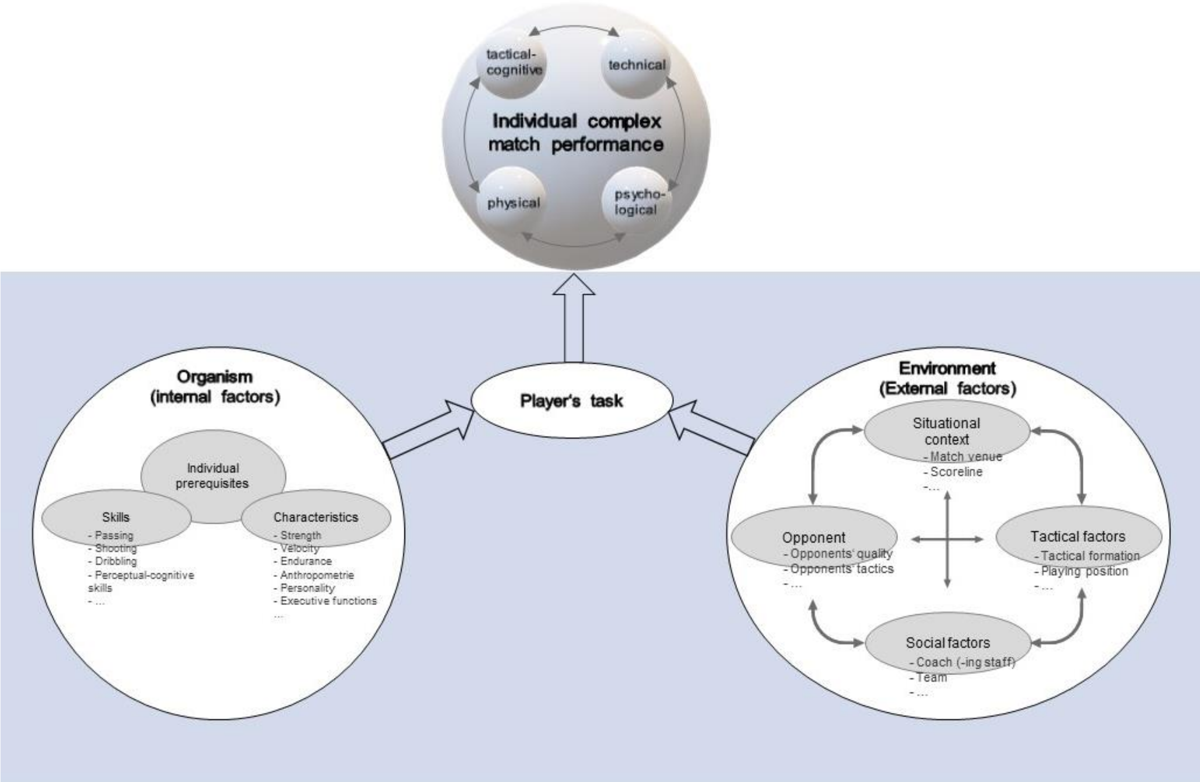

Figure 2.4: Model of the individual complex match performance in professional male soccer.

As already mentioned, this new *model of the individual complex match performance in professional male soccer* is not only based on Newell's design but also includes aspects from models of Weineck and Hohmann and Brack. As with Weineck, a distinction is made between four sub-areas of the match performance. In detail, physical, technical, tactical-cognitive, and psychological parts of the match performance are differentiated. In addition, as with Hohmann and Brack, the directly observable match performance is at the center of the model. In addition, external factors moderating match performance can also be found in the new model approach (similar to the model by Hohmann and Brack). Finally, the measurable individual complex match performance arises directly from the task the player has to solve in the respective match situation (similar to the model by Hohmann and Brack). Concluding, the present model of the individual complex match performance in professional male soccer is the result of considering the sub-aspects of the already presented models of Newell, Weineck, and Hohmann and Brack. Therefore, the present model combines the strengths of the previously presented models to make match performance and its context clearer. Concurrently, this approach allows one to derive more highly falsifiable hypotheses, which can subsequently be investigated.

In addition, the process of the development and elaboration of the new model will be briefly outlined. First, several initial model approaches were discussed with experienced researchers who have several years of experience in researching the performance capacities and the match performance of professional soccer players. Subsequently, the new model was adapted in several rounds of revision based on the given feedback by the researchers. Subsequently, the revised approach was presented and discussed in several scientific sessions. Based on the results of these rounds of discussion, the model for individual complex match performance in professional male soccer was enhanced. The scientists and practitioners involved in the revision process of the model have published numerous scientific papers (>100 publications in scientific peer-reviewed journals) as well as practical experience in professional soccer clubs (e.g. German Bundesliga). The people involved were employed by universities, professional soccer clubs, and soccer associations. Their areas of experience range from theoretical-scientific areas (e.g. performance diagnostics, physiology, psychology, etc.) to the practical application in professional soccer (e.g. coach, match analyst, sports psychologist, athletic coach, etc.). The revision process including the feedback of a plethora of experts has differentiated and improved the new model.

In the following, the three essential sub-areas of the model of individual complex match performance will be examined in more detail and supported with study results. In detail, first, the individual complex match performance and the player task are considered. Second, the organism, in particular the internal factors, will be examined in more detail. Finally, the environment will be considered (i.e. external influencing factors). The following chapters are not intended to be a detailed analysis of the literature but rather aim to present excerpts of the current state of research to generate a comprehension of the respective sub-area of the model.

2.3 Individual Complex Match Performance

In the following chapter, the player's task and the individual complex match performance will be outlined in detail (i.e. upper part of the model in *Figure 2.4*). The individual complex match performance in the new model approach arises from the processing and solution of the movement task presented to the player in the match (Hossner et al., 2015). According to Göhner, the players' task can be characterized by five structural elements: a material movendum, a mover, a specific movement space, sport-specific rules, and a movement goal (Göhner, 1992). The material movendum is the object on which the fulfillment of the movement goal can be determined (i.e. movendum = the ball) (Schwameder et al., 2013). Hence, the mover is the player who moves the movendum (i.e. the ball) (Schwameder et al., 2013). Moreover, the specific movement space concerns the environmental conditions in which the movement task is presented and solved (i.e. the movement space [= soccer field] neither hinders nor promotes the player's activity) (Schwameder et al., 2013). In addition, there exist sport-specific rules conditioning the other task characteristics (e.g. movendum = size of the ball; mover = performance class; movement goals = to win, a goal must be scored; environmental conditions = importance of lines indicating the penalty area) (Schwameder et al., 2013). Finally, the main specific movement goal in soccer is final state-oriented (i.e. scoring and preventing goals) (Schwameder et al., 2013). The visible and, thus, measurable individual match performance consists of the processing and solution to the presented task and will be discussed as match performance in the following sections of this dissertation. The match performance of a player can be subdivided into four essential aspects. In detail, physical, technical, tactical-cognitive, and psychological aspects can be differentiated (Sarmento et al., 2014). To gain a more detailed insight into the complex match performance, each of the four aspects will be assessed more specifically in the following paragraphs.

First, the technical aspect of match performance mainly deals with on-ball actions. Therefore, the focus is on the execution of technical skills such as passing, shooting, or dribbling. However, there are also technical skills that cannot be attributed to on-ball actions (e.g. tackling). However, previous technical match performance research mainly focused on on-ball actions as these occur more frequently. Therefore, technical skills referring to off-ball actions will be disregarded in the following. Moreover, a distinction can be made between quantitative (e.g. number of passes) and qualitative characteristics (e.g. success rate of passes) of technical match performance variables. Professional players averagely pass the ball 27.4 times per match, while completing 74.2 % of these passes successfully (Bradley et al., 2011). Furthermore, professionals head the ball 3.9 times, cross the ball 1.8 times, and shoot the ball toward the goal 1.4 times per match (Dellal et al., 2011; Liu et al., 2015). Moreover, technical match performance evolved throughout the years resulting in an increasing number of passes (i.e. up to 40% increase in seven years) and increasing passing success rates (i.e. about 10% increase in seven years) (Barnes et al., 2014).

Second, the physical parts of match performance represent the physical demands of soccer. From a physical perspective, soccer is an intermittent game with iterating cycles of very high intensities (Dolci et al., 2020). On average, players run between 10 and 13 km in one match, most of which is covered in low intensities (Di Salvo et al., 2007; Sarmento et al., 2014; Stølen et al., 2005). These low-intensity phases are repeatedly interrupted by phases of high intensity. In detail, players cover 8-9% of their total running distance in high-intensity ranges (> 20 km/h) and 2-3% of their total running distance in sprint intensities (> 25 km/h) (Sarmento et al., 2014; Stølen et al., 2005). In addition, a player averages between 600-650 accelerations and decelerations per match (Dolci et al., 2020). Furthermore, the majority of the high-intensity actions range between 2.6 and 3.1 seconds in time and 16.6 and 20.2 meters in distance (Ade et al., 2016). Moreover, the physical activities of players appear in a multidirectional fashion (Altmann, 2020). The direction of the walking movements (i.e. low-intensity) is linear forward in 48.7 % and backward, lateral, or curved in one direction in 30.7 % of all cases (Bloomfield et al., 2007). In the remaining 20.6 %, there is no movement in any direction. Moreover, only about half of the high-intensity runs are linear, while all others are curved or show at least one change of direction (Ade et al., 2016; Fitzpatrick et al., 2019). These directional changes are usually of a large angle so sharp directional changes (i.e. >90°) are relatively rare (Ade et al., 2016; Nedelec et al., 2014; Robinson et al., 2011). Finally, the multidirectional movements of a soccer player result in 700 directional changes and up to 1400 changes in physical activity per match (Bloomfield et al., 2007; Sporis et al., 2010). Moreover, several studies reveal that the physical effort of players in professional matches constantly evolved resulting in an increased physical load (e.g. increasing total distance and number of high-intensity actions) (Barnes et al., 2014; Harper et al., 2021; Lago-Peñas et al., 2022).

Third, tactical-cognitive components of match performance describe the decisions and the resulting movements players execute during the match to solve the presented task in the respective match situation at a tactical level (Escher, 2020). The decisions and resulting movements of players always follow the goal of optimally achieving the objectives of the soccer game. In detail, game objectives differ according to the phase of the game (e.g. attacking play, defensive play, defensive transition, and offensive transition). The four distinct phases of match play describe the process of a soccer game. In attacking play, the own team controls the ball, while in defensive play, the opposing team is in ball control. Furthermore, if the own team conquers the ball in defensive play, there is a switch from defense to offense, called offensive transition. Moreover, the opposite switch occurs when the own team loses the ball during attacking play, also known as defensive transition. Referring to the objectives of soccer, the game objectives mainly include scoring goals and controlling the ball in own possession (i.e. attacking play and offensive transition) and preventing goals and recovering the ball in opposing possession (i.e. defensive play and defensive transition) (Escher, 2020; Henseling & Maric, 2018; Moura et al., 2012). Concluding, at a player level, the tactical-cognitive performance comprises the tactical application of physical (e.g. running in a specific direction) and technical (e.g. passing toward a specific player) efforts, through the cognitive level of decision-making (i.e. solving the presented task), to optimally achieve the objectives of the respective match phase in the current match situation. For example, the effectiveness of a pass on a tactical-cognitive level could be described by the number of opponents outplayed vertically or the space control gained in the attacking third after the pass (Power et al., 2017; Rein et al., 2017). Therefore, players passing decisions (e.g. where to pass) can be evaluated on a tactical-cognitive level. Furthermore, a study revealed that passes causing more disruption in the opponent's defensive organization lead to more successful attacks (Forcher et al., 2021; Goes et al., 2018). Moreover, also shots can be evaluated on a tactical-cognitive level. In detail, the predictive xGoals models evaluate shots in terms of their tactical quality and can provide information on which shots (e.g. location, type of shot, etc.) are more likely to result in goals (DFL, 2022; Herold et al., 2021). Through such analyses, the decisions of the players can be evaluated on a tactical-cognitive level (e.g. did it make sense to shoot at the goal in the analyzed match situation). However, not only technical actions (e.g. passes and shots) can be used to evaluate attacking sequences on a tactical-cognitive level. In detail, specific characteristics of attacking sequences can be used to evaluate the positioning of players on the field (i.e. physical effort, e.g. run in specific direction) (Link et al., 2016). In defensive phases of the match other objectives and, consequently, a different tactical behaviour needs to appear in contrast to offensive match phases. Therefore, the decisions of players (e.g. where to run) need to change according to the respective match phase. For example, pressure on the ball and the opponent must be increased to achieve defensive objectives (Forcher, Altmann, et al., 2022). In addition, it is important to exert pressure on the ball-leading player and to put pressure on passing options close to the ball through the proper positioning and movement of all players to regain the ball (Forcher, Forcher, Altmann, et al., 2022). In contrast, it would make no sense, for example, to increase the pressure on the ball leading player when in possession. In summary, the match phase and the match situation should be considered when describing and evaluating the tactical-cognitive aspect of match performance.

Fourth, when considering the psychological aspects of match performance, perceptual-cognitive skills play an important role. Perceptual-cognitive skills refer to the skill of identifying and using the information in relation to the environment (e.g. to select and execute appropriate movement responses) (Mann et al., 2007). For example, perceptual-cognitive skills include response accuracy, response time, number of visual fixations, visual fixation duration, and quiet eye (i.e. the final fixation located on a specific object) (Vickers et al., 2019). The way players use these perceptual-cognitive skills in dynamic match situations has a significant influence on the quality of the subsequent decisions (Ehmann et al., 2021). In detail, studies show that experts are more accurate in their decisions and quicker in recognizing the behavior of their opponents (Mann et al., 2007). On a functional level, experts fixate the match situation less frequently with their eyes, whereas one fixation lasts for a longer period (Mann et al., 2007). This enables experts to extract more task-relevant information per fixation of a scene in comparison to less skilled athletes. Furthermore, the accuracy of responses is greater and the time in which stimuli lead to a movement response is shorter for experts (Mann et al., 2007). Moreover, the relative prolonged quiet eye period is an important indicator of an athlete's performance level (Mann et al., 2007). In detail, the quiet eye period refers to the last period in front of the movement response, during which experts fixate on a target or object for a comparatively long period (Vickers et al., 2019). Concluding, perceptual-cognitive skills are an important component of the psychological aspect of match performance in soccer.

In addition to perceptual-cognitive skills, psychological constructs referring to the player's personality are important factors moderating psychological aspects of match performance (Abdullah et al., 2016; Alves et al., 2022; Jackson et al., 1998; Kreiner-Phillips & Orlick, 1992; Sarkar & Fletcher, 2014). For example, high commitment, high focus, and the setting of short-and long-term goals are essential factors for successful performance (Gould et al., 2002; Krane & Williams, 2006). In addition, elite athletes are characterized by greater motivation in comparison to other athletes (Durand-Bush & Salmela, 2002). In professional soccer players, self-confidence, anxiety control, and mental preparation in particular have been identified as relevant success factors for match performance (de Freitas et al., 2013). However, to the best of the author's knowledge, to date, there exist no studies measuring individual aspects of the psychological match performance in professional soccer directly during a match. Therefore, further details of the psychological match performance in professional soccer remain unclear.

In summary, there are several findings on the physical aspects of match performance (Dolci et al., 2020). Although there are already studies analyzing the technical and tactical-cognitive aspects of match performance, there is a considerable need for research in these areas (Barnes et al., 2014; Forcher, Altmann, et al., 2022). Furthermore, to the best of the author's knowledge, there is currently no study measuring psychological match performance in professional soccer. Moreover, there is an immense need for research on psychological constructs (e.g. perceptual-cognitive skills) and their influence on match performance in soccer (Alves et al., 2022). Concluding, it seems worthwhile to analyze how other factors (e.g. organism or environment) influence match performance in physical, technical, tactical-cognitive, and psychological aspects. Hence, the following sections will provide information on the influence of internal and external factors on match performance in soccer.

2.4 Organism [Internal Factors]

In the following chapter, the organism and, thus, a selection of internal factors influencing match performance in soccer will be presented (i.e. left part of the model in *Figure 2.4*). Within internal factors, the model mainly discriminates between skills and characteristics (see *Figure 2.4: Model of the individual complex match performance in professional male soccer*). Since the definitions of skills and their differentiation towards abilities are not uniform, it is necessary to formulate a definition for skills and abilities (A. Burton & Rodgerson, 2001). In the following, skills are defined as movement classes belonging to the same form and function (Altmann, 2020). In contrast, abilities (e.g. endurance), which are assigned to characteristics in the model of the individual complex match performance, are referred to as general, overarching traits forming the basis for the execution of various movement skills (A. W. Burton

& Miller, 1998). Therefore, the following sections intend to explain how skills and characteristics (e.g. abilities) can influence the individual complex match performance.

Moreover, since match performance differs between playing divisions, differences in internal and external factors between different performance levels (i.e. different divisions) can provide additional insights (Dellal et al., 2011; Rampinini et al., 2007). Concluding, besides the direct influence of internal or external factors on match performance also the differences between different performance levels will be considered in the following. This should round the following presentation of external and internal factors and their influence on the individual complex match performance.

Initially, skills will be considered. As noted earlier, skills describe form and function-like movement classes. The mastery of these skills has a direct influence on the individual complex match performance. For example, the skill of passing is crucial for successful participation in the attacking game. In addition, a player needs to be able to dribble the ball and, thus, control it. Furthermore, to win matches, goals must be scored. Therefore, the skill of shooting the ball is fundamental. In addition to the technical skills and their significance regarding the individual complex match performance, several other skills are of similar importance. By way of example, skills also include perceptual-cognitive skills. As already mentioned in the section on psychological aspects of the match performance, perceptual cognitive skills include response accuracy, response time, number of visual fixations, duration of visual fixations, and quiet eye. As described above, the mastery of these skills is important for well-functioning decision-making, which in turn immediately influences a player's match performance (e.g. successful perceptual stimulus processing and decision-making can lead to improved anticipation) (Ehmann et al., 2021). Concluding, this excerpt substantiates the enormous effect skills have on individual complex match performance.

Besides the initially discussed skills, characteristics form a main part of the internal factors, influencing the complex match performance of an individual. Therefore, various characteristics will be considered in the following paragraphs.

One part of the characteristics is abilities such as endurance, speed, and strength. As defined previously, abilities can be characterized as general, overarching traits. The level of expression of these abilities can be determined through various diagnostic parameters (e.g. VO_2-Max for endurance). These parameters can be determined using performance diagnostic tests (e.g. spiroergometric incremental treadmill test). To document the influence of the abovementioned abilities on match performance, various parameters (i.e. relevant for the respective ability) and their connection with performance in soccer will be outlined in the following.

In this dissertation, endurance is defined as the ability to secure a load-adequate energy supply for the organism, which delays fatigue-related declines in performance and influences recovery (Hottenrott & Hoos, 2013). The influence of endurance on match performance in soccer has been investigated previously. In detail, outputs in performance diagnostic tests to assess endurance (e.g. incremental treadmill test, continuous field test) reveal a strong correlation with physical match performance indicators (e.g. total distance, high-intensity distance) (Aquino, Carling, Maia, et al., 2020). Furthermore, findings indicate that various endurance-associated variables (e.g. lactate thresholds during treadmill tests, VO_2-Max) are related to the total distance covered in a match (Aquino, Carling, Maia, et al., 2020). In addition, the results of a YO-YO intermittent recovery test (= an endurance field test) reveal a large correlation with total distance, high-intensity distance, and very high-intensity distance covered in a match (Aquino, Carling, Maia, et al., 2020). Furthermore, players at the elite level demonstrate better endurance (e.g. higher VO_2 max) compared to players competing at lower skill levels (Slimani & Nikolaidis, 2019). In conclusion, endurance influences match performance and at higher performance levels endurance-related variables are better developed.

Furthermore, besides endurance, the ability of speed also influences match performance. Regarding the definition of speed, Altmann states that there is no general overarching ability defined as speed for speed-related actions in soccer (Altmann, 2020). Following Altmann, speed in soccer is a task-specific movement ability allowing the movement to be executed as fast as possible, either as a reaction to an external stimulus or without an external stimulus as a pre-planned movement (Altmann, 2020). However, there exist different performance diagnostic test procedures to test speed in a task-specific way (e.g. linear sprint test, direction change sprint test), which lead to different diagnostic parameters (e.g. time for 30m linear sprint). Several studies show that elite players are faster in 15 m, 25 m, 30 m, and 40 m linear sprint tests than players of a lower performance level (Slimani & Nikolaidis, 2019). Thus, for example, the ability to complete a linear sprint task in a minimum amount of time is a key variable in assigning players to different performance levels (Slimani & Nikolaidis, 2019).

Concluding, the task-specific ability to perform movements as fast as possible is a vital moderator of the match performance.
In addition, strength is also an important characteristic influencing match performance. In the following strength is defined as the ability to use muscular strength to overcome resistance, counteract the resistance with yielding, or keep the resistance static (Hottenrott & Hoos, 2013). Similarly, there exist various diagnostic tests (e.g. countermovement jump, measurement of maximum strength in a squat) and related parameters (e.g. maximum force in a jump in a countermovement jump, one repetition maximum in a squat) to measure strength. Studies reveal that the strength in the lower extremities (e.g. maximum isometric strength, one repetition maximum in a squat) is higher in elite players than in amateur players (Slimani & Nikolaidis, 2019). Furthermore, elite players also demonstrate better results in squat jump and countermovement jump assessments than their amateur counterparts (Slimani & Nikolaidis, 2019). One could conclude that performance in squat jump and countermovement jump assessments are a performance-limiting factor that determines good or less good performance and thus has an influence on match performance. In conclusion, the results suggest that strength is also a significant factor influencing performance in a match on a professional level.
Besides the abovementioned abilities of endurance, speed, and strength, other characteristics are also important factors moderating the match performance of a player. These characteristics include, for example, anthropometry. In detail, anthropometry refers to the determination of the mechanical characteristics of the human body and its parts (Schwameder et al., 2013). Studies indicate that professional players are characterized by more muscle mass compared to youth players, who have not yet progressed to the professional level (Jorquera Aguilera et al., 2012). Another investigation reveals that anthropometric variables (e.g. body mass, muscle mass [total and percentage], and sitting height) differ between performance levels, with professionals weighing more, having more muscle mass, and being taller (Bernal-Orozco et al., 2020). Furthermore, the percentage of body fat is smaller in professionals compared to sub-elite players (Slimani & Nikolaidis, 2019). Moreover, some studies examine the influence of anthropometric variables (e.g. body mass, muscle mass) on match performance and reveal that anthropometric variables interact with match performance parameters (e.g. total distance) (Aquino, Carling, Maia, et al., 2020). In addition, anthropometry also includes the definition of various body types, which are commonly

divided into three main categories in the scientific context (= three somatotypes). Somatotypes are divided into endomorphy (i.e. relative fatness), mesomorphy (i.e. relative musculoskeletal robustness), and ectomorphy (i.e. relative linearity or slenderness) properties (Slimani & Nikolaidis, 2019). Several studies suggest that there is a significant difference between performance levels regarding somatotypes (Slimani & Nikolaidis, 2019). Concluding, anthropometric variables vary between performance levels and, therefore, as mentioned above, anthropometry is a characteristic influencing match performance in soccer.

To transition from physical characteristics (e.g. endurance) to psychological characteristics, the following paragraph describes a further characteristic, namely the personality of a player. The most common and regularly used model to describe personality is called the 'Big Five' (Wilson & Dishman, 2015). The Big Five model measures personality in terms of the following five constructs: Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness (Wilson & Dishman, 2015). Allen et al. reveal that there is little difference in personality traits between professional and amateur players, though elite players are more extroverted and emotionally stable than their less skilled counterparts (2013). Furthermore, the results of Spielmann et al. indicate that the personality traits of professional soccer players are highly individual (2022). However, studies show differences in personality traits moderating performance and long-term success in sports. For example, Allen et al. show that better athletes have higher levels of conscientiousness and agreeableness and lower levels of neuroticism (2013). At present, it is difficult to prove the influence of personality on match performance in soccer at a match level, as this current performance on a match day is influenced by a variety of other factors (see *Figure 2.4 Model of the individual complex match performance in professional male soccer*). However, study results suggest that personality traits, for example, the quality of preparation for a match, can influence match performance and, thus, also affect success over a longer time (Allen et al., 2013). In the professional soccer context, spectators can also influence the performance of players (e.g. better performance at home matches (see *3.5 Environment [External Factors]*)). Studies indicate that players with higher levels of extraversion outperform other players when large crowds attend the match (Allen et al., 2013). In addition, personality is an important factor in determining whether players from the youth or amateur level progress to the professional level (Allen et al., 2013). Accordingly, personality influences long-term success (e.g. whether a player progresses to the professional level), as well as the ability to perform in a professional league (e.g. with spectators).

Besides personality, another psychological characteristic influencing match performance is executive functions. In detail, executive functions include inhibition, working memory, and cognitive flexibility (Diamond, 2013). In the soccer context, it is important to adapt to changing environments (i.e. concerns cognitive flexibility), to store and process the information received, to compare it with existing knowledge (i.e. concerns working memory), and to suppress possible movement responses, such as when a passing option is covered by an opponent (i.e. concerns inhibition) (Beavan et al., 2020). Previous research reveals that the level of executive functions can be used to differentiate between elite and amateur players (Verburgh et al., 2014). The results of Beaven et al. suggest that the threshold hypothesis also applies to executive functions (2020). According to the threshold hypothesis, players need to have a certain level of executive functions to be able to compete at an elite level, but a higher degree of executive functions cannot be associated with better performance at present. Therefore, it is important to highlight that players need to have a certain level of executive functions to be able to perform at the professional level.

Concluding, skills (e.g. passing) and characteristics (e.g. endurance) influence the individual complex match performance. Furthermore, studies reveal that several characteristics can be used to differentiate between professional and lower-level athletes. Since match performance in soccer differs according to the playing level, differences between professional and lower-level players can be associated with differences in match performance (Dellal et al., 2011; Rampinini et al., 2007). To put it in a nutshell, skills and characteristics are important moderators of the individual complex match performance of professional male soccer players.

2.5 Environment [External Factors]

In the next section, the influence of the environment on the individual complex match performance will be considered (i.e. right part of the model in *Figure 2.4*). The external factors influencing performance can be divided into situational context (e.g. match venue), tactical factors (e.g. playing position), social factors (e.g. coach), and opponent (e.g. opponent quality). In the following paragraphs, all four sub-areas of the external factors will be examined and illustrated using various examples.

First, the situational context in soccer will be considered. In the following, situational context refers to variables related to the external framework conditions of a soccer match, i.e. the situation of the match. The situational context includes, for example, the match venue or the scoreline. Study results indicate that teams playing at home have a higher ball possession rate than teams playing away (Lago & Martín, 2007; Lago-Peñas & Dellal, 2010). Furthermore, home teams play more crosses and shots, while away teams reveal more interceptions and tackles (Taylor et al., 2008). In addition, several studies reveal that home teams cover a greater total distance than away teams (Castellano et al., 2011; Lago et al., 2010). Furthermore, home teams also run more distance in low-intensity and high-intensity speed zones (Castellano et al., 2011; Lago-Peñas et al., 2011). Concluding, the match venue, i.e. playing at home or away, influences match performance.

In addition, the current score (= scoreline) can also influence the performance of players. Trailing is associated with a higher ball possession percentage compared to leading or drawing (Lago, 2009; Lago & Martín, 2007; Lago-Peñas & Dellal, 2010). Furthermore, leading teams perform more interceptions, clearances, and aerial duels while trailing teams play more crosses, dribbles, and passes (Taylor et al., 2008). Since trailing teams have more possession, it can be logically concluded that they perform more on-ball actions (e.g. passes), while the leading teams (= less possession) perform more off-ball actions (e.g. interceptions). Furthermore, trailing teams run higher distances at various speed zones and perform more high-intensity activities than their leading counterparts (Castellano et al., 2011; Lago et al., 2010; Lago-Peñas et al., 2011). In summary, the situational context (e.g. scoreline, match venue) markedly influences match performance.

Second, tactical factors, such as playing position and tactical formation, can affect the match performance of soccer players. As already defined in the introduction, tactical factors are predetermined tactical variables (e.g. playing position), including various classifications (e.g. central defender, wide defender, etc.). In detail, tactical factors influence the frequency and nature of the situations a player is facing during a match (Escher, 2020). Exemplarily, the tactical factors of playing position and tactical formation will provide information about the influence of tactical factors on match performance.

The playing position is defined by the vertical (e.g. defenders, midfielders, and forwards) and horizontal (e.g. central vs. wide) distribution of the ten outfield players on the pitch resulting in different categorizations at a player level (e.g. central defender, wide defender, central midfielder, wide midfielder, and forward) (Bauer et al., 2023). An excerpt from study results can outline the effect of the playing position on physical and technical aspects of the match performance. Central midfielders, wide defenders, and wide midfielders reveal the greatest high-intensity distance, while forwards and central midfielders indicate less high-intensity distance (Altmann et al., 2021; Bush, Barnes, et al., 2015). Furthermore, the greatest sprint distance is covered by wide playing positions (e.g. wide defenders and wide midfielders) (Sarmento et al., 2014). Similarly, wide players accelerate more often compared to central playing positions (Vigh-Larsen et al., 2017). Furthermore, central defenders display the smallest amount of dribblings and ball losses while forwards lose the ball the most of all playing positions (Dellal et al., 2011; Liu et al., 2015). Furthermore, wide midfielders and wide defenders cross the ball most frequently (Dellal et al., 2011; Liu et al., 2015). Moreover, forwards shoot the most, although they indicate the fewest ball possessions and play the fewest passes of all playing positions (Liu et al., 2015). Hence, the playing position influences match performance to a distinct degree.

Another tactical factor whose influence on match performance has been increasingly studied in recent years is tactical formation. Tactical formation describes the distribution of the players on the field at a team level. In detail, the tactical formation describes the number of players playing in each positional group focusing only on the vertical categorization mentioned above (e.g. 4-5-1 = 4 defenders, 5 midfielders, 1 forward) (Bauer et al., 2023). For instance, an investigation shows that players in a 4-3-3 formation perform more high-intensity runs than in a 4-4-2 formation (Aquino, Palucci Vieira, et al., 2017). Further, results indicate that players in a 4-5-1 formation perform more high-intensity runs when in possession of the ball compared to 4-4-2 or 4-3-3 formations (Bradley et al., 2011). Moreover, players competing in a 4-4-2 formation play more passes than in other formations (Arjol-Serrano et al., 2021; Bradley et al., 2011). In contrast, another study shows fewer passes for players in a 4-4-2 formation (Aquino et al., 2019). Furthermore, a recent study reveals a higher number of dribblings for teams in a 4-4-2 formation (Arjol-Serrano et al., 2021). Similarly, results are contradictory as another study shows the fewest dribblings for teams in a 4-4-2 formation (Bradley et al., 2011). Moreover, an experimental approach by Memmert et al. indicates that a 3-5-2 formation outperforms a 4-2-3-1 in different variables referring to the tactical-cognitive match performance (e.g. length per width ratio of the surface area, pressure passing efficiency) (Memmert et al., 2019). Concluding, tactical factors influence match performance, while the results regarding tactical formation still need to get more consistent and, thus, robust to draw comprehensive conclusions.

Third, social factors affecting the player can also influence match performance. In detail, in this dissertation, social factors concern the social framework in which the player behaves during a match. Social factors include, for example, the coach and the coaching staff surrounding the player (i.e. social environment). For instance, a study indicates that changing a coach can significantly improve the short-term performance of players (Gómez et al., 2021). In addition, the coach's behavior (e.g. competence, leadership) can affect group cohesion and a player's motivation (Fiorese et al., 2017; González-Ponce et al., 2022). As mentioned in the section on the psychological aspect of the individual complex match performance, motivation and other psychological constructs (e.g. team cohesion) can influence the match performance of an individual player. In this context, Cuenca clarifies that the motivational climate in a team can be affected by the coach to a large extent and that an advantageous motivational climate is essential for performance in soccer (2019). To sum up, the coach and his staff are an essential part of the social environment of a player and, therefore, can influence match performance.

The discussed topics about the coach directly lead to another social factor: the team in which the player is competing. In a team (i.e. a social group) various aspects need to be considered. Besides the group cohesion already mentioned above, the group structure (e.g. position, status, roles, and norms), the group process (e.g. objectives, cooperation, competition, communication, and collective efficacy), and the group output (i.e. the consequence of the group in soccer is the individual and team match performance) are important for functioning teams (González-Ponce et al., 2022). In soccer, for example, group cohesion and group processes (e.g. collective efficacy) are important moderators for match performance (Fiorese et al., 2017; Fuster-Parra et al., 2015). In addition, role ambiguity (= lack of information about the role) or role conflict (= contradiction between expected and established roles) can affect group cohesion and, therefore, possibly trigger team conflicts (González-Ponce et al., 2022). These group processes are crucial for a functioning and, hence, a well-performing team in soccer (González-Ponce et al., 2022). The presented studies and their results suggest that the coach(-ing staff) and the team are possibly important factors influencing match performance. However, a direct influence of social factors on various aspects of match performance (e.g. physical, technical, tactical-cognitive, and psychological) has not yet been investigated.

Fourth, the opposing team is another external factor influencing the match performance of a player (e.g. quality and tactics of the opponent). The most frequently studied factor related to the opponent is the quality (e.g. high [strong] vs. low [weak] quality of opposition). In detail, when a team is playing against a stronger opponent, the percentage of ball possession decreases (Lago, 2009; Lago & Martín, 2007; Lago-Peñas & Dellal, 2010). Moreover, teams reveal more passes but fewer dribbles when competing against stronger opponents (Taylor et al., 2008). Furthermore, players cover more total distance as well as distance in different speed zones (e.g. high-intensity) when playing against stronger opponents (Castellano et al., 2011; Lago et al., 2010; Lago-Peñas et al., 2011). In addition to opposition quality, as already mentioned in the section on tactical factors, the tactical orientation of the opponent also influences the performance of the players. For example, Carling reveals that players cover more total distance and pass the ball less often when the opponent plays in a 4-2-3-1 formation compared to a 4-4-2 formation (2011). In summary, the opponent (e.g. opponent quality, opponent tactics) influences the match performance of a player.

In the sections above, the influence of several external factors on the individual complex match performance was considered. However, the reciprocal influence within the external factors must also be included in the model. For example, situational variables, such as the scoreline, can change the tactical orientation of a team (e.g. be more defensive when leading vs. be more offensive when trailing). In addition, the quality of the opponent can influence whether and how the coaching staff interacts with the player (e.g. commands from the coach to help the players against strong opposing players). This excerpt of a variety of possible mutual influences within the environment of a match situation reinforces the importance of this topic. Therefore, the interaction of the situational context, the social factors, the tactical factors, and the opponent has to be considered when characterizing factors influencing the individual complex match performance in a modeling approach.

After the internal and external factors have been examined in detail, the interaction of the main parts of the model will be considered in the following. Therefore, to return to the individual complex match performance, the interaction of the main parts of the model (i.e. organism, environment, players' task) should be briefly outlined. As mentioned earlier, the individual complex match performance consists of the processing of the players' task and the solution of this task which results in a movement. Therefore, regarding the individual complex match performance aspects of movement planning and execution are included. This results in the individual complex match performance to be described in technical, physical, tactical-cognitive, and psychological aspects. Moreover, the organism and the environment influence how the players' task is characterized and how the task can be solved by the player. On the one hand, for example, speed (= part of the organism) influences whether a player can reach a through ball: If he is fast enough to reach the pass before his opponent, he may be able to shoot at goal (players' task = shot on goal). If he is slower than his opponent, he may have to enter a defensive duel to win the ball back (players' task = defensive duel). On the other hand, the playing position (= part of the environment) influences the frequency a player has to solve a certain match situation (= players' task) (e.g. central defenders compete in aerial duels more often than other playing positions). To sum up, internal (= organism) and external (= environment) factors influence the characteristics of the players' task, which in turn affects the outcome (i.e. outcome = the individual complex match performance). Based on this interaction, the structure of the model of the individual complex match performance in professional male soccer is created, which is illustrated in *Figure 2.4: Model of the individual complex match performance in professional male soccer*.

The outlined model approach, as already mentioned, attempts to incorporate the strengths of existing models (e.g. division of match performance into four sub-aspects) and also includes further strengths in the design. However, the model design also has limitations that should be addressed. Firstly, there are currently no studies examining the psychological part of the individual complex match performance. Secondly, the studies that examine the influence of factors from the environment or the organism on match performance refer almost exclusively to the physical and technical aspects of the individual complex match performance. With some exceptions, the effect of different variables on tactical-cognitive aspects of match performance has also been investigated. The effect of internal and external factors on psychological match performance aspects has not yet been investigated. Concluding, there is still a lack of research on some aspects of the presented model, which can be investigated by scientific studies in the future.

However, this directly leads to the ultimate benefit of the model. At the center of the presented model stands the visible and, therefore, measurable individual complex match performance. As already outlined, this structure allows deriving highly falsifiable hypotheses from this model that can subsequently be tested through scientific research. Therefore, future research can benefit from deriving highly falsifiable research questions and hypotheses based on the model approach, which then can be investigated with scientific research methods in the future. Moreover, the model approach provides an extensive overview of the variety of factors potentially influencing the individual complex match performance of a professional male soccer player. However, there are still gaps in the literature regarding some aspects of the model (e.g. psychological match performance). In addition, the model can never represent reality but attempts to describe soccer match performance based on structuring and simplification of reality. Concluding, the model contains some limitations which indeed can be balanced by the opportunities that come with this approach.

Building on the presentation of the model, the following chapter will provide information on how the questions of the scientific papers, which form the main part of this dissertation, can be derived from the *model of the individual complex match performance in professional male soccer*.

3 Aims and Scope of this Thesis

After in *1. Introduction* the topics of the dissertation were presented, in *2. Theoretical Background* a model of the match performance in soccer was evolved. In the following section, the aim is to derive research questions from the presented *model of the individual complex match performance in professional male soccer*, which will subsequently be subjected to falsification tests using empirical research methods. Therefore, the following section will outline the connection between the theoretical parts and the main sections of this dissertation, which consist of six scientific studies.

After the objectives and methods of the *Papers I* to *VI* have been briefly described in the upcoming paragraphs, the *model of the individual complex match performance in professional male soccer* introduced earlier will be linked to each paper. As outlined in the strengths of the presented model, the questions and hypotheses of *Papers I* to *VI* can be derived from this modeling approach. In the following, an individual figure locates each research question of the three research gaps in the structure of the model and, therefore, illustrates how the respective research question can be derived from the model.

As already noted, the aim of this dissertation is the tactical contextualization of the match performance in professional soccer, using the German Bundesliga as an example. One review and five original research articles, published in international peer-reviewed scientific journals (*Paper I-V*) or currently under review (*Paper VI*), address this aim. In the following, the aims and the general methodology of each paper will be outlined complemented by an illustrated overview of the structure of the included publications in *Figure 3.1*.

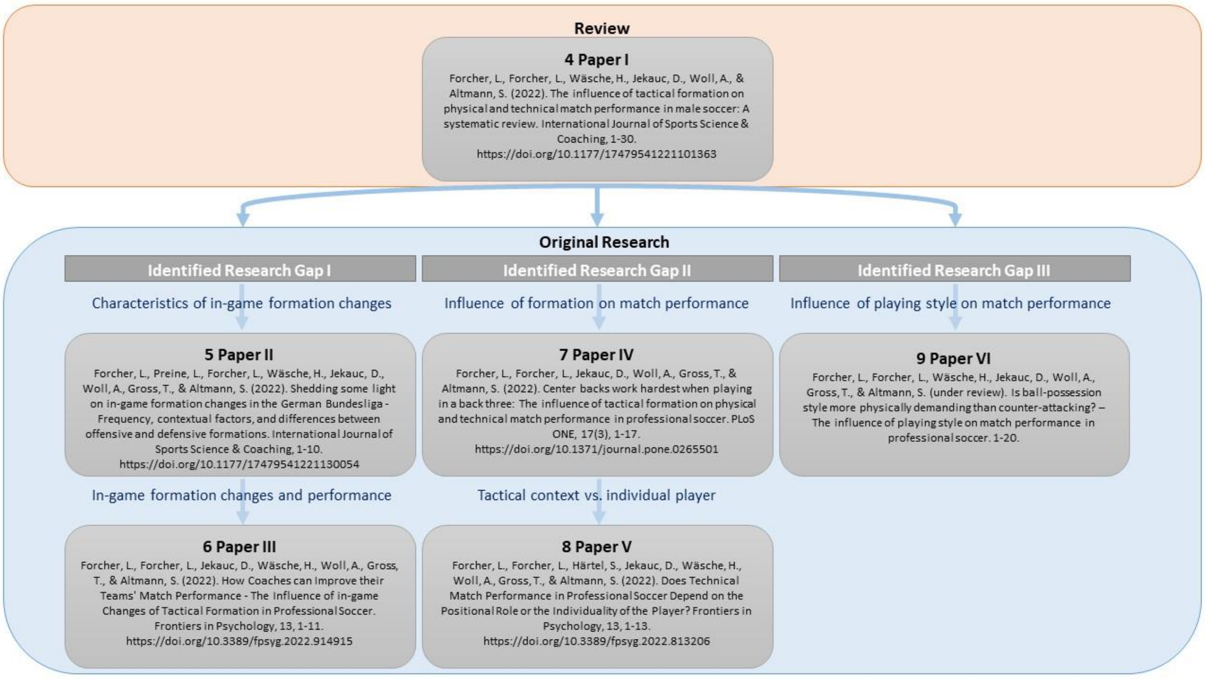

Figure 3.1: Overview of the structure of the included scientific papers.

3.1 Review [Paper I]

Paper I

The studies included in this dissertation deal with tactical factors and their influence on match performance in soccer. Tactical factors have experienced a rising interest in research and have already been studied frequently. So far, in this context, the playing position has been the main focus of research (Slimani & Nikolaidis, 2019). In addition to the playing position, the tactical factor of tactical formation has gained importance in soccer research in recent years. As indicated in *2 Theoretical Background*, several studies investigated the influence of tactical formation on match performance. However, the current state of research lacks an overview summarizing the influence of tactical formation on match performance. Therefore, *Paper I* aims to summarize the literature on the influence of tactical formation on the match performance of male soccer players. Additionally, the review addresses the effects of the combination of the tactical factors of playing position and tactical formation on match performance.

The review was conducted according to the guidelines for systematic reviews and summarizes the available literature (Page et al., 2021). The results of this review include the effect of tactical formation on physical and technical match performance. In addition, the effect of the combination of playing position and tactical formation on physical and technical match performance is addressed.

Subsequently, based on the results of the review, three main research gaps were identified, which are considered in the following sections. All three research gaps include the investigation of the influence of tactical factors on match performance in professional soccer and, therefore, can help to achieve the aim of this dissertation. By specifically addressing existing research gaps in this research field, the tactical contextualization of the match performance in professional soccer could be improved.

3.2 Identified Research Gap I - In-game Formation Changes [Paper II & III]

The results of *Paper I* have revealed a gap in the research on tactical factors in soccer. In detail, the studies included in the review (*Paper I*) either did not consider or excluded matches with formation changes within games [in-game]. Therefore, the first identified research gap regards the investigation of in-game formation changes and the effect these in-game changes of formation have on match performance.

Paper II

As mentioned above, all papers included in the review (*Paper I*) either did not address or excluded matches with an in-game formation change. As tactical formations can possibly change during matches, it could be decisive to control for in-game formation changes to avoid possible shortcomings. Furthermore, the included studies did not distinguish between offensive and defensive formations. As formations differ between the phases of play (e.g. attacking play or defensive play), it seems important to distinguish between offensive and defensive formations (Bauer et al., 2023). Therefore, *Paper II* aims to analyze the frequency of in-game formation changes, what contextual factors are associated with the in-game formation changes and the occurrence of differing offensive and defensive formations.

The sample of this study consists of video footage from 81 matches of the 2020/2021 German Bundesliga season. The data is collected through observation and each team is analyzed independently.

As *Paper II* only investigates the frequency of in-game formation changes, an essential link for future research is to investigate the influence of in-game formation changes on match performance. This perspective is examined in *Paper III*.

Paper III

Paper II reveals that in-game formation changes are a frequent tactical tool in the German Bundesliga. As outlined in *3.5 Environment [External Factors]* tactical factors can influence match performance. Therefore, one could conclude that changes in the tactical context occurring during matches (e.g. in-game formation change) could similarly influence the match performance of players. Therefore, *Paper III* aims to examine the effects of in-game formation changes on match performance. Furthermore, coach-specific differences regarding in-game formation changes are to be analyzed.

The sample for this investigation consists of video footage from three consecutive seasons of one single German Bundesliga team (= 98 matches). Each season respectively was managed by a different coach. Match performance is measured at a team level using a notational analysis of offensive and defensive performance indicators (e.g. goals).

After the objectives and methods of *Papers II* and *III* have been outlined, the *model of the individual complex match performance in professional male soccer* will be linked to each research question of *Identified Research Gap I* in *Figure 3.2*.

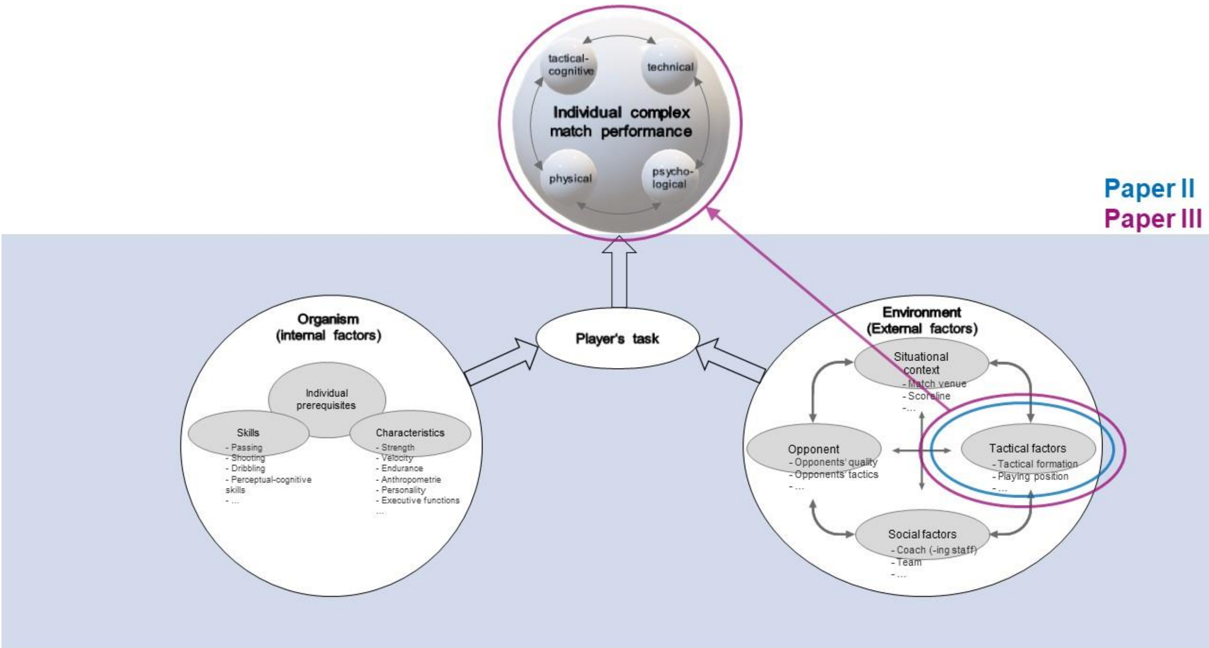

Figure 3.2: Location of Papers II and III in the model of the individual complex match performance in professional male soccer.

Both, *Papers II* and *Paper III*, investigate the tactical factor of tactical formation. In detail, the change of formation during the match and the influence of this change on the match performance is the main research interest in *Paper II* and *III*. On the one hand, *Paper II* examines the frequency of in-game formation changes [blue]. On the other hand, *Paper III* investigates the influence of in-game changes in tactical formation on match performance [purple]. To sum up, both studies mainly investigate tactical factors, with a special focus on changes in tactical formation during matches.

3.3 Identified Research Gap II – Influence of Formation/Individual [Paper IV & V]

Two major limitations of the studies included in *Paper I* are that these investigations used small samples (16-61 matches) and only compared two or three different tactical formations. As existing studies revealed a plurality of different tactical formations, it seems worthwhile investigating more than three distinct tactical formations to ensure an increased approximation to reality (Bauer et al., 2023). Therefore, the second identified research gap aims to investigate the effect of tactical formation on match performance using a large sample size and simultaneously compare a greater variety of different tactical formations.

Paper IV

The tactical context (e.g. tactical formation) can impact match performance in technical and physical aspects (see *3.5 Environment [External Factors]*). Therefore, it is important to capture the tactical context when attempting to examine influences on the match performance of professional soccer players. In this context, as outlined above, the results of *Paper I* indicated that it seems worthwhile investigating the influence of tactical formations on match performance using a larger sample and more distinct tactical formations. Thus, *Paper IV* aims to investigate whether tactical formation affects the physical and technical match performance of professional soccer players in the German Bundesliga.

The sample of *Paper IV* consists of technical and physical match performance data from 267 matches of the 2018/19 German Bundesliga season. Match performance is measured at an individual level and the effect of tactical formation (e.g. 4-4-2, 4-4-2 diamond, 4-2-2-2, 4-3-3, 4-5-1, 4-2-3-1, 3-4-3, 3-5-2) on match performance is analyzed independently for each positional group (e.g. wide defender, central defender, wide midfielder, central midfielder, and forward).

A fruitful avenue for future research resulting from the investigation of *Paper IV* is to analyze the proportion of the influence of tactical factors, such as the tactical formation and the playing position, on match performance. Therefore, *Paper V* addresses this research perspective.

Paper V

As mentioned in *3.4 Organism [Internal Factors]* different players feature different skills (e.g. technical skills like passing) and characteristics (e.g. physical capacities like endurance). Therefore, since players are different individuals they might reveal differing technical and physical match performance even though playing in the same tactical context (i.e. different players in the same playing position and tactical formation). Furthermore, the outlined scenario can be reversed. In detail, a player can also reveal similar technical and physical match performances even though the tactical context changes (i.e. similar player in another playing position and tactical formation). To address this topic, two previous investigations focused on the proportion of the contribution of individual characteristics and tactical factors to physical and technical match performance (Altmann et al., 2021; Schuth et al., 2016).

However, both investigations did not refer to the impact of tactical formations and focused solely on the playing position when considering the tactical context. Therefore, *Paper V* aims to investigate to which proportion the technical match performance of professional soccer players is dependent on the individuality of the player or on the tactical context (i.e. playing position and tactical formation).

The sample of *Paper V* consists of performance data from the 2018/19 German Bundesliga season (267 matches). The technical match performance data is analyzed at an individual level. First, players are identified who play in different playing positions. Second, normative data for each playing position and tactical formation is raised. Third, to explore to which extent players either adapted or maintained their performance when changing the tactical context (i.e. changing the playing position in a specific tactical formation), the players changing positions are compared to the normative data.

Following the brief presentation of the aims and methods of *Papers IV* and *Paper V*, the *model of the individual complex match performance in professional male soccer* will be linked to the studies included in *Identified Research Gap II* in *Figure 3.3*.

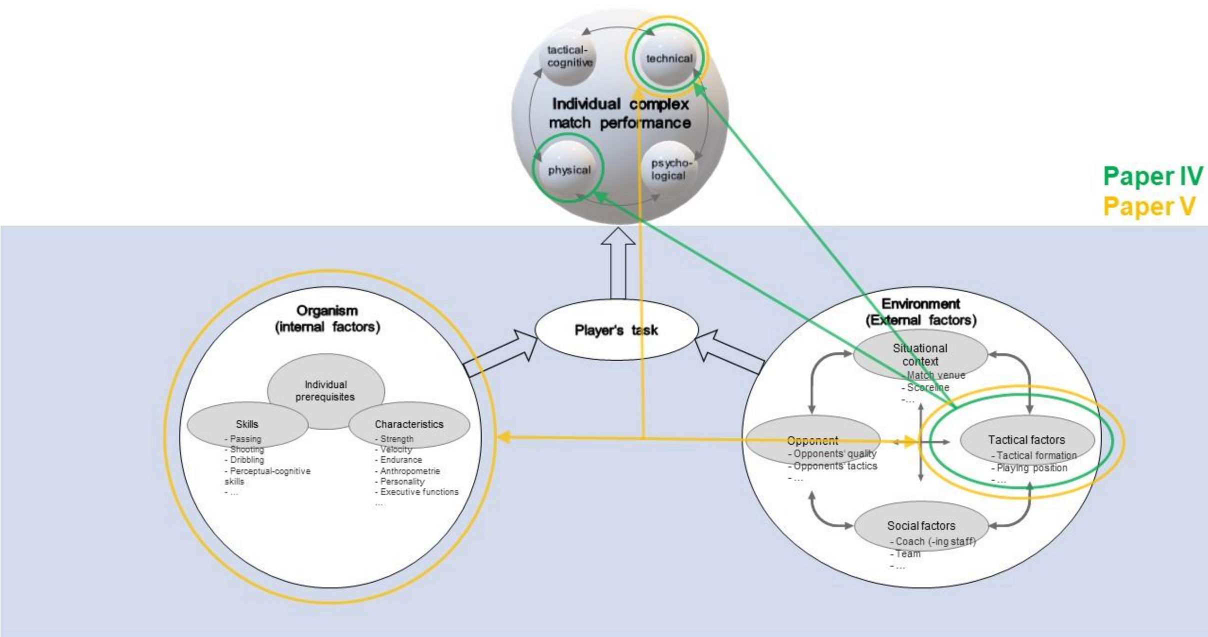

Figure 3.3: Location of Papers IV and V in the model of the individual complex match performance in professional male soccer.

Paper IV and *Paper V* study the influence of the combination of tactical factors tactical formation and playing position. *In detail, Paper IV* deals with the tactical factors of playing position and tactical formation and their influence on technical and physical match performance [green]. Furthermore, *Paper V* analyzes the effect of tactical factors, such as playing position and tactical formation, on technical match performance in comparison to the individuality of the respective player [yellow]. Concluding, studies of *Identified Research Gap II* investigate the influence of different tactical factors (e.g. playing position and tactical formation) on technical and physical match performance.

3.4 Identified Research Gap III – Influence of Playing Style [Paper VI]

After two major limitations of the studies included in *Paper I* have been examined and studied in *Identified Research Gaps I* and *II*, a further component of this dissertation is the exploration of further tactical factors and their influence on match performance. A tactical factor whose influence on match performance has rarely been studied to date is the playing style of a team.

Paper VI

Several studies have already investigated different playing styles in soccer (Kempe et al., 2014; Tenga & Larsen, 2003). Most studies reported different offensive playing styles (Redwood-Brown, 2008; Ruiz-Ruiz et al., 2013; Travassos et al., 2013). However, these studies mainly focused on the definition of different styles rather than examining the influence of those playing styles on match performance. Therefore, *Paper VI* aims to analyze the effect of offensive playing style on match performance as well as success-related factors.

The sample of *Paper VI* consists of official match data of 153 matches of the 2020/21 German Bundesliga season. The offensive playing style is examined using an already-existing formula that quantifies the offensive playing style (Kempe et al., 2014). Subsequently, the effect of the offensive playing style on physical and technical match performance as well as success-related parameters at a team level is investigated.

After presenting the objective of *Paper VI*, the *model of the individual complex match performance in professional male soccer* will be linked to the investigation of *Identified Research Gap III* in *Figure 3.4*.

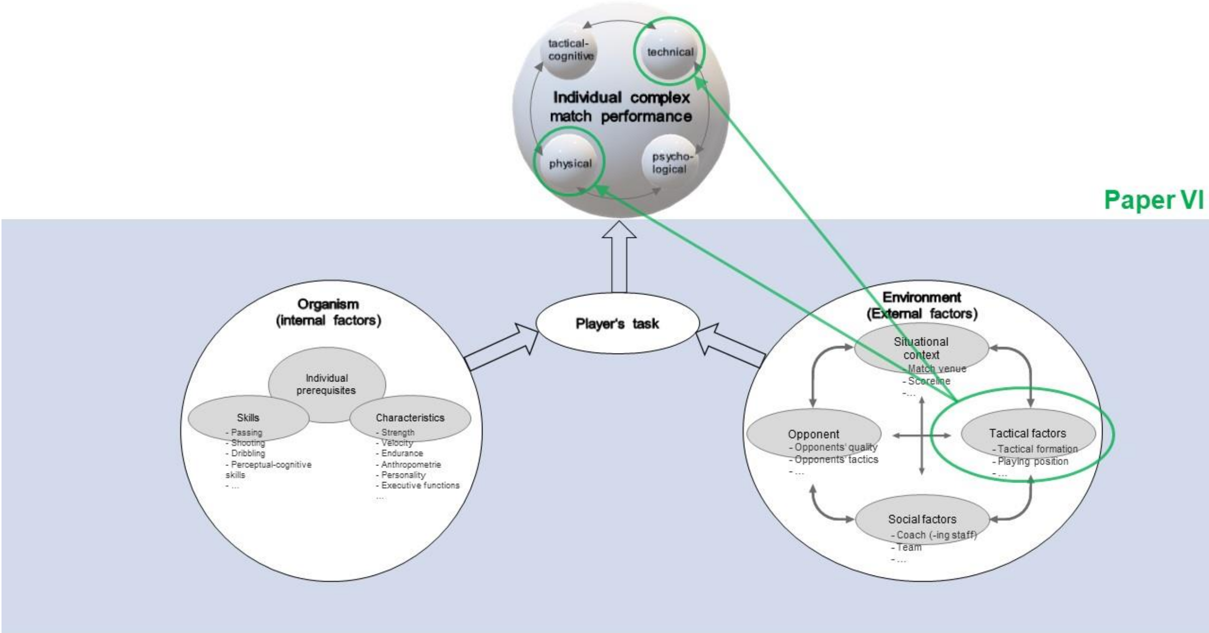

Figure 3.4: Location of Paper VI in the model of the individual complex match performance in professional male soccer.

As outlined above, *Paper VI* deals with the influence of tactical factors and their effect on match performance. In detail, *Paper VI* examines the effect of the tactical factor playing style on technical and physical match performance [green]. In summary, as can be deduced from this example, the research questions of all studies included in this dissertation deal with tactical factors and their influence on match performance in a multifaceted fashion.

4 The influence of tactical formation on physical and technical match performance in male soccer: A systematic review (Paper I)

Published version of the review article

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4.1 Abstract

The number of investigations that specifically address the influence of formation on soccer performance has increased in recent years. Since there is no overview that summarizes these effects, this systematic review aims to synthesize the available literature on the effects of tactical formation on physical and technical match performance.

According to the PRISMA 2020 guidelines, a systematic search was performed (Data Bases: PubMed, Web of Science). Studies were included, if they reported any physical (e.g. sprinting distance) or technical (e.g. number of passes) match performance parameter and compared at least two different formations. The study outcomes were synthesized descriptively.

The effect of formation on physical performance was investigated in ten studies while three studies investigated the effect on technical performance (11 studies included). The studies revealed that formation has an effect on physical and technical match performance of soccer players both on a team and a positional level. On a team level, smaller differences were observed for formations that are similar in the number of players in each playing position (i.e. 4-5-1, 4-2-3-1). Furthermore, physical match performance was higher in formations with three defenders (e.g. 3-5-2) in comparison to formations with four defenders (e.g. 4-4-2). On a positional level, all positions were affected in a similar way by formation.

Therefore, formation affects the physical and technical match performance of soccer players and if the playing position is also considered, the results become even more meaningful. The studies were very heterogenous regarding their methodology (i.e. parameters, sample size). The findings can help coaches to design their training programs and to prepare the players for a specific positional role depending on the tactical formation.

Keywords: team sports, football, tactics, running performance, technical performance

4.2 Highlights

- Tactical formation affects physical and technical match performance in soccer.

- On a team level, physical match performance is higher in formations with three defenders (e.g. 3-5-2) in comparison to formations with four defenders (e.g. 4-4-2).

- When comparing formations (i.e. 4-5-1, 4-2-3-1) on a team level, that are similar in the number of players in each playing position (defender, midfielders, forwards), the differences were smaller.

- On a positional level, all positional groups are affected in a similar way. However, the sprinting distance of full backs and central midfielders remained rather stable between tactical formations, while more pronounced differences were found for all remaining positions.

4.3 Introduction

In general, the performance of a soccer team is influenced by a variety of factors like the market value, playing at home or away, or the opponent quality (Lepschy et al., 2018, Lepschy et al., 2020, Lepschy et al., 2021). Since more and more investigations especially analyzed the physical (e.g. distance covered at different speed zones, number of sprints, number of decelerations) and technical (e.g. number of passes, number of dribbling's, number of shots) match performance of individual players, the influence of different contextual factors on individual soccer match performance was examined in different studies (Barrera et al., 2021; Lepschy et al., 2021; Paraskevas et al., 2020). For example, the origin of the league, the competitive level, and the quality of the opposition team impact the physical and technical match performance of soccer players (Dellal et al., 2011; Lago, 2009; Rampinini et al., 2007). Besides these contextual factors, tactical variables which could potentially influence match performance have recently received increasing attention.

Tactical factors (e.g. playing position, tactical formation) determine the way players behave on the pitch. In different situations (e.g. defending or attacking) players act differently according to their positional role in the tactical formation. To be more specific, players in distinct playing positions need to behave tactically different to help their team in various game-play situations. Previous studies have examined physical and technical match performance and were able to show that the players' performance is highly dependent on tactical factors (Altmann et al., 2021; Schuth et al., 2016). It is commonly accepted that the tactical factor playing position impacts the match performance of soccer players (Dolci et al., 2020). Looking at the physical performance, wide positions (wide midfielder, full back) display the highest high-intensity and sprinting distances (Aquino, Carling, Palucci Vieira, et al., 2020; Paraskevas et al., 2020; Rivilla-Garcia et al., 2018). Further, central midfielders show the highest total running distance of all positional groups (Aquino, Palucci Vieira, et al., 2017; Di Salvo et al., 2007; Vigh-Larsen et al., 2017). Regarding technical performance, forwards tend to most often lose duels and have most turnovers, while midfielders (wide, central) indicate more ball-possessions than other positions (Dellal et al., 2010).

In the following, another tactical factor should be considered: the tactical formation. Tactical formation is fundamentally defined by the number of players playing in each positional group. For example, a 4-4-2 formation consists of four defenders, four midfielders, and two forwards.

The tactical formation characterizes the distribution of the players on the pitch and therefore, influences the defensive and offensive interaction of the players during the match (Low et al., 2021; Memmert et al., 2019). Indeed, the match performance of different playing positions can change according to the tactical formation. Subsequently, the influence of tactical formations on physical and technical match performance was examined by an increasing amount of investigations. For example, Bradley et al. (2011) distinguished between three positional groups (defenders, midfielders, and attackers) and found that defenders showed lower total distance and high-intensity distance when playing in a 4-4-2 formation, compared to defenders in a 4-3-3 or 4-5-1 formation. Another investigation revealed that midfielders (central, wide, or offensive) play more passes in a 4-4-2 formation, than midfielders in a 4-2-3-1 formation (Arjol-Serrano et al., 2021).

Previous reviews have already looked at the match performance of soccer players from a variety of perspectives (Dolci et al., 2020; Forcher, Altmann, et al., 2022; Goes et al., 2020; Low et al., 2020; Sarmento et al., 2014). However, the current body of literature is characterized by heterogeneous methodological approaches, and an overview that summarizes the way tactical formation affects soccer match performance on a team and a positional level does not exist. Most of the mentioned reviews focused on collective behavior and do not consider the individual match performance of players. Therefore, this systematic review aims to synthesize the available literature on the effects of tactical formation on physical and technical match performance of male soccer players both on a team and a positional level. The results of this review could help scientists and practitioners to describe and understand the influence of tactical formation on physical and technical match performance. Further, they could facilitate selecting the players for a specific positional role in a particular tactical formation and adapting training and recovery processes to prepare the players for the demands of a specific position in a preferred tactical formation.

4.4 Methods

This systematic review was written according to the guidelines of the PRISMA 2020 statement (Page et al., 2021). The review was not registered prior to submission.

4.4.1 Data Bases and Search Strategy

The literature search was undertaken using the electronic databases PubMed and Web of Science. The search was executed on June 16, 2021. The following search phrases were used:

(1) Soccer OR Football

(2) Formation OR System OR Tactical OR Tactics

(3) Position OR Performance OR Physical OR Technical OR Load OR Running OR Acceleration OR Deceleration OR Total Distance OR High-intensity OR Sprinting OR Passing OR Shooting OR Crossing OR Dribbling OR Duel

First, each of the search items (1-3) was conducted independently according to Hands and Jonge (2020). Afterward, one Boolean search using the AND operator was performed. Accordingly, the results of both databases were combined to produce the total search outcome. One reviewer (LeoF) conducted the selection of articles by screening the titles, the abstracts, and subsequent the full-texts. If any discrepancies occurred, they were resolved through discussion until consensus was reached (LeoF, LeaF, SA, HW, DJ). There was no restriction on the publication date. Only articles written in English and published in peer-reviewed journals were considered. Further selection criteria are mentioned in the next paragraph. Later, a manual search was conducted by screening the reference list and by checking the citation list of each included paper.

4.4.2 Study Selection Criteria

To set clear inclusion and exclusion criteria, the PICOS method was used (see Paper I. Supplementary Table 1). Only investigations dealing with healthy male professional soccer players (adult & youth players) were included. The articles were only included when reporting any physical (e.g. distance covered at different speed zones, number of sprints, number of decelerations) or technical (e.g. number of passes, number of dribblings, number of shots) match performance parameter. Further, they had to compare at least two different tactical formations. Subsequently, articles that compared performance measures between playing positions but did not consider at least two tactical formations were excluded. Further, studies reporting results for only one tactical formation, including friendly matches or focusing on the effect of the opposition team tactical formation were excluded too. Review articles or conference abstracts were not considered in this systematic review.

4.4.3 Methodological Quality Assessment

All included articles were evaluated by one reviewer (LeoF) on methodological quality according to predetermined criteria (see Paper I. Supplementary Table 4 and Paper I. Supplementary Table 5). The criteria were adapted from Castellano et al. (Castellano et al., 2014) because they already examined methodological quality in a similar research field. To determine the overall quality, each fulfilled criterium was rewarded with one point, resulting in a maximum score of seven. The final scores were rated as low methodological quality for final scores below 50% (score 1-3.5), medium methodological quality for scores between 50-75% (score 4-5), and good methodological quality for final scores over 75% (6-7).

4.4.4 Data Extraction and Summary Measures

The data were extracted by one reviewer (LeoF), generally referring to study characteristics and outcome measures.

Study characteristics included variables like country, competition, playing season, the number of games, the number of players, and the number of teams that were included. Further, the tracking system of each study was reported. Tracking systems were either a global positioning system (GPS), a local positioning system (LPS), or a multicamera tracking system including the respective company. In addition, it was recorded how the tactical formations were collected and how in-game changes in tactical formation were handled. These study characteristics were included because previous studies have shown that those contextual factors can have an impact on the outcomes (Barnes et al., 2014; Dellal et al., 2011; Rampinini et al., 2007).

In the present review, all technical and physical match performance parameters that were investigated in the respective study were included. The results of the studies were divided by applying two differentiations. First, technical and physical outcomes were separated. Second, outcomes regarding the tactical formation only and outcomes that considered tactical formation in addition to playing position were separated as well. Hence, there are four separate outcome sections. To assess the effect of tactical formation on match performance, the percentage difference between the outcome measures of the different tactical formations was documented. Further, Cohen's d effect sizes [ES] were calculated for each physical or technical match performance parameter, respectively. To interpret the magnitude of differences, the ES were categorized into trivial (ES < 0.2), small (0.2 ≤ ES < 0.5), medium (0.5 ≤ ES < 0.8) and large (ES ≥ 0.8) effects (Cohen, 1988). If a study did not report ES themselves, the ES was calculated using the information provided in the respective articles. If the sample sizes for the respective groups were not mentioned in the specific article, the data were requested from the corresponding authors. In case the authors did not respond, ES could not be estimated.

Due to the expected small number of included studies we decided to synthesize the results descriptively.

If numeric data was missing or the results were obviously erroneous, the corresponding authors were contacted as well. When the respective authors did not respond, the particular sections were tagged subsequently (i.e. "not specified").

4.5 Results

4.5.1 Search Results and Study Selection

A flow diagram for the selection of the studies can be found in Figure 4.1. The results of the database searches are presented in Paper I. Supplementary Table 2. In total, 16,228 articles were identified. The manual search through reference lists and citing lists of included studies resulted in one additional article being identified. Screening of title and abstract resulted in 81 articles assessed for eligibility. Moving on, 70 articles were excluded due to the reasons presented in Figure 4.1. Exclusion reasons were: only one formation included (two articles) (Alves-Ferreira et al., 2020; Paraskevas et al., 2020), analyzing opposition tactical formation (two articles) (Aquino, Carling, Palucci Vieira, et al., 2020; Carling, 2011), or no formations included (66 articles).

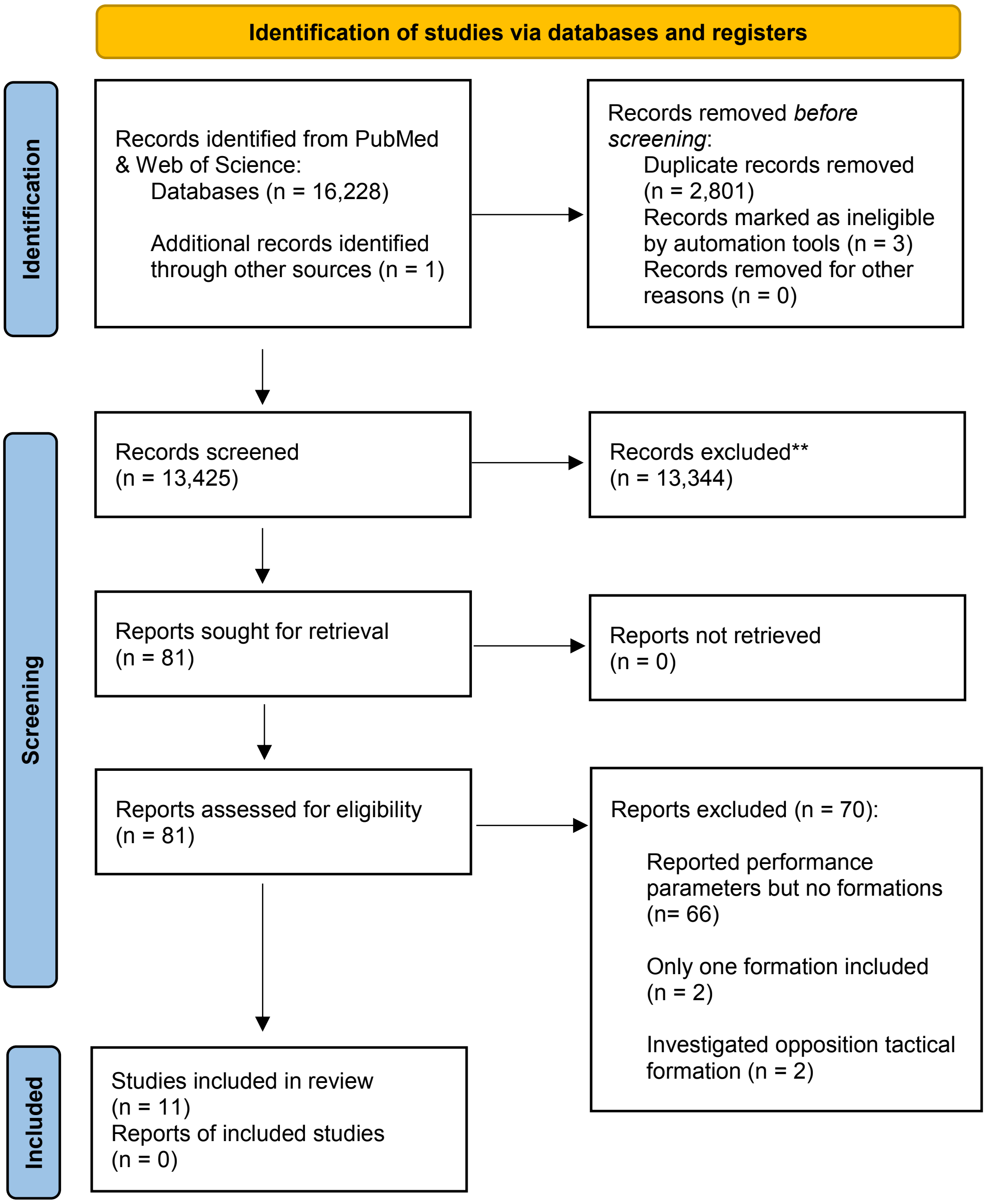

Figure 4.1. Flow diagram of the search and selection strategy for inclusion of articles.

4.5.2 Methodological Quality Assessment

All included articles (11) were assessed for methodological quality. For all studies, the average quality score was 5.0 (range 3-7) out of possible 7 points, leading to a medium overall rating of methodological quality.

All eleven included studies precisely stated the study purposes and clearly presented their results with statistical analysis. Most of the studies (Aquino et al., 2019; Aquino, Palucci Vieira, et al., 2017; Arjol-Serrano et al., 2021; Borghi et al., 2020; Modric et al., 2020; Riboli et al., 2021; Tierney et al., 2016; Vilamitjana et al., 2021) only mentioned the number of players or games but did not address the number of single-player match observations for every respective group. Further, six studies did only compare two different tactical formations.

4.5.3 Study Characteristics

Based on the suggestions of Rico-González et al. (2021), the characteristics of each study are described in Table 4.1. For each article, information about publication year, country, competition, season, the included games, the included players, the included teams, the tracking system, the respective company, the recording of tactical formation and the way each study dealt with in-game formation changes is provided. The studies were published from 2011 until 2021 and the recorded seasons ranged from 2006/07 until 2018/19. While two studies were conducted in England, Brazil, and Italy respectively, the remaining five studies were conducted in different countries (e.g. Norway, Russia, Croatia, Spain & Argentina). Five studies dealt with the first league and two studies with the second league of the respective country. The other four studies examined other competitions (e.g. U18/U21's, Sao Paulo State Season, World Cup Russia, U19's). The size of the data sets ranged from 16 to 61 games, 19 to 153 players, and 1 to 19 teams. From the included studies (eleven), three investigations compared five or more tactical formations. Moreover, two studies only compared two different tactical formations.

Most of the studies used global positioning (GPS) (six) and multi-camera tracking systems (three) to track the match performance while one study used both tracking systems. Only one study used a local positioning system (LPS).

All eleven included studies reported physical performance parameters. Moreover, three studies further investigated technical match performance. The most common physical parameters were total distance, jogging distance, medium-intensity distance, high-intensity distance, sprinting distance, number of sprints, number of high-intensity activities, acceleration, and decelerations. The most common technical parameters were the number of passes and dribblings.

While four studies collected formations through observation by two qualified coaches or researchers and one study collected formations through observation by one qualified coach, six studies did not provide information on the methodology used to collect tactical formation. Four studies excluded games with in-game formation changes and one study found no in-game formation changes. In the remaining six studies, the procedure with in-game formation changes was not explained.

Table 4.1. Study characteristics.

Article	Country	Competition	Season	Games included	Players included	Teams included	System	Company	Recording of tactical formation	Way to deal with in-game formation changes
Bradley et al. (2011)	England	FA Premier League	2006/07	20	153	10	Multiple-camera tracking	ProZone Sports Ltd.	Observation by two qualified coaches	Games with in-game formation changes were excluded
Tierney et al. (2016)	England	U18s und U21s	2014/15	43	46	2	GPS	Stat sports Newry	Not explained	Games with in-game formation changes were excluded
Aquino et al. (2017)	Brasil	Sao Paulo State Season, Brazilian season, 4th Brazilian season	2015-16	48	36	1	GPS	QSTARZ	Observation by one qualified coach	Games with in-game formation changes were excluded
Palucci Vieira et al. (2018)	Brasil	Sao Paulo First Divison, State Championship, Brazilian National Fourth divison, Brazilian National third divison	2015-17	59	40	1	GPS	QSTARZ	Not explained	Not explained
Baptista et al. (2019)	Norway	norwegian first division	2017	15	22	1	LPS	ZXY Sport	Observation by two qualified coaches	No games with in-game formation changes were found
Aquino et al. (2019)	Russia	World Cup in Russia	2018	61	Not specified	Not specified	Multi-camera tracking	STATS SportVU	Observation by two qualified scientists/aches	Observation throughout whole game time (it was not explained what happened with games with in-game formation changes)
Modric et al. (2020)	Croatia	Croation first division	2018/19	17	20	1	GPS	S7 Vector, Catapult	Not explained	Not explained
Borghi et al. (2020)	Italy	U19s professional	2017/18	31	23	1	GPS	PlayerTek	Not explained	Not explained
Arjol Serrano et al. (2021)	Spain	Spanish 2nd division	Not specified	31	23	1	GPS & Multi-camera tracking	APEX, WyScout	Observation by two qualified coaches	Games with in-game formation changes were excluded

Article	**Country**	**Competition**	**Season**	**Games included**	**Players included**	**Teams included**	**System**	**Company**	**Recording of tactical formation**	**Way to deal with in-game formation changes**
Borghi et al. (2020)	Italy	U19s professional	2017/18	31	23	1	GPS	PlayerTek	Not explained	Not explained
Arjol Serrano et al. (2021)	Spain	Spanish 2nd division	Not specified	31	23	1	GPS & Multi-camera tracking	APEX, WyScout	Observation by two qualified coaches	Games with in-game formation changes were excluded

4.5.4 Match Performance Outcomes and Main Findings

As mentioned above, the results of all eleven included studies were separated into four sections. First, the effect of tactical formation on physical performance and technical performance will be addressed separately. Second, the effect of the tactical formation in different playing positions will be outlined. Similarly, the physical and technical performance will be addressed individually. To get a robust summary of results, only performance parameters that were recorded in at least two (technical parameters) or three (physical parameters) studies will be analyzed in the following section.

4.5.4.1 Influence of the Tactical Formation on Physical Match Performance

10 studies analyzed the effect of the tactical formation on physical match performance (see Table 4.2).

Total distance

The effect of tactical formation on total distance was examined 10 times. The ES range was trivial to small (percentage difference range [PD]=0.02-10.30%; effect size range [ES]=0.01-0.44; ES not applicable for 2 studies). The studies showed that the tactical formations with the highest total distance were either 3-5-2 (Aquino et al., 2019; Baptista et al., 2019; Tierney et al., 2016) or 4-3-3 (Aquino, Palucci Vieira, et al., 2017a; Bradley et al., 2011; Palucci Vieira et al., 2018). No clear trend regarding the tactical formation with the lowest total distance was observed.

Jogging distance

The effect of the tactical formation on jogging distance (7-14 km/h / 7-15 km/h) was examined 2 times. The ES range was trivial to small (PD=0.22-10.51%; ES=0.01-0.28). No clear trend regarding the tactical formation with the highest and lowest jogging distance was observed.

Medium-intensity distance

The effect of the tactical formation on medium-intensity distance (≥ 14.4 km/h / 15.1-20 km/h / >14.4 km/h) was examined 3 times. The ES range was trivial to small (PD=0.19-8.36%; ES=0.02-0.18; ES not applicable for 1 study). The respective studies found the largest medium-intensity distance in 4-2-3-1 (Aquino et al., 2019; Arjol-Serrano et al., 2021) and the lowest in 4-4-2 (Aquino et al., 2019; Arjol-Serrano et al., 2021).

High-intensity distance

The effect of the tactical formation on high-intensity running distance (≥19.8 km/h / 20.1-25 km/h / >19.8 km/h) was examined 5 times. The ES range was trivial to medium (PD=0.13-

22.59%; ES=0.00-0.73; ES not applicable for 1 study). The highest high-intensity running distance was found in 4-4-2 (Arjol-Serrano et al., 2021; Carling, 2011) and 3-5-2 (Borghi et al., 2020; Tierney et al., 2016). However, Aquino et al. (2019) and Tierney et al. (2016) found the lowest high-intensity running distance for 4-4-2.

Sprinting distance

The effect of the tactical formation on sprinting distance (≥25.2 km/h / >25 km/h) was examined 3 times. The ES range was trivial to small (PD=0.00-25.39%; ES=0.00-0.33). No clear trend regarding the tactical formation with the highest and lowest sprinting distance was observed.

Number of sprints

The effect of the tactical formation on the number of sprints (≥25.2 km/h / >25 km/h) was examined 3 times. The ES range was trivial to large (PD=0.21-14.00%; ES=0.01-1.27; ES not applicable for 1 study). Studies showed that the tactical formations 4-3-3 (Aquino et al., 2019; Borghi et al., 2020) showed the highest, and the formation 4-4-2 (Aquino et al., 2019; Borghi et al., 2020) the lowest amount of sprints.

Number of high-intensity actions

The effect of the tactical formation on the number of high-intensity actions was examined 4 times. The ES range was trivial to medium (PD=1.67-29.51%; ES=0.05-0.64; ES not applicable for 1 study). Studies showed the highest number of high-intensity actions for the 4-3-3 (Aquino, Palucci Vieira, et al., 2017; Palucci Vieira et al., 2018) and the lowest for the 4-4-2 (Aquino, Palucci Vieira, et al., 2017; Palucci Vieira et al., 2018) formation.

Number of accelerations

The effect of the tactical formation on the number of accelerations was examined 4 times. The ES range was trivial to large (PD=2.94-26.32%; ES= 0.11-1.43; ES not applicable for 1 study). Studies revealed the highest number of accelerations for the 4-2-3-1 (Arjol-Serrano et al., 2021; Tierney et al., 2016) formation. No clear trend regarding the tactical formation with the lowest number of accelerations was observed.

Table 4.2. Results of the studies examining the effect of only tactical formation on physical performance. For each performance parameter respectively, the formations are mentioned in declining order regarding the outcome values. In parenthesis, the percental differences between the respective parameter values for each formation and following the effect sizes are presented.

Article	Formation	Results: Parameter	Results: Differences between formations (percentages; effect size)	Quality score
Bradley et al. (2011)	• 4-4-2 • 4-3-3 • 4-5-1	total distance	4-3-3 > 4-4-2 > 4-5-1 (0.79-1.63; 0.08-0.16)	7/7
		walking (0.7-7.1 km/h)	4-5-1 > 4-3-3 > 4-2-2 (1.51-31.82; 0.20-3.44)	
		jogging (7.2-14.3 km/h)	4-3-3 > 4-4-2 > 4-5-1 (0.33-4.44; 0.02-0.28)	
		high-intensity running (≥ 14.4 km/h)	4-3-3 > 4-4-2 > 4-5-1 (1.86-4.22; 0.07-0.15)	
		very high-intensity running (≥ 19.8 km/h)	4-4-2 > 4-3-3 > 4-5-1 (2.55-6.10; 0.07-0.18)	
		high intensive actions	4-4-2 > 4-3-3 > 4-5-1 (1.67-5.17; 0.05-0.16)	
Tierney et al. (2016)	• 4-4-2 • 4-3-3 • 3-5-2 • 3-4-3 • 4-2-3-1	Total distance	3-5-2 > 4-3-3 > 3-4-3 > 4-4-2 > 4-2-3-1 (0.36-4.82; 0.07-0.88)	6/7
		High-speed running (≥19,8 km/h)	3-5-2 > 3-4-3 > 4-2-3-1 > 4-3-3 > 4-4-2 (2.42-22.59; 0.09-0.73)	
		High metabolic load distance	3-5-2 > 4-2-3-1 > 3-4-3 > 4-3-3 > 4-4-2 (1.46-22.57; 0.06-1.61)	
		Accelerations	4-2-3-1 > 3-5-2 > 4-4-2 > 4-3-3 > 3-4-3 (2.94-26.32; 0.11-1.30)	
		Decelerations	4-2-3-1 > 3-5-2 > 3-4-3 > 4-3-3 > 4-4-2 (1.96-19.67; 0.08-0.93)	
Aquino et al. (2017)	• 4-4-2 • 4-3-3	Total distance	4-3-3 > 4-4-2 (10.30; not applicable)	5/7
		maximal sprinting speed	4-3-3 > 4-4-2 (6.51; not applicable)	
		mean speed	4-3-3 > 4-4-2 (6.12; not applicable)	
		high-intensity activities	4-3-3 > 4-4-2 (28.42; not applicable)	
Palucci Vieira et al. (2018)	• 4-4-2 • 4-3-3	total distance	4-3-3 > 4-4-2 (5.43; 0.40)	6/7
		maximal running speed	4-3-3 > 4-4-2 (6.02; 0.44)	
		mean speed	4-3-3 > 4-4-2 (5.77; 0.43)	
		high-intensity activities	4-3-3 > 4-4-2 (29.51; 0.64)	

Article	Formation	Parameter	Differences between formations (percentages; effect size)	Quality score
Baptista et al. (2019)	• 4-5-1 • 3-5-2	Total distance	3-5-2 > 4-5-1 (0.38; 0.29)	5/7
		High-intensity runs (≥19.8 km/h)	4-5-1 > 3-5-2 (9.00; 1.85)	
		High-intensity running distance (≥19.8 km/h)	4-5-1 > 3-5-2 (2.24; 0.33)	
		Sprints (≥25.2 km/h)	4-5-1 > 3-5-2 (14.00; 1.27)	
		Sprinting distance (≥25.2 km/h)	3-5-2 > 4-5-1 (1.07; 0.09)	
		Accelerations	4-5-1 > 3-5-2 (6.61; 1.43)	
		Acceleration distance	4-5-1 > 3-5-2 (4.89; 0.84)	
		Decelerations	4-5-1 > 3-5-2 (7.31; 1.49)	
		Deceleration distance	4-5-1 > 3-5-2 (6.43; 1.12)	
		Turns	4-5-1 > 3-5-2 (10.15; 1.75)	
Aquino et al. (2019)	• 4-2-3-1 • 4-3-2-1 • 3-4-3 • 4-3-3 • 4-4-2 • 3-3-2-2	Total distance	3-3-2-2 > 4-2-3-1 > 3-4-3 > 4-3-3 > 4-4-2 > 4-3-2-1 (0.02-4.51; 0.00-0.19)	5/7
		Sprints (>25 km/h)	4-3-3 > 4-2-3-1 > 3-3-2-2 > 3-4-3 > 4-3-2-1 > 4-4-2 (0.36-11.76; 0.01-0.23)	
		Maximum running speed	3-3-2-2 = 3-4-3 > 4-3-3 > 4-3-2-1 > 4-2-3-1 > 4-4-2 (0.36-2.21; 0.00-0.14)	
		Walking distance (0-7 km/h)	4-3-2-1 > 3-3-2-2 > 4-2-3-1 > 4-4-2 > 4-3-3 > 3-4-3 (0.11-12.10; 0.01-1.07)	
		Jogging distance (7.1-15 km/h)	3-3-2-2 > 4-2-3-1 > 4-3-3 > 3-4-3 > 4-4-2 > 4-3-2-1 (0.22-10.51; 0.01-0.28)	
		High-intensity running distance (15.1-20 km/h)	4-2-3-1 > 3-3-2-2 > 3-4-3 > 4-3-3 > 4-3-2-1 > 4-4-2 (0.19-8.36; 0.02-0.15)	
		Very high-intensity running distance (20.1-25 km/h)	4-2-3-1 > 4-3-3 > 4-3-2-1 > 3-3-2-2 > 3-4-3 > 4-4-2 (0.13-9.97; 0.00-0.20)	
		Sprinting distance (>25 km/h)	3-3-2-2 > 4-3-2-1 > 3-4-3 = 4-3-3 > 4-2-3-1 > 4-4-2 (0.00-25.39; 0.00-0.33)	

Article	Formation	Results		Quality score
Arjol-Serrano et al. (2021)	4-2-3-1 4-4-2	**Parameter**	**Differences between formations (percentages; effect size)**	3/7
		Total distance	4-2-3-1 > 4-4-2 (0.84; not applicable)	
		Distance >14.4 km/h	4-2-3-1 > 4-4-2 (2.89; not applicable)	
		Distance >19.8 km/h	4-4-2 > 4-2-3-1 (4.98; not applicable)	
		Distance >25.0 km/h	4-4-2 > 4-2-3-1 (16.78; not applicable)	
		Accelerations (2-4 ms^2)	4-2-3-1 > 4-4-2 (5.62; not applicable)	
		Accelerations (>4 ms^2)	4-4-2 > 4-2-3-1 (17.65; not applicable)	
		Decelerations (2-4 ms^2)	4-2-3-1 > 4-4-2 (8.22; not applicable)	
		Decelerations (>4 ms^2)	4-4-2 > 4-2-3-1 (6.67; not applicable)	
Vilamitjana et al. (2021)	3-4-3 4-2-3-1	**Parameter**	**Differences between formations (percentages; effect size)**	3/7
		High intensity load rate [m/min]	4-2-3-1 > 3-4-3 (7.78; not applicable)	
		High speed running/sprints load rate [m/min]	4-2-3-1 > 3-4-3 (14.10; not applicable)	
		High speed runs	3-4-3 = 4-2-3-1 (0.00; not applicable)	
		Sprints	4-2-3-1 > 3-4-3 (13.89; not applicable)	
		Mean heart rate	4-2-3-1 > 3-4-3 (0.41; not applicable)	
		Maximal heart rate	4-2-3-1 > 3-4-3 (0.21; not applicable)	
Riboli et al. (2021)	3-4-1-2 3-4-2-1 3-5-2 4-3-3 4-4-2	**Parameter**	**Differences between formations (percentages; effect size)**	6/7
		1 min peak: Total distance	4-4-2 > 3-4-2-1 > 4-3-3 > 3-4-1-2 > 3-5-2 (0.11-0.95; 0.01-0.07)	
		1 min peak: High speed running distance (15-20 km/h)	4-4-2 > 3-4-2-1 > 3-5-2 = 4-3-3 > 3-4-1-2 (0.00-2.86; 0.00-0.12)	
		1 min peak: Very High speed running distance (20-24 km/h)	4-4-2 > 3-5-2 = 4-3-3 > 3-4-1-2 > 3-4-2-1 (0.00-7.07; 0.00-0.27)	
		1 min peak: Sprint distance (>20 km/h)	3-4-2-1 > 3-4-1-2 > 4-4-2 > 4-3-3 > 3-5-2 (0.51-11.11; 0.01-0.27)	
		1 min peak: Acceleration/Deceleration	3-4-2-1 > 3-4-1-2 > 3-5-2 > 4-3-3 > 4-4-2 (0.92-10.65; 0.04-0.48)	
		1 min peak: Metabolic power	3-4-2-1 > 3-4-1-2 > 3-5-2 > 4-3-3 > 4-4-2 (0.50-6.15; 0.03-0.19)	
		1 min peak: High metabolic load distance (>20 W/kg)	3-4-2-1 = 4-4-2 > 3-4-1-2 > 4-3-3 > 3-5-2 (0.00-2.15; 0.02-0.10)	

Article	Formation	Results		Quality score
		Parameter	**Differences between formations (percentages; effect size)**	
Borghi et al. (2020)	4-4-2 4-3-3 3-5-2	Total distance	4-4-2 > 3-5-2 > 4-3-3 (1.15-4.27; 0.12-0.44)	5/7
		High speed running distance (>19.8 km/h)	3-5-2 > 4-4-2 > 4-3-3 (0.18-0.78; 0.01-0.03)	
		Powerplays (> 22 W/kg)	3-5-2 > 4-4-2 > 4-3-3 (0.07-0.85; 0.00-0.03)	
		Powerscore (W/kg)	4-4-2 > 4-3-3 > 3-5-2 (1.92-6.62; 0.21-0.76)	
		Sprints (>25 km/h)	4-3-3 > 3-5-2 > 4-4-2 (0.21-1.72; 0.01-0.05)	
		Accelerations	3-5-2 > 4-3-3 > 4-4-2 (3.19-8.42; 0.17-0.41)	

4.5.4.2 Influence of the Tactical Formation on Technical Match Performance

3 studies analyzed the effect of tactical formation on technical match performance (see Table 4.3).

Number of passes

The effect of the tactical formation on the number of passes was examined 2 times. The ES range was trivial to large (PD=0.00-51.42%; ES=0.00-0.96; ES not applicable for 1 study). Studies revealed that the highest number of passes were played in the 4-4-2 formation (Arjol-Serrano et al., 2021; Bradley et al., 2011). No clear trend regarding the tactical formation with the lowest number of passes was observed.

Number of dribblings

The effect of the tactical formation on the number of dribblings was examined 2 times. The ES range was trivial to large (PD==14.29-40.00%; ES=0.09-0.21; ES not applicable for 1 study). No clear trend regarding the tactical formation with the highest and lowest number of dribblings was observed.

Table 4.3. Results of the studies examining the effect of only tactical formation on technical performance. For each performance parameter respectively, the formations are mentioned in declining order regarding the outcome values. In parenthesis, the percental differences between the respective parameter values for each formation and following the effect sizes are presented.

Article	Formation	Results		Quality score
Bradley et al. (2011)	4-4-2 4-3-3 4-5-1	**Parameter**	**Differences between formations (percentages; effect size)**	7/7
		passes	4-4-2 > 4-3-3 > 4-5-1 (11.46-51.42; 0.23-0.96)	
		% succesful passes	4-4-2 > 4-3-3 > 4-5-1 (2.51-11.03; 0.13-0.61)	
		Passes received	4-4-2 > 4-3-3 > 4-5-1 (11.36-37.75; 0.23-0.80)	
		Touches per possession	4-3-3 > 4-4-2 > 4-5-1 (3.85-8.33; 0.18-0.33)	
		Dribbles	4-3-3 > 4-5-1 > 4-4-2 (25.00-40.00; 0.09-0.21)	
		Final third entries	4-3-3 > 4-4-2 > 4-5-1 (6.35-14.55; 0.10-0.21)	
		Possessions won	4-4-2 > 4-3-3 > 4-5-1 (5.07-24.59; 0.10-0.41)	
		Possessions lost	4-3-3 > 4-4-2 > 4-5-1 (3.11-8.17; 0.11-0.24)	
Aquino et al. (2019)	• 4-2-3-1 • 4-3-2-1 • 3-4-3 • 4-3-3 • 4-4-2 • 3-3-2-2	**Parameter**	**Differences between formations (percentages; effect size)**	5/7
		Ball possession (%)	3-3-2-2 > 4-2-3-1 > 4-3-3 > 3-4-3 > 4-3-2-1 > 4-4-2 (1.20-15.81; 0.08-0.93)	
		Ball possession - defensive zone (%)	4-3-3 > 3-4-3 > 4-4-2 > 4-3-2-1 > 4-2-3-1 > 3-3-2-2 (0.67-22.22; 0.03-0.87)	
		Ball possession - midfield zone (%)	3-4-3 > 3-3-2-2 > 4-3-2-1 > 4-2-3-1 > 4-3-3 > 4-4-2 (0.18-12.38; 0.01-0.87)	
		Ball possession - attack zone (%)	4-2-3-1 > 4-4-2 > 3-3-2-2 > 4-3-3 = 4-3-2-1 > 3-4-3 (0.00-27.81; 0.00-0.90)	
		Completed passes	4-2-3-1 > 3-3-2-2 > 3-4-3 > 4-3-3 > 4-3-2-1 > 4-4-2 (0.08-58.51; 0.00-1.07)	

Article	Formation	Results: Parameter	Results: Differences between formations (percentages; effect size)	Quality score
Arjol-Serrano et al. (2021)	• 4-2-3-1 • 4-4-2	Game volume	4-4-2 > 4-2-3-1 (16.29; not applicable)	3/7
		Ratio interceptions-turnover	4-4-2 > 4-2-3-1 (1000.00; not applicable)	
		Defensive volume	4-4-2 > 4-2-3-1 (5.04; not applicable)	
		Interceptions	4-4-2 > 4-2-3-1 (14.29; not applicable)	
		Opposing pitch interceptions	4-2-3-1 = 4-4-2 (0.00; not applicable)	
		Defensive volume	4-4-2 > 4-2-3-1 (5.04; not applicable)	
		Clearances	4-4-2 > 4-2-3-1 (9.09; not applicable)	
		Offensive volume	4-4-2 > 4-2-3-1 (18.32; not applicable)	
		Total pass	4-4-2 > 4-2-3-1 (17.74; not applicable)	
		Long pass	4-4-2 > 4-2-3-1 (1.79; not applicable)	
		Short-medium pass	4-4-2 > 4-2-3-1 (19.89; not applicable)	
		Forward pass	4-4-2 > 4-2-3-1 (16.25; not applicable)	
		Attack zone pass	4-4-2 > 4-2-3-1 (2.99; not applicable)	
		Goal shot	4-4-2 > 4-2-3-1 (30.00; not applicable)	
		Crosses	4-2-3-1 > 4-4-2 (30.00; not applicable)	
		Dribbles	4-4-2 > 4-2-3-1 (14.29; not applicable)	

4.5.4.3 Influence of the Tactical Formation in Different Playing Positions on Physical Match Performance

9 studies analyzed the effect of tactical formation in different playing positions on physical match performance (see Table 4.4).

Total distance

The effect of the tactical formation in different playing positions on total distance was examined 7 times. For center backs (5 studies), the ES range was trivial to large (PD=0.11-8.64%; ES=0.08-1.31; ES not applicable for 2 studies). Center backs showed the highest total distance in 3-5-2 (Borghi et al., 2020; Modric et al., 2020; Tierney et al., 2016) and the smallest in 4-4-2 (Arjol-Serrano et al., 2021; Modric et al., 2020) or 4-3-3 (Borghi et al., 2020; Tierney et al., 2016) formations. For full backs (4 studies), the ES range was large (PD=1.39-9.14%; ES=0.96-5.58; ES not applicable for 2 studies). Full backs showed the highest total distance in either 3-5-2 (Baptista et al., 2019; Modric et al., 2020; Tierney et al., 2016) or 4-4-2 (Arjol-Serrano et al., 2021; Borghi et al., 2020) formations. No clear trend regarding the tactical formation with the lowest total distance for full backs was observed. For central midfielders (4 studies), the ES range was trivial to large (PD=0.12-7.25%; ES=0.02-0.83; ES not applicable for 2 studies). Central midfielders showed the smallest total distance in the 4-4-2 (Arjol-Serrano et al., 2021; Tierney et al., 2016) or the 3-5-2 (Baptista et al., 2019; Borghi et al., 2020) formation. No clear trend regarding the tactical formation with the highest total distance for central midfielders was observed. For wide midfielders (3 studies), the ES range was trivial to large (PD=0.27-6.89%; ES=0.07-1.48; ES not applicable for 2 studies). Wide midfielder showed the smallest total distance in 4-2-3-1 (Arjol-Serrano et al., 2021; Tierney et al., 2016) and the largest in 4-4-2 (Arjol-Serrano et al., 2021; Borghi et al., 2020) formation. For forwards (5 studies), the ES range was trivial to large (PD=0.08-25.32%; ES=0.02-1.00; ES not applicable for 2 studies). Forwards showed the largest total distance in 3-5-2 (Baptista et al., 2019; Modric et al., 2020; Tierney et al., 2016) and the smallest in 4-4-2 (Arjol-Serrano et al., 2021; Modric et al., 2020) formations.

High-intensity distance

The effect of the tactical formation in different playing positions on high-intensity distance (≥19.8 km/h / >19.8 km/h) was examined 7 times. For center backs (5 studies), the ES range was trivial to large (PD=2.02-30.84%; ES=0.19-1.00; ES not applicable for 2 studies). Center backs showed the highest high-intensity distance in the 3-5-2 (Modric et al., 2020; Tierney et al., 2016) and the smallest in the 4-4-2 (Arjol-Serrano et al., 2021; Borghi et al., 2020; Modric et al., 2020) formation. For full backs (4 studies), the ES was large (PD=1.17-42.76%; ES=0.33-1.57; ES not applicable for 2 studies). Full backs showed the highest high-intensity distance in 3-5-2 (Modric et al., 2020; Tierney et al., 2016) and the smallest in 4-4-2 (Arjol-Serrano et al., 2021; Modric et al., 2020) formations. For central midfielders (4 studies), the ES range was small to large (PD=3.08-38.65%; ES=0.39-0.90; ES not applicable for 2 studies). Central midfielders showed the highest high-intensity distance in the 3-5-2 (Borghi et al., 2020; Tierney et al., 2016) and the smallest in the 4-4-2 (Arjol-Serrano et al., 2021; Tierney et al., 2016) formation. For wide midfielders (3 studies), the ES was large (PD=0.97-19.27%; ES=1.33; ES not applicable for 2 studies). No clear trend regarding the tactical formation with the highest or lowest high-intensity distance for wide midfielders was observed. For forwards (5 studies), the ES range was trivial to large (PD=1.69-153.26%; ES=0.08-0.88; ES not applicable for 2 studies). Forwards showed the highest high-intensity distance in the 3-5-2 (Baptista et al., 2019; Modric et al., 2020; Tierney et al., 2016) or 4-4-2 (Arjol-Serrano et al., 2021; Borghi et al., 2020) formation and the smallest in the 4-2-3-1 (Arjol-Serrano et al., 2021; Tierney et al., 2016) formation.

Sprinting distance

The effect of the tactical formation in different playing positions on sprinting distance (≥25.2 km/h / >25.0 km/h) was examined 4 times. For center backs (3 studies), the ES range was small to medium (PD=13.21-40.53%; ES=0.33-0.53; ES not applicable for 1 study). Center backs showed the highest sprinting distance in 3-5-2 (Baptista et al., 2019; Modric et al., 2020) and the smallest in 4-4-2 (Arjol-Serrano et al., 2021; Modric et al., 2020) formations. For full backs (2 studies), the ES was small (PD=0.56-11.33%; ES=0.23; ES not applicable for 1 study). Full backs showed the lowest sprinting distance in the 4-4-2 (Arjol-Serrano et al., 2021; Modric et al., 2020) formation. No clear trend regarding the tactical formation with the lowest sprinting distance for full backs was observed. For central midfielders (2 studies), the ES was small (PD=6.69-77.08%; ES=0.24; ES not applicable for 1 study). No clear trend regarding the tactical formation with the highest and lowest sprinting distance for central midfielders was observed. For wide midfielders (1 study), no ES could be calculated (PD=15.79%; ES=ES not applicable for 1 study). No clear trend regarding the tactical formation with the highest and lowest sprinting distance for wide midfielders was observed. For forwards (3 studies), the ES range was medium to large (PD=20.49-30.99%; ES=0.50-1.11; ES not applicable for 1 study).

Forwards showed the highest sprinting distance in the 3-5-2 (Baptista et al., 2019; Modric et al., 2020) formation. No clear trend regarding the tactical formation with the lowest sprinting distance for forwards was observed.

Number of sprints

The effect of the tactical formation in different playing positions on the number of sprints (≥25.2 km/h / >25.0 km/h) was examined 3 times. For center backs (3 studies), the ES range was trivial to medium (PD=3.13-7.60%; ES=0.18-0.57; ES not applicable for 1 study). Center backs showed the highest amount of sprints in the 3-5-2 (Borghi et al., 2020; Modric et al., 2020) and the smallest amount in the 4-4-2 (Borghi et al., 2020; Modric et al., 2020) formation. For full backs (2 studies), the ES range was small to large (PD=2.44-7.69%; ES=0.28-0.92; ES not applicable for 1 study). Full backs showed the fewest sprints in the 4-4-2 (Arjol-Serrano et al., 2021; Modric et al., 2020) formation. No clear trend regarding the tactical formation with the highest amount of sprints for full backs was observed. For central midfielders (3 studies), the ES range was trivial to medium (PD=0.04-12.56%; ES=0.13-0.51; ES not applicable for 1 study). No clear trend regarding the tactical formation with the highest and lowest amount of sprints for central midfielders was observed. For wide midfielders (2 studies), the effect was large (PD=6.36-23.19%; ES=1.57; ES not applicable for 1 study). No clear trend regarding the tactical formation with the highest and lowest amount of sprints for wide midfielders was observed. For forwards (3 studies), the ES range was trivial to medium (PD=0.26-11.95%; ES=0.01-0.54; ES not applicable for 1 study). Forwards showed the fewest sprints in the 4-4-2 (Arjol-Serrano et al., 2021; Borghi et al., 2020) formation. No clear trend regarding the tactical formation with the highest amount of sprints for forwards was observed.

Number of accelerations

The effect of the tactical formation in different playing positions on the number of accelerations was examined 5 times. For center backs (4 studies), the ES range was trivial to medium (PD=3.13-7.60%; ES=0.18-0.57; ES not applicable for 1 study). Center backs showed the most accelerations in the 3-5-2 (Borghi et al., 2020; Modric et al., 2020) and the least in the 4-4-2 (Borghi et al., 2020; Modric et al., 2020) formation. For full backs (3 studies), the ES range was small to large (PD=2.44-7.69%; ES=0.28-0.92; ES not applicable for 1 study). Full backs showed the least accelerations in the 4-4-2 (Arjol-Serrano et al., 2021; Modric et al., 2020) formation. No clear trend regarding the tactical formation with the highest amount of accelerations for full backs was observed. For central midfielders (3 studies), the ES was large

(PD=0.81-12.56%; ES=0.04-1.13; ES not applicable for 1 study). No clear trend regarding the tactical formation with the highest and lowest amount of accelerations for central midfielders was observed. For wide midfielders (2 studies), the ES was large (PD=6.36-23.19; ES=1.57; ES not applicable for 1 study). No clear trend regarding the tactical formation with the highest and lowest amount of accelerations for wide midfielders was observed. For forwards (4 studies), the ES range was trivial to medium (0.26-11.95%; ES=0.01-0.54; ES not applicable for 1 study). Forwards showed the least accelerations in the 4-4-2 (Arjol-Serrano et al., 2021; Borghi et al., 2020) formation. No clear trend regarding the tactical formation with the highest amount of accelerations for forwards was observed.

Number of decelerations

The effect of the tactical formation in different playing positions on the number of decelerations was examined 4 times. For center backs (3 studies), the ES range was small to large (PD=2.90-12.50%; ES=0.28-0.97; ES not applicable for 1 study). Center backs showed the least decelerations in the 4-4-2 (Arjol-Serrano et al., 2021; Modric et al., 2020) formation. No clear trend regarding the tactical formation with the highest amount of decelerations for center backs was observed. For full backs (2 studies), the ES was medium (PD=4.11-6.29%; ES=0.73; ES not applicable for 1 study). Full backs showed the least decelerations in the 4-4-2 (Arjol-Serrano et al., 2021; Modric et al., 2020) formation. No clear trend regarding the tactical formation with the highest amount of decelerations for full backs was observed. For central midfielders (2 studies), the ES was large (PD=1.80-8.10%; ES=0.82; ES not applicable for 1 study). No clear trend regarding the tactical formation with the highest and lowest amount of decelerations for central midfielders was observed. For wide midfielders (1 study), no ES could be calculated (PD=11.18%; ES=not applicable; ES not applicable for 1 study). No clear trend regarding the tactical formation with the highest and lowest amount of decelerations for wide midfielders was observed. For forwards (3 studies), the ES range was medium (PD=5.89-18.75%; ES=0.53-0.60; ES not applicable for 1 study). Forwards showed the least decelerations in the 4-4-2 (Arjol-Serrano et al., 2021; Modric et al., 2020) formation. No clear trend regarding the tactical formation with the highest amount of decelerations for forwards was observed.

Table 4.4. Results of the studies examining the effect of playing positions in different tactical formations on physical performance. For each performance parameter respectively, the formations are mentioned in declining order regarding the outcome values. In parenthesis, the percental differences between the respective parameter values for each formation and following the effect sizes are presented.

Article	Formation	Position	Results: Parameter	Results: Position	Results: Differences between formations (percentages; effect size)	Quality score
Bradley et al. (2011)	• 4-4-2 • 4-3-3 • 4-5-1	• Defender • Midfielder • Attacker	total distance	Defender	4-4-2 > 4-5-1 > 4-3-3 (0.49-3.76; 0.06-0.48)	7/7
				Midfielder	4-5-1 > 4-3-3 > 4-4-2 (0.17-0.80; 0.03-0.13)	
				Attacker	4-3-3 > 4-5-1 > 4-4-2 (0.30-11.17; 0.03-1.26)	
			High-intensive actions	Defender	4-4-2 > 4-3-3 > 4-5-1 (5.38-19.35; 0.14-0.51)	
				Midfielder	4-5-1 > 4-4-2 > 4-3-3 (0.68-8.96; 0.03-0.43)	
				Attacker	4-3-3 > 4-4-1 > 4-5-1 (1.85-31.48; 0.08-1.12)	
			Recovery time	Defender	4-5-1 > 4-3-3 > 4-4-2 (4.29-20.00; 0.11-0.59)	
				Midfielder	4-3-3 > 4-5-1 > 4-4-2 (4.88-11.36; 0.21-0.56)	
				Attacker	4-5-1 > 4-4-2 > 4-3-3 (3.64-26.19; 0.15-0.93)	
			high-intensity running (≥ 14.4 km/h)	Defender	4-4-2 > 4-3-3 > 4-5-1 (0.50-11.19; 0.14-0.51)	
				Midfielder	4-5-1 > 4-4-2 > 4-3-3 (1.90-6.05; 0.03-0.43)	
				Attacker	4-3-3 > 4-5-1 > 4-4-2 (3.56-28.08; 0.08-1.12)	
			very high-intensity running (≥ 19.8 km/h)	Defender	4-4-2 > 4-3-3 > 4-5-1 (0.40-15.24; 0.01-0.38)	
				Midfielder	4-4-2 > 4-5-1 > 4-3-3 (1.36-13.50; 0.06-0.48)	
				Attacker	4-3-3 > 4-4-1 > 4-5-1 (9.20-32.76; 0.35-1.24)	

Article	Formation	Position	Results: Parameter	Results: Position	Results: Differences between formations (percentages; effect size)	Quality score
Tierney et al. (2016)	• 4-4-2 • 4-3-3 • 3-5-2 • 3-4-3 • 4-2-3-1	• Center back • Full back • Central midfielder • Wide midfielder • Forward	Total distance	Center back	3-5-2 > 4-4-2 > 4-2-3-1 > 3-4-3 > 4-3-3 (0.35-8.64; not applicable)	6/7
				Full back	3-5-2 > 4-2-3-1 > 4-3-3 > 4-4-2 > 3-4-3 (1.40-9.14; not applicable)	
				Central midfielder	3-5-2 > 4-3-3 > 3-4-3 > 4-2-3-1 > 4-4-2 (0.12-7.25; not applicable)	
				Wide midfielder	4-3-3 > 3-5-2 > 4-4-2 > 3-4-3 > 4-2-3-1 (0.46-6.98; not applicable)	
				Forward	3-5-2 > 3-4-3 > 4-3-3 > 4-4-2 > 4-2-3-1 (0.11-25.31; not applicable)	
			High-speed running (≥19,8 km/h)	Center back	3-5-2 > 4-2-3-1 > 3-4-3 > 4-4-2 > 4-3-3 (3.45-22.49; not applicable)	
				Full back	3-5-2 > 4-2-3-1 > 4-3-3 > 4-4-2 > 3-4-3 (1.17-42.76; not applicable)	
				Central midfielder	3-5-2 > 4-2-3-1 > 3-4-3 > 4-3-3 > 4-4-2 (3.08-38.65; not applicable)	
				Wide midfielder	3-4-3 > 4-3-3 > 4-2-3-1 > 3-5-3 > 4-4-2 (0.97-16.57; not applicable)	
				Forward	3-5-2 > 4-3-3 > 3-4-3 > 4-4-2 > 4-2-3-1 (10.29-153.26; not applicable)	
			High metabolic load distance	Center back	3.5.2 > 4-2-3-1 > 3-4-3 > 4-3-3 > 4-4-2 (1.75-19.18; not applicable)	
				Full back	3-5-2 > 4-2-3-1 > 4-3-3 > 3-4-3 > 4-4-2 (1.49-24.30; not applicable)	
				Central midfielder	4-2-3-1 > 3-4-3 > 3-5-2 > 4-3-3 > 4-4-2 (1.14-30.80; not applicable)	
				Wide midfielder	3-4-3 > 4-2-3-1 > 3-5-2 > 4-3-3 > 4-4-2 (2.27-14.40; not applicable)	
				Forward	3-5-2 > 4-3-3 > 3-4-3 > 4-4-2 > 4-2-3-1 (6.45-60.95; not applicable)	

Article	Formation	Position	Results			Quality score
			Parameter	**Position**	**Differences between formations (percentages; effect size)**	
Aquino et al. (2017)	• 4-4-2 • 4-3-3	• Center back • Full back • Central midfielder • Wide midfielder • Forwards	Maximal running speed	Center back	4-3-3 > 4-4-2 (5.05; not applicable)	
				Full back	4-3-3 > 4-4-2 (4.95; not applicable)	
				Central midfielder	4-3-3 > 4-4-2 (4.84; not applicable)	
				Wide midfielder	4-3-3 > 4-4-2 (4.75; not applicable)	
				Forward	4-3-3 > 4-4-2 (4.65; not applicable)	
			high-intensity activities	Center back	4-3-3 > 4-4-2 (35.11; not applicable)	
				Full back	4-3-3 > 4-4-2 (31.49; not applicable)	
				Central midfielder	4-3-3 > 4-4-2 (28.50; not applicable)	
				Wide midfielder	4-3-3 > 4-4-2 (26.07; not applicable)	
				Forward	4-3-3 > 4-4-2 (24.02; not applicable)	

Article	Formation	Position	Results: Parameter	Results: Position	Results: Differences between formations (percentages; effect size)	Quality score
Baptista et al. (2019)	• 4-5-1 • 3-5-2	• Center back • Wide positions • Central midfielder • Forward	Total distance	Center back	4-5-1 > 3-5-2 (2.58; 1.21)	5/7
				Wide positions	3-5-2 > 4-5-1 (2.70; 1.48)	
				Central midfielder	4-5-1 > 3-5-2 (1.59; 0.83)	
				Forward	3-5-2 > 4-5-1 (0.08; 0.03)	
			High-intensity runs (≥19.8 km/h)	Center back	4-5-1 > 3-5-2 (28.01; 2.26)	
				Wide positions	3-5-2 > 4-5-1 (2.13; 0.35)	
				Central midfielder	4-5-1 > 3-5-2 (7.84; 0.85)	
				Forward	4-5-1 > 3-5-2 (3.18; 0.32)	
			High-intensity running distance (≥19.8 km/h)	Center back	4-5-1 > 3-5-2 (18.79; 1.00)	
				Wide positions	3-5-2 > 4-5-1 (14.15; 2.09)	
				Central midfielder	4-5-1 > 3-5-2 (5.29; 0.43)	
				Forward	3-5-2 > 4-5-1 (10.24; 0.88)	
			Sprints (≥25.2 km/h)	Center back	4-5-1 > 3-5-2 (22.22; 0.63)	
				Wide positions	4-5-1 > 3-5-2 (0.71; 0.07)	
				Central midfielder	4-5-1 = 3-5-2 (0.00; 0.00)	
				Forward	3-5-2 > 4-5-1 (8.59; 0.53)	
			Sprinting distance (≥25.2 km/h)	Center back	3-5-2 > 4-5-1 (13.21; 0.33)	
				Wide positions	3-5-2 > 4-5-1 (17.56; 1.73)	
				Central midfielder	4-5-1 > 3-5-2 (6.96; 0.24)	
				Forward	3-5-2 > 4-5-1 (21.10; 1.11)	
			Accelerations	Center back	4-5-1 > 3-5-2 (5.86; 0.57)	
				Wide positions	4-5-1 > 3-5-2 (8.33; 1.27)	
				Central midfielder	4-5-1 > 3-5-2 (11.45; 1.13)	
				Forward	4-5-1 > 3-5-2 (3.37; 0.33)	
			Acceleration distance	Center back	4-5-1 > 3-5-2 (6.09; 0.50)	
				Wide positions	4-5-1 > 3-5-2 (3.38; 0.50)	
				Central midfielder	4-5-1 > 3-5-2 (8.18; 0.71)	
				Forward	4-5-1 > 3-5-2 (1.19; 0.12)	

Article	Formation	Position	Results: Parameter	Results: Position	Results: Differences between formations (percentages; effect size)	Quality score
Baptista et al. (2019)	• 4-5-1 • 3-5-2	• Center back • Wide positions • Central midfielder • Forward		Central midfielder	4-5-1 > 3-5-2 (8.18; 0.71)	5/7
				Forward	4-5-1 > 3-5-2 (1.19; 0.12)	
			Decelerations	Center back	4-5-1 > 3-5-2 (12.50; 0.97)	
				Wide positions	4-5-1 > 3-5-2 (0.93; 0.14)	
				Central midfielder	4-5-1 > 3-5-2 (8.10; 0.82)	
				Forward	4-5-1 > 3-5-2 (6.68; 0.53)	
			Deceleration distance	Center back	4-5-1 > 3-5-2 (15.33; 1.03)	
				Wide positions	3-5-2 > 4-5-1 (0.83; 0.13)	
				Central midfielder	4-5-1 > 3-5-2 (9.91; 0.85)	
				Forward	3-5-2 > 4-5-1 (2.00; 0.17)	
			turns	Center back	4-5-1 > 3-5-2 (24.81; 1.86)	
				Wide positions	4-5-1 > 3-5-2 (8.51; 1.04)	
				Central midfielder	3-5-2 > 4-5-1 (13.90; 1.59)	
				Forward	4-5-1 > 3-5-2 (23.91; 1.39)	

Article	Formation	Position	Results			Quality score
			Parameter	**Position**	**Differences between formations (percentages; effect size)**	
Modric et al. (2020)	• 3-5-2 / 3-4-1-2 • 4-4-2 / 4-2-3-2	• Center back • Full back • Midfielder • Forward	Total distance	Center back	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (2.18; 1.31)	4/7
				Full back	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (8.65; 5.58)	
				Midfielder	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (2.74; 1.72)	
				Forward	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (6.85; 3.35)	
			High-intensity running distance (>19.8 km/h)	Center back	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (30.84; 0.74)	
				Full back	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (34.86; 1.57)	
				Midfielder	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (15.55; 0.54)	
				Forward	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (15.11; 0.60)	
			High-speed running distance (19.8-25.1 km/h)	Center back	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (28.78; 0.78)	
				Full back	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (44.36; 2.53)	
				Midfielder	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (20.43; 0.75)	
				Forward	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (15.00; 0.62)	
			Sprinting distance (≥25.2 km/h)	Center back	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (40.53; 0.53)	
				Full back	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (11.33; 0.23)	
				Midfielder	4-4-2/4-1-3-1 > 3-5-2/3-4-1-2 (9.31; 0.19)	
				Forward	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (20.49; 0.50)	
			Accelerations	Center back	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (3.13; 0.30)	
				Full back	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (7.69; 0.92)	
				Midfielder	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (9.95; 1.46)	
				Forward	4-4-2/4-1-3-1 > 3-5-2/3-4-1-2 (0.26; 0.01)	
			Decelerations	Center back	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (2.90; 0.28)	
				Full back	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (6.29; 0.73)	
				Midfielder	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (9.53; 1.41)	
				Forward	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (5.89; 0.60)	

Article	Formation	Position	Results			Quality score
			Parameter	**Position**	**Differences between formations (percentages; effect size)**	
Modric et al. (2020)	• 3-5-2 / 3-4-1-2 • 4-4-2 / 4-2-3-2	• Center back • Full back • Midfielder • Forward	High-intensity accelerations	Center back	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (16.75; 0.36)	4/7
				Full back	4-4-2/4-1-3-1 > 3-5-2/3-4-1-2 (11.43; 0.40)	
				Midfielder	4-4-2/4-1-3-1 > 3-5-2/3-4-1-2 (8.02; 0.21)	
				Forward	4-4-2/4-1-3-1 > 3-5-2/3-4-1-2 (7.33; 0.23)	
			High-intensity decelerations	Center back	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (28.06; 0.77)	
				Full back	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (14.32; 0.57)	
				Midfielder	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (18.89; 0.67)	
				Forward	3-5-2/3-4-1-2 > 4-4-2/4-1-3-1 (7.77; 0.35)	

Article	Formation	Position	Results			Quality score
			Parameter	**Position**	**Differences between formations (percentages; effect size)**	
Arjol-Serrano et al. (2021)	• 4-2-3-1 • 4-4-2	• Center back • Full back • Central midfielder • Wide midfielder • Offensive midfielder • Forward	Total distance	Center back	4-2-3-1 > 4-4-2 (0.11; not applicable)	3/7
				Full back	4-4-2 > 4-2-3-1 (1.39; not applicable)	
				Central midfielder	4-2-3-1 > 4-4-2 (5.32; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (2.32; not applicable)	
				Offensive midfielder	4-2-3-1 > 4-4-2 (4.24; not applicable)	
				Forward	4-2-3-1 > 4-4-2 (0.23; not applicable)	
			Distance >14.4 km/h	Center back	4-2-3-1 > 4-4-2 (7.20; not applicable)	
				Full back	4-2-3-1 > 4-4-2 (1.72; not applicable)	
				Central midfielder	4-2-3-1 > 4-4-2 (22.72; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (14.39; not applicable)	
				Offensive midfielder	4-2-3-1 > 4-4-2 (1.19; not applicable)	
				Forward	Unrealistic results	
			Distance >19.8 km/h	Center back	4-2-3-1 > 4-4-2 (2.02; not applicable)	
				Full back	4-2-3-1 > 4-4-2 (5.40; not applicable)	
				Central midfielder	4-2-3-1 > 4-4-2 (32.01; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (15.37; not applicable)	
				Offensive midfielder	4-2-3-1 > 4-4-2 (1.42; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (11.27; not applicable)	
			Distance >25.0 km/h	Center back	4-2-3-1 > 4-4-2 (13.24; not applicable)	
				Full back	4-2-3-1 > 4-4-2 (0.56; not applicable)	
				Central midfielder	4-2-3-1 > 4-4-2 (77.08; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (15.79; not applicable)	
				Offensive midfielder	4-4-2 > 4-2-3-1 (20.47; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (30.99; not applicable)	

Article	Formation	Position	Results			Quality score
			Parameter	**Position**	**Differences between formations (percentages; effect size)**	
Arjol-Serrano et al. (2021)	• 4-2-3-1 • 4-4-2	• Center back • Full back • Central midfielder • Wide midfielder • Offensive midfielder • Forward	Accelerations (2-4 ms^2)	Center back	4-2-3-1 > 4-4-2 (3.13; not applicable)	3/7
				Full back	4-2-3-1 > 4-4-2 (2.44; not applicable)	
				Central midfielder	4-4-2 > 4-2-3-1 (1.83; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (6.36; not applicable)	
				Offensive midfielder	4-2-3-1 > 4-4-2 (31.18; not applicable)	
				Forward	4-2-3-1 > 4-4-2 (11.95; not applicable)	
			Accelerations (>4 ms^2)	Center back	4-4-2 > 4-2-3-1 (7.14; not applicable)	
				Full back	4-4-2 > 4-2-3-1 (21.05; not applicable)	
				Central midfielder	4-4-2 > 4-2-3-1 (42.86; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (13.33; not applicable)	
				Offensive midfielder	4-2-3-1 > 4-4-2 (29.41; not applicable)	
				Forward	4-2-3-1 = 4-4-2 (0.00; not applicable)	
			Decelerations (2-4 ms^2)	Center back	4-2-3-1 > 4-4-2 (4.29; not applicable)	
				Full back	4-2-3-1 > 4-4-2 (4.11; not applicable)	
				Central midfielder	4-2-3-1 > 4-4-2 (1.80; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (11.18; not applicable)	
				Offensive midfielder	4-2-3-1 > 4-4-2 (9.77; not applicable)	
				Forward	4-2-3-1 > 4-4-2 (18.75; not applicable)	
			Decelerations (>4 ms^2)	Center back	4-4-2 > 4-2-3-1 (17.39; not applicable)	
				Full back	4-4-2 > 4-2-3-1 (5.71; not applicable)	
				Central midfielder	4-4-2 > 4-2-3-1 (12.00; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (2.94; not applicable)	
				Offensive midfielder	4-2-3-1 > 4-4-2 (15.38; not applicable)	
				Forward	4-2-3-1 > 4-4-2 (3.23; not applicable)	

Article	Formation	Position	Results: Parameter	Results: Position	Results: Differences between formations (percentages; effect size)	Quality score
Borghi et al. (2020)	• 4-4-2 • 4-3-3 • 3-5-2	• Center back • Full back • Central midfielder • Wide midfielder • Forward	Total distance	Center back	3-5-2 > 4-4-2 > 4-3-3 (0.41-5.51; 0.08-0.99)	5/7
				Full back	4-4-2 > 4-3-3 (4.62; 0.96)	
				Central midfielder	4-4-2 > 4-3-3 > 3-5-2 (0.17-1.57; 0.02-0.24)	
				Wide midfielder	4-4-2 > 3-5-2 (0.27; 0.07)	
				Forward	4-4-2 > 4-3-3 > 3-5-2 (0.21-8.05; 0.02-1.00)	
			High speed running distance (>19.8 km/h)	Center back	4-3-3 > 3-5-2 > 4-4-2 (4.34-9.38; 0.19-0.36)	
				Full back	4-4-2 > 4-3-3 (5.71; 0.33)	
				Central midfielder	3-5-2 > 4-4-2 > 4-3-3 (8.89-20.82; 0.39-0.90)	
				Wide midfielder	3-5-2 > 4-4-2 (19.27; 1.33)	
				Forward	4-4-2 > 4-3-3 > 3-5-2 (1.69-7.45; 0.08-0.41)	
			Powerplays (> 22 W/kg)	Center back	3-5-2 > 4-3-3 > 4-4-2 (0.97-8.86; 0.07-0.47)	
				Full back	4-4-2 > 4-3-3 (4.29; 0.34)	
				Central midfielder	3-5-2 > 4-4-2 > 4-3-3 (2.05-4.50; 0.12-0.25)	
				Wide midfielder	4-4-2 = 3-5-2 (0.00; 0.00)	
				Forward	4-4-2 > 4-3-3 > 3-5-2 (5.26-11.98; 0.26-0.91)	
			Powerscore (W/kg)	Center back	4-4-2 > 3-5-2 > 4-3-3 (1.39-4.47; 0.23-0.78)	
				Full back	4-4-2 > 4-3-3 (7.90; 1.65)	
				Central midfielder	3-5-2 > 4-4-2 > 4-3-3 (0.63-3.26; 0.12-0.54)	
				Wide midfielder	3-5-2 > 4-4-2 (1.55; 0.33)	
				Forward	4-4-2 > 3-5-2 > 4-3-3 (0.42-4.00; 0.05-0.51)	
			Sprints (>25 km/h)	Center back	4-3-3 > 3-5-2 > 4-4-2 (2.27-11.38; 0.10-0.43)	
				Full back	4-4-2 > 4-3-3 (5.89; 0.30)	
				Central midfielder	3-5-2 > 4-4-2 > 4-3-3 (4.05-14.29; 0.13-0.51)	
				Wide midfielder	3-5-2 > 4-4-2 (23.19; 1.57)	
				Forward	4-4-2 > 4-3-3 > 3-5-2 (3.88-9.05; 0.18-0.54)	
			Accelerations	Center back	3-5-2 > 4-3-3 > 4-4-2 (3.08-7.60; 0.18-0.46)	
				Full back	4-4-2 > 4-3-3 (4.78; 0.28)	
				Central midfielder	3-5-2 > 4-3-3 > 4-4-2 (0.81-12.56; 0.04-0.80)	
				Wide midfielder	3-5-2 > 4-4-2 (23.19; 1.57)	
				Forward	4-3-3 > 3-5-2 > 4-4-2 (3.88-9.05; 0.18-0.54)	

Article	Formation	Position	Parameter	Position	Differences between formations (percentages; effect size)	Quality score
Vilamitjana et al. (2021)	• 3-4-3 • 4-2-3-1	• Center back • Full back • Central midfielder • Wide midfielder • Forward	High intensity load rate [m/min]	Center back	4-2-3-1 > 3-4-3 (13.89; not applicable)	3/7
				Full back	3-4-3 > 4-2-3-1 (0.42; not applicable)	
				Central midfielder	4-2-3-1 > 3-4-3 (9.95; not applicable)	
				Wide midfielder	4-2-3-1 > 3-4-3 (1.67; not applicable)	
				Forward	4-2-3-1 > 3-4-3 (24.15; not applicable)	
			High speed running/sprints load rate [m/min]	Center back	4-2-3-1 > 3-4-3 (26.67; not applicable)	
				Full back	4-2-3-1 > 3-4-3 (6.90; not applicable)	
				Central midfielder	4-2-3-1 > 3-4-3 (3.85; not applicable)	
				Wide midfielder	4-2-3-1 > 3-4-3 (6.93; not applicable)	
				Forward	4-2-3-1 > 3-4-3 (40.19; not applicable)	
			High speed runs	Center back	3-4-3 > 4-2-3-1 (4.21; not applicable)	
				Full back	4-2-3-1 > 3-4-3 (0.40; not applicable)	
				Central midfielder	4-2-3-1 > 3-4-3 (6.08; not applicable)	
				Wide midfielder	4-2-3-1 > 3-4-3 (21.40; not applicable)	
				Forward	3-4-3 > 4-2-3-1 (4.09; not applicable)	
			Sprints	Center back	4-2-3-1 > 3-4-3 (17.65; not applicable)	
				Full back	4-2-3-1 > 3-4-3 (6.49; not applicable)	
				Central midfielder	4-2-3-1 > 3-4-3 (5.13; not applicable)	
				Wide midfielder	4-2-3-1 > 3-4-3 (37.21; not applicable)	
				Forward	4-2-3-1 > 3-4-3 (18.02; not applicable)	
			Mean heart rate	Center back	4-2-3-1 > 3-4-3 (1.41; not applicable)	
				Full back	3-4-3 > 4-2-3-1 (1.15; not applicable)	
				Central midfielder	3-4-3 > 4-2-3-1 (1.78; not applicable)	
				Wide midfielder	4-2-3-1 > 3-4-3 (0.31; not applicable)	
				Forward	3-4-3 > 4-2-3-1 (0.41; not applicable)	
			Maximal heart rate	Center back	4-2-3-1 > 3-4-3 (0.63; not applicable)	
				Full back	3-4-3 > 4-2-3-1 (0.67; not applicable)	
				Central midfielder	4-2-3-1 > 3-4-3 (0.97; not applicable)	
				Wide midfielder	3-4-3 > 4-2-3-1 (1.65; not applicable)	
				Forward	4-2-3-1 > 3-4-3 (1.17; not applicable)	

Article	Formation	Position	Results			Quality score
			Parameter	**Position**	**Differences between formations (percentages; effect size)**	
Riboli et al. (2021)	• 3-4-1-2 • 3-4-2-1 • 3-5-2 • 4-3-3 • 4-4-2	• Center back • Full back • Central midfielder • Wide midfielder • Wide forward • Forward	Total distance [1 min peak]	Center back	4-4-2 > 3-4-1-2 > 3-4-2-1 > 4-3-3 > 3-5-2 (0.33-5.21; 0.02-0.31)	6/7
				Full back	3-4-2-1 > 4-4-2 > 3-5-2 > 4-3-3 > 3-4-1-2 (1.01-20.65; 0.15-1.51)	
				Central midfielder	3-4-1-2 > 4-4-2 > 4-3-3 > 3-5-2 > 3-4-2-1 (0.05-5.79; 0.01-0.41)	
				Wide midfielder	3-4-2-1 > 3-5-2 > 4-3-3 > 3-4-1-2 > 4-4-2 (0.42-5.31; 0.03-0.46)	
				Wide forward	3-5-2 > 4-3-3 > 4-4-2 > 3-4-1-2 > 3-4-2-1 (0.70-9.41; 0.08-1.14)	
				Forward	4-3-3 > 4-4-2 > 3-5-2 > 3-4-2-1 > 3-4-1-2 (0.39-4.74; 0.02-0.26)	
			High speed running distance (15-20 km/h) [1 min peak]	Center back	4-4-2 > 3-4-1-2 > 3-5-2 > 4-3-3 > 3-4-2-1 (0.21-6.67; 0.01-0.40)	
				Full back	4-4-2 > 3-4-2-1 > 3-5-2 > 4-3-3 > 3-4-1-2 (5.34-28.19; 0.20-1.62)	
				Central midfielder	3-4-1-2 > 4-4-2 > 4-3-3 > 3-5-2 > 3-4-2-1 (1.17-14.71; 0.06-0.69)	
				Wide midfielder	3-4-2-1 > 3-4-1-2 > 4-4-2 > 3-5-2 > 4-3-3 (0.46-19.16; 0.04-0.55)	
				Wide forward	4-3-3 > 4-4-2 > 3-4-2-1 > 3-5-2 > 3-4-1-2 (0.18-24.54; 0.01-2.11)	
				Forward	4-4-2 > 4-3-3 > 3-5-2 > 3-4-2-1 > 3-4-1-2 (0.67-15.05; 0.02-0.54)	

Article	Formation	Position	Results			Quality score
			Parameter	**Position**	**Differences between formations (percentages; effect size)**	
Riboli et al. (2021)	• 3-4-1-2 • 3-4-2-1 • 3-5-2 • 4-3-3 • 4-4-2	• Center back • Full back • Central midfielder • Wide midfielder • Wide forward • Forward	Very High speed running distance (20-24 km/h) [1 min peak]	Center back	4-4-2 > 3-5-2 > 3-4-2-1 = 4-3-3 > 3-4-1-2 (0.00-6.37; 0.00-0.24)	6/7
				Full back	3-4-2-1 > 4-4-2 > 3-5-2 > 4-3-3 > 3-4-1-2 (6.15-36.08; 0.22-1.26)	
				Central midfielder	4-4-2 > 4-3-3 > 3-4-1-2 > 3-5-2 > 3-4-2-1 (0.75-17.63; 0.03-0.55)	
				Wide midfielder	4-4-2 = 3-5-2 > 3-4-2-1 > 4-3-3 > 3-4-1-2 (0.00-4.80; 0.00-0.16)	
				Wide forward	4-3-3 > 3-5-2 > 4-4-2 > 3-4-1-2 > 3-4-1-2 (3.78-23.40; 0.13-1.06)	
				Forward	4-3-3 > 4-4-2 > 3-5-2 > 3-4-1-2 > 3-4-2-1 (1.41-22.49; 0.04-0.70)	
			Sprint distance (>24 km/h) [1 min peak]	Center back	4-4-2 > 3-4-2-1 > 3-4-1-2 > 3-5-2 > 4-3-3 (0.84-19.64; 0.02-0.52)	
				Full back	3-4-2-1 > 4-4-2 > 4-3-3 > 3-5-2 > 3-4-1-2 (0.62-26.86; 0.02-0.74)	
				Central midfielder	3-4-1-2 > 3-4-2-1 > 3-5-2 > 4-3-3 > 4-4-2 (1.51-21.08; 0.04-0.43)	
				Wide midfielder	4-3-3 > 3-4-2-1 = 3-4-1-2 > 3-5-2 = 4-4-2 (0.00-20.86; 0.00-0.56)	
				Wide forward	3-4-2-1 > 4-3-3 > 3-5-2 > 3-4-1-2 > 4-4-2 (0.66-32.66; 0.02-0.72)	
				Forward	3-4-2-1 > 4-4-2 > 4-3-3 > 3-5-2 > 3-4-1-2 (0.78-9.02; 0.02-0.19)	

Article	Formation	Position	Results			Quality score
			Parameter	**Position**	**Differences between formations (percentages; effect size)**	
Riboli et al. (2021)	• 3-4-1-2 • 3-4-2-1 • 3-5-2 • 4-3-3 • 4-4-2	• Center back • Full back • Central midfielder • Wide midfielder • Wide forward • Forward	Acceleration /Deceleration [1 min peak]	Center back	3-5-2 > 3-4-2-1 > 4-4-2 > 4-3-3 > 3-4-1-2 (0.91-23.94; 0.05-1.75)	6/7
				Full back	3-5-2 > 4-3-3 > 4-4-2 > 3-4-2-1 > 3-4-1-2 (0.32-40.24; 0.01-1.78)	
				Central midfielder	4-3-3 > 3-4-2-1 > 3-5-2 > 4-4-2 > 3-4-1-2 (1.92-36.58; 0.09-2.74)	
				Wide midfielder	4-3-3 > 3-5-2 > 3-4-2-1 > 4-4-2 > 3-4-1-2 (4.09-35.64; 0.20-2.04)	
				Wide forward	3-5-2 > 4-3-3 > 3-4-2-1 > 4-4-2 > 3-4-1-2 (2.64-27.70; 0.13-1-95)	
				Forward	4-3-3 > 4-4-2 > 3-4-2-1 > 3-5-2 > 3-4-1-2 (0.63-28.72; 0.03-1.34)	
			Avergae metabolic power [1 min peak]	Center back	3-4-2-1 > 3-4-1-2 > 4-3-3 > 4-4-2 > 3-5-2 (0.52-2.67; 0.03-0.18)	
				Full back	3-4-2-1 > 4-3-3 > 4-4-2 = 3-5-2 > 3-4-1-2 (0.00-16.59; 0.00-1.13)	
				Central midfielder	3-4-1-2 > 3-5-2 > 4-3-3 > 4-4-2 = 3-4-2-1 (0.00-5.97; 0.00-0.30)	
				Wide midfielder	3-4-2-1 > 3-5-2 > 4-3-3 > 3-4-1-2 > 4-4-2 (0.48-22.45; 0.03-1.14)	
				Wide forward	3-5-2 > 4-3-3 > 3-4-2-1 > 3-4-1-2 > 4-4-2 (0.51-14.87; 0.05-1.17)	
				Forward	3-4-2-1 > 4-4-2 > 3-4-1-2 > 3-5-2 = 4-3-3 (0.00-3.16; 0.00-0.14)	
				Wide forward	3-5-2 > 4-3-3 > 3-4-2-1 > 4-4-2 > 3-4-1-2 (1.84-17.80; 0.10-1.25)	
				Forward	4-3-3 > 4-4-2 > 3-5-2 > 3-4-1-2 > 3-4-2-1 (0.85-6.24; 0.03-0.22)	

Article	Formation	osition	Results			Quality score
			Parameter	**Position**	**Differences between formations (percentages; effect size)**	
Riboli et al. (2021)	• 3-4-1-2 • 3-4-2-1 • 3-5-2 • 4-3-3 • 4-4-2	• Center back • Full back • Central midfielder • Wide midfielder • Wide forward • Forward	High metabolic load distance (>20 W/kg) [1 min peak]	Center back	4-4-2 > 3-4-2-1 > 3-4-1-2 > 3-5-2 > 4-3-3 (0.70-4.48; 0.03-0.21)	6/7
				Full back	3-4-2-1 > 4-4-2 > 3-5-2 > 4-3-3 > 3-4-1-2 (3.35-34.84; 0.23-1.67)	
				Central midfielder	3-4-1-2 > 4-4-2 > 4-3-3 > 3-5-2 > 3-4-2-1 (0.48-10.04; 0.03-0.48)	
				Wide midfielder	3-4-2-1 > 4-4-2 > 3-4-1-2 > 4-3-3 > 3-5-2 (0.59-12.45; 0.03-0.49)	
				Wide forward	3-5-2 > 4-3-3 > 3-4-2-1 > 4-4-2 > 3-4-1-2 (1.84-17.80; 0.10-1.25)	
				Forward	4-3-3 > 4-4-2 > 3-5-2 > 3-4-1-2 > 3-4-2-1 (0.85-6.24; 0.03-0.22)	

4.5.4.4 Influence of the Tactical Formation in Different Playing Positions on Technical Match Performance

1 study analyzed the effect of tactical formation in different playing positions on technical match performance (see Table 4.5). Therefore, a robust summary of results is not applicable.

Table 4.5. Results of the studies examining the effect of playing positions in different tactical formations on technical performance. For each performance parameter respectively, the formations are mentioned in declining order regarding the outcome values. In parenthesis, the percental differences between the respective parameter values for each formation and following the effect sizes are presented.

Article	Formation	Position	Results: Parameter	Results: Position	Results: Differences between formations (percentages; effect size)	Quality score
Arjol-Serrano et al. (2021)	• 4-2-3-1 • 4-4-2	• Center back • Full back • Central midfielder • Wide midfielder • Offensive midfielder • Forward	Game volume	Center back	4-4-2 > 4-2-3-1 (4.30; not applicable)	3/7
				Full back	4-4-2 > 4-2-3-1 (12.72; not applicable)	
				Central midfielder	4-4-2 > 4-2-3-1 (32.34; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (27.75; not applicable)	
				Offensive midfielder	4-4-2 > 4-2-3-1 (41.44; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (21.25; not applicable)	
			Ratio interceptions-turnover	Center back	4-4-2 > 4-2-3-1 (29.41; not applicable)	
				Full back	4-4-2 > 4-2-3-1 (100.00; not applicable)	
				Central midfielder	4-4-2 > 4-2-3-1 (47.50; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (642.86; not applicable)	
				Offensive midfielder	4-2-3-1 > 4-4-2 (52.38; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (40.35; not applicable)	
			Defensive volume	Center back	4-2-3-1 > 4-4-2 (4.64; not applicable)	
				Full back	4-2-3-1 > 4-4-2 (5.22; not applicable)	
				Central midfielder	4-4-2 > 4-2-3-1 (9.33; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (34.38; not applicable)	
				Offensive midfielder	4-4-2 > 4-2-3-1 (16.67; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (40.35; not applicable)	

Article	Formation	Position	Results			Quality score
			Parameter	**Position**	**Differences between formations (percentages; effect size)**	
Arjol-Serrano et al. (2021)	• 4-2-3-1 • 4-4-2	• Center back • Full back • Central midfielder • Wide midfielder • Offensive midfielder • Forward	Interceptions	Center back	4-4-2 > 4-2-3-1 (8.47; not applicable)	3/7
				Full back	4-4-2 > 4-2-3-1 (1.72; not applicable)	
				Central midfielder	4-4-2 > 4-2-3-1 (19.42; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (28.21; not applicable)	
				Offensive midfielder	4-4-2 > 4-2-3-1 (66.18; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (60.00; not applicable)	
			Opposing pitch interceptions	Center back	4-2-3-1 > 4-4-2 (16.67; not applicable)	
				Full back	4-2-3-1 > 4-4-2 (33.33; not applicable)	
				Central midfielder	4-4-2 > 4-2-3-1 (15.38; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (50.00; not applicable)	
				Offensive midfielder	4-4-2 > 4-2-3-1 (38.10; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (20.00; not applicable)	
			Clearances	Center back	4-4-2 > 4-2-3-1 (3.13; not applicable)	
				Full back	4-2-3-1 = 4-4-2 (0.00; not applicable)	
				Central midfielder	4-2-3-1 = 4-4-2 (0.00; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (21.74; not applicable)	
				Offensive midfielder	4-2-3-1 = 4-4-2 (0.00; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (27.27; not applicable)	
			Offensive volume	Center back	4-4-2 > 4-2-3-1 (6.34; not applicable)	
				Full back	4-4-2 > 4-2-3-1 (16.48; not applicable)	
				Central midfielder	4-4-2 > 4-2-3-1 (39.42; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (22.61; not applicable)	
				Offensive midfielder	4-4-2 > 4-2-3-1 (36.82; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (17.11; not applicable)	
			Total pass	Center back	4-4-2 > 4-2-3-1 (7.11; not applicable)	
				Full back	4-4-2 > 4-2-3-1 (16.50; not applicable)	
				Central midfielder	4-4-2 > 4-2-3-1 (38.60; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (28.32; not applicable)	
				Offensive midfielder	4-4-2 > 4-2-3-1 (34.78; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (14.02; not applicable)	

Article	Formation	Position	Results: Parameter	Results: Position	Results: Differences between formations (percentages; effect size)	Quality score
Arjol-Serrano et al. (2021)	• 4-2-3-1 • 4-4-2	• Center back • Full back • Central midfielder • Wide midfielder • Offensive midfielder • Forward	Long pass	Center back	4-2-3-1 > 4-4-2 (24.29; not applicable)	3/7
				Full back	4-4-2 > 4-2-3-1 (12.68; not applicable)	
				Central midfielder	4-4-2 > 4-2-3-1 (24.73; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (47.83; not applicable)	
				Offensive midfielder	4-4-2 > 4-2-3-1 (10.71; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (46.67; not applicable)	
			Short-medium pass	Center back	4-4-2 > 4-2-3-1 (13.31; not applicable)	
				Full back	4-4-2 > 4-2-3-1 (16.55; not applicable)	
				Central midfielder	4-4-2 > 4-2-3-1 (40.94; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (26.11; not applicable)	
				Offensive midfielder	4-4-2 > 4-2-3-1 (35.75; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (11.56; not applicable)	
			Forward pass	Center back	4-4-2 > 4-2-3-1 (5.64; not applicable)	
				Full back	4-4-2 > 4-2-3-1 (18.54; not applicable)	
				Central midfielder	4-4-2 > 4-2-3-1 (38.56; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (28.79; not applicable)	
				Offensive midfielder	4-4-2 > 4-2-3-1 (30.45; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (3.09; not applicable)	
			Attack zone pass	Center back	4-2-3-1 > 4-4-2 (60.00; not applicable)	
				Full back	4-4-2 > 4-2-3-1 (10.28; not applicable)	
				Central midfielder	4-4-2 > 4-2-3-1 (39.13; not applicable)	
				Wide midfielder	4-2-3-1 > 4-4-2 (63.89; not applicable)	
				Offensive midfielder	4-4-2 > 4-2-3-1 (11.76; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (8.24; not applicable)	
			Goal shot	Center back	4-2-3-1 = 4-4-2 (0.00; not applicable)	
				Full back	4-4-2 > 4-2-3-1 (50.00; not applicable)	
				Central midfielder	4-2-3-1 > 4-4-2 (80.00; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (38.46; not applicable)	
				Offensive midfielder	4-4-2 > 4-2-3-1 (5.26; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (42.86; not applicable)	

Article	Formation	Position	Results			Quality score
			Parameter	**Position**	**Differences between formations (percentages; effect size)**	
Arjol-Serrano et al. (2021)	• 4-2-3-1 • 4-4-2	• Center back • Full back • Central midfielder • Wide midfielder • Offensive midfielder • Forward	Goal shot	Center back	4-2-3-1 = 4-4-2 (0.00; not applicable)	3/7
				Full back	4-4-2 > 4-2-3-1 (50.00; not applicable)	
				Central midfielder	4-2-3-1 > 4-4-2 (80.00; not applicable)	
				Wide midfielder	4-4-2 > 4-2-3-1 (38.46; not applicable)	
				Offensive midfielder	4-4-2 > 4-2-3-1 (5.26; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (42.86; not applicable)	
			Crosses	Center back	Unrealistic results	
				Full back	4-2-3-1 > 4-4-2 (14.29; not applicable)	
				Central midfielder	4-4-2 > 4-2-3-1 (44.83; not applicable)	
				Wide midfielder	4-2-3-1 > 4-4-2 (157.14; not applicable)	
				Offensive midfielder	4-4-2 > 4-2-3-1 (42.86; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (33.33; not applicable)	
			Dribbles	Center back	4-2-3-1 > 4-4-2 (200.00; not applicable)	
				Full back	4-4-2 > 4-2-3-1 (11.76; not applicable)	
				Central midfielder	4-4-2 > 4-2-3-1 (14.29; not applicable)	
				Wide midfielder	4-2-3-1 > 4-4-2 (41.18; not applicable)	
				Offensive midfielder	4-4-2 > 4-2-3-1 (35.29; not applicable)	
				Forward	4-4-2 > 4-2-3-1 (5.26; not applicable)	

4.6 Discussion

The aim of this systematic review was to synthesize the available literature on the effects of tactical formation on physical and technical match performance of male soccer players both on a team and a positional level. Eleven studies were identified reporting match performance parameters according to different tactical formations. The main finding was that the tactical formation has an effect on soccer match performance. On a team level, the differences that occurred increase when comparing formations with three center backs (back-3) to formations with four center backs (back-4). Comparably, the differences were smaller when comparing formations that were similar in the number of defenders, midfielders, and forwards (e.g. 4-5-1, 4-2-3-1). On a positional level, the differences between formations become more pronounced. In general, the physical and technical match performance of all playing positions were similarly affected by tactical formation. However, in contrast to all other positions, the sprinting distance of full backs and central midfielders remained rather stable between formations.

4.6.1 Overview and Study Characteristics

There was high variability between the methodological approaches of the studies included in this review (e.g. tracking system, types of competition, number of formations investigated). Further, the sample sizes were relatively small in most of the studies (n ranged from 15-61 games). This can be an issue, especially when the small sample sizes are divided into groups (different formations & positions), as the number of players per group and hence the explanatory power further decreases. Moreover, some studies only investigated one or two teams what might limit the representativity of their results. Therefore, the comparability and validity of the studies are limited. Hence, the comparisons in this review are not presented in absolute numbers but in a relative manner.

Overall, the studies averaged 5 out of 7 possible points in the quality assessment, leading to a medium score of study quality. Nevertheless, the variance in the quality of the studies was high. Only one study managed to score all 7 possible points (Bradley et al., 2011). Arjol-Serrano (2021), and Vilamitjana et al. (2021) only reached 3 quality points leading to a low methodological quality. Like six other studies, these two did not clearly state the sample size and the number of observations for each group. This topic limits not only the single study but also the outcome measures in this review. Due to this fact, in some studies, no ES could be estimated. Further, only four studies compared more than two different tactical formations which only reflects a small part of the variety of tactical formations in soccer. All in all, this leads to restricted comparability of the studies included in this review.

4.6.2 Effect of the Tactical Formation on Performance

On a team level, ten studies investigated the effects of tactical formation on physical parameters and only three studies reported the effects of tactical formation on technical parameters.

For most of the physical parameters (total distance, jogging distance, medium-intensity distance, sprinting distance), the differences between tactical formations were of only small ES. However, tactical formation affected high-intensity distance, number of sprints, number of high-intensity actions, and the number of accelerations at least with a medium ES. For high-intensity distance, the number of sprints, as well as the number of high-intensity activities, players in a 4-4-2 showed lower physical performance than in other formations (Aquino et al., 2019; Aquino, Palucci Vieira, et al., 2017; Borghi et al., 2020; Palucci Vieira et al., 2018; Tierney et al., 2016). The 4-4-2 formation can be considered as the most symmetrical formation used in soccer and overall the gaps, therefore, are potentially smaller between players than in other formations (e.g. 3-5-2). Hence, for the players in a 4-4-2, it might be easier to be compact without being highly physically demanded during a game. This could be a potential explanation for these findings.

The differences between tactical formations increase when looking at the technical performance of soccer players (Arjol-Serrano et al., 2021; Bradley et al., 2011). When analyzing the number of passes, the effect of the tactical formation was up to large. Therefore, players tend to adapt their technical performance on a larger scale than their physical performance when changing the tactical formation.

One interesting outcome was that differences between formations increase when comparing formations with three vs. four center backs in the defending row. Some studies (Baptista et al., 2019; Vilamitjana et al., 2021) only compared two formations with a back-3 and a back-4, and the differences were more pronounced compared to formations that were similar in the number of defenders, midfielders, and forwards. The difference in the number of center backs in a formation tends to be a key aspect when looking at the effects of the tactical formation on soccer match performance. Three center backs ensure higher defensive protection compared to formations with fewer center backs. The three center backs have to cover the length and the width of the field, while in other formations (e.g. 4-3-3), there are four defenders to do so. Therefore, full backs in a 3-4-3 or 3-5-2 formation can be more offensive than in classic formations with two center backs (e.g. 4-4-2). These differences tend to be one essential aspect in consideration of the influence of tactical formations on match performance. Another obvious finding was that a comparison of similar formations (e.g. 4-5-1, 4-2-3-1) revealed only small differences in physical match performance (e.g. Aquino et al., 2019; Bradley et al., 2011). In these formations, the number of players in each positional group is equal. The formations contain two center backs, two full backs, three central midfielders, two wide midfielders, and one forward. The differences that come within these formations, therefore, are very small. Hence, comparing these formations leads to small differences in match performance parameters.

4.6.3 Effect of the Tactical Formation in Different Playing Positions on Performance

On a positional level, deeper insights into how tactical formations affect match performance in soccer could be revealed. When investigating not only the effect of tactical formation on performance but also consider the playing position, the explanatory power of the results increases.

For center backs, the effect of formation on total distance, high-intensity distance, and the number of decelerations was large. Only for the sprinting distance, the number of sprints, and the number of accelerations the effect was only up to medium. On the one hand, center backs showed higher physical performance in a 3-5-2 formation than in other formations. They covered more total distance, high-intensity distance, sprinting distance, and accelerated more often in this formation (Baptista et al., 2019; Borghi et al., 2020; Modric et al., 2020; Tierney et al., 2016). On the other hand, results reveal a lower physical performance for center backs in the 4-4-2 formation. Center backs covered less total distance, high-intensity distance, sprinting distance, and showed fewer accelerations and decelerations in a 4-4-2 (Arjol-Serrano et al., 2021; Borghi et al., 2020; Modric et al., 2020; Tierney et al., 2016).

The physical performance of full backs is affected by the formation on a large scale as well. Only the sprinting distance revealed a small effect. Full backs show greater total and high-intensity distance in a 3-5-2 formation (Baptista et al., 2019; Modric et al., 2020; Tierney et al., 2016) and smaller high-intensity distance, sprinting distance, and the number of decelerations

in a 4-4-2 formation (Arjol-Serrano et al., 2021; Modric et al., 2020).
The effect of formation on physical performance for central and wide midfielders was also large for total distance, high-intensity distance, the number of accelerations and decelerations. Only the sprinting distance of wide midfielders showed a small effect. No clear trend could be observed in which formation central and wide midfielders showed the greatest or the lowest match performance.
Forwards show a large effect for total, high-intensity, and sprinting distance. For the number of sprints, accelerations, and decelerations the effect was only up to medium. Forwards showed the smallest total distance, the number of sprints, the number of accelerations, and the number of decelerations in a 4-4-2 formation (Arjol-Serrano et al., 2021; Borghi et al., 2020; Modric et al., 2020). However, forwards as well revealed the highest total, high-intensity, and sprinting distance in a 3-5-2 formation (Baptista et al., 2019; Modric et al., 2020; Tierney et al., 2016).
To sum up, it can be stated that the physical performance of all positions is influenced in a similar way (medium to high ES) by the tactical formation. Only the sprinting distance of full backs and central midfielders seems to be largely unaffected by tactical formation indicated by only trivial to small ES. Studies repeatedly revealed higher sprinting distances for full backs and lower sprinting distances for central midfielders (Altmann et al., 2021; Baptista et al., 2018). If assumed that the sprinting volume of full backs is close to the highest sprinting distance possible for a player in one game, it could be concluded that the sprinting distances of full backs are not affected by tactical formation because the wide players sprint as much as possible in any tactical formation. Regarding central midfielders, the results of ES and PD were conflicting (i.e. small ES and large PD) and therefore this result should be treated with caution. For all positions, higher physical match performance in 3-5-2 formations was found. The higher physical performance of players in the 3-5-2 formation could be explained by the fact, that in this formation the flanks are only covered by one player. In every other formation, the external lanes are covered by two players. In a 3-5-2 formation players possibly need to adapt to this situation by being more physically demanded.
Further, for all positions lower physical match performance in 4-4-2 formations could be revealed. A possible explanation for the lower physical performance in the 4-4-2 formation could be symmetry. As mentioned earlier, it is easier for the players to be compact in a 4-4-2 formation. Therefore, the physical demands of the 4-4-2 could be smaller than in other

formations (e.g. 3-5-2). Moreover, the 4-4-2 formation is well-balanced in the number of players in each playing position. By contrast, in other formations there are different numbers of player representing each position. In the 4-4-2 formation, two players act in each of the five playing positions considered in this review. Therefore, the formation can be indicated as good balanced, which might also influence the physical performance of the players.

Only one study investigated the technical performance of varying playing positions in different tactical formations (Arjol-Serrano et al., 2021). The study revealed more interceptions and clearances for center backs in a 4-4-2 formation compared to center backs in a 4-2-3-1 formation. Moreover, all positional groups (center back, full back, central midfielders, offensive midfielder, wide midfielder, forward) played more total passes and forward passes in a 4-4-2 formation compared to a 4-2-3-1 formation. Furthermore, forwards showed more goal shots in the 4-4-2 formation compared to the 4-2-3-1 formation. However, this was the only study available study regarding technical performance. Therefore, the results should be treated with caution.

The results of this review yield several practical implications that can be used by coaches and medical staff of soccer teams. When coaches play in formations that are similar (e.g. 4-5-1, 4-2-3-1), the physical match performance will likely be affected to only a small extent. By contrast, when coaches plan to play in a 3-5-2 formation they could possibly select players that can tolerate the high physical demands of this specific tactical formation. Moreover, when playing in a 4-4-2 they can anticipate lower physical demands during the match. This potential change in both external and internal load, when changing tactical formation should be considered in terms of designing training programs and the recovery process after matches.

4.6.4 Limitations

The findings of this systematic review should be considered with regard to their limitations. Due to the heterogeneity of the included studies and the quality of some analyses, the conclusions of this review are only generalizable to a limited extent. Because of the wide range of included studies, it is difficult to interpret the true effect of tactical formations. While a meta-analysis would possibly help to get more expressive and meaningful results, such an analysis could not be conducted because of the heterogenous and high number of different outcome measures and various methodological approaches used in the studies included in this review. Moreover, most of the studies included in this review can be considered as observational studies rather than intervention studies (e.g. actively manipulating tactical formation in a controlled environment). Therefore, no clear causal inferences about the isolated effect of changing tactical formation can be drawn on this basis.

Addressing the limitations of the included studies, a variety of different parameters to describe physical and technical performance was used and therefore, single parameters (e.g. power score (W/kg), touches per possession) were only investigated once. This aspect is especially evident regarding studies investigating technical performance. Moreover, because there were only three studies reporting technical parameters, the results regarding technical performance are of limited generalizability. Referring to the physical performance parameters, the studies rarely used the same velocity bands to describe distances covered at jogging, intensity, high-intensity, and sprinting speeds. Therefore, the comparison between the different studies lacks consistency. As mentioned in the section referring to the study characteristics, the included studies used small sample sizes. The transferability and representativity of results, therefore, have to be questioned. Further, some studies did not report sample sizes of each relevant group. Hence, the calculation of ES was not applicable and subsequent robust statements were not possible for every study. To address this problem, we also calculated percentual differences. In addition, only three studies investigated technical parameters and therefore the results regarding technical performance are restricted. Moreover, studies compared different amounts of tactical formations. With most studies just comparing two or three different tactical formations (see Table 4.1), the heterogeneity of the complex reality in soccer is not portrayed. In addition, the included studies mostly compared different tactical formations and did not report any formation changes within included games. In addition, six studies respectively did not report how formations were received and how in-game formation changes were handled.

Fruitful avenues for future research would be to investigate the above-mentioned formation changes. This would lift the quality of investigations and helps to further approach the reality of the soccer game. With the study quality in mind, it would be helpful to rise the comparability of studies investigating match performance with regards to the tactical formation. Researchers could benefit from comparing more different and especially the same formations to extent explanatory power when comparing results between studies. Studies should clearly out roll the sample sizes for each respective group that others can re-enact the methodological procedures and further increase sample sizes to get more robust results that are generalizable.

To support their results, future studies should include other contextual variables (e.g. match location, score-line, opposition quality) since they influence technical and physical match performance. Lastly, given the scarce research in technical performance, investigating the influence of tactical formations on such parameters would provide further insides in this regard.

4.7 Conclusion

This systematic review revealed that tactical formation affects the physical and technical match performance of male soccer players.

On a team level, the largest differences between formations were observed for the comparison of formations with four defenders to formations with three defenders. By contrast, the differences between tactical formations were smaller when comparing formations that are similar considering the number of players in each playing position (e.g. defenders, midfielder & forwards in: 4-5-1, 4-2-3-1).

On a positional level, players of all positions in the 3-5-2 formation revealed higher and in the 4-4-2 formation lower physical performance. A possible explanation for these findings is that the 4-4-2 formation is balanced in the number of players acting in each playing position. In the 3-5-2 formation the flanks are only covered by one player on each side of the field, which might influence the physical performance of all positional groups. In general, all playing positions were affected in a similar way by the tactical formation. Nevertheless, the sprinting distance of full backs and central midfielders remained rather stable between formations, while more pronounced differences were found for all remaining positions.

Only 3 studies analyzed technical performance parameters and the majority of included parameters were not comparable between investigations. Hence, no clear conclusion can be drawn.

From a practical point of view, the current results can help coaches to understand the changes in the performance of players that come with changes in the tactical formation. For example, they could use the results presented in this review to design training programs and plan recovery processes in relation to the higher physical match demands when i.e. playing in a formation with three defenders. Further, clubs could scout for players with specific characteristics that match the technical and physical demands of the specific tactical formation preferred in the respective the club.

5 Shedding some light on in-game formation changes in the German Bundesliga: Frequency, contextual factors, and differences between offensive and defensive formations (Paper II)

Published version of the research note article

Forcher, **L.**, Preine, L., Forcher, L., Wäsche, H., Jekauc, D., Woll, A., Gross, T., & Altmann, S. (2022). Shedding some light on in-game formation changes in the German Bundesliga: Frequency, contextual factors, and differences between offensive and defensive formations. International Journal of Sports Science & Coaching, 13, 1-10. https://doi.org/10.1177/17479541221130054

5.1 Abstract

The tactical formation is considered an important factor in soccer, however, changes in tactical formation during matches [in-game] and the distinction between offensive and defensive formations have rarely been considered in previous studies analyzing match performance. Therefore, objectives of this study were to investigate the following research questions: i) How frequently do in-game formation changes occur? ii) What contextual factors are associated with these changes? iii) How often do defensive and offensive formations differ?

The sample consisted of 81 matches (n=162 single team cases) of the 2020/21 German Bundesliga season. For each case, the starting formations (i.e. defensive & offensive) and in-game formation changes were recorded by observation of video data. For each in-game formation change, the contextual variables 'point in time', 'substitutions', and 'goals' were recorded.

In-game formation changes were found in 29.6% of the cases studied. Most in-game formation changes were discovered for the second half (95.2%), when the own team substituted at least one player (76.2%), and when the opposing team was leading the match (69.0%). In 25.3% of the investigated cases, the offensive and defensive formations of a team differed.

Concluding, in-game formation changes are a relatively common phenomenon and, therefore, must be considered in the methodology of future research on tactical formation in soccer. The same applies to the distinction between offensive and defensive formation. Furthermore, coaches can use the findings to anticipate possible opposing team in-game formation changes earlier (e.g. in the second half, when the own team is leading and the opponent is substituting a player).

Keywords: soccer, team sports, football, tactics, scouting, coach, trainer

5.2 Highlights

- The teams in the German Bundesliga changed their tactical formation during a match in 29.6% of the investigated cases (n=42 in-game formation changes in 162 investigated matches).

- Most in-game formation changes were recorded in the second half (95.2%), when the own team substituted at least one player (76.2%), and when the opponent was leading (69.0%).

- The teams in the German Bundesliga played with differing offensive and defensive tactical formations in 25.3% of the investigated cases (n=41 times in 162 investigated matches).

5.3 Introduction

Match performance in soccer is essentially determined by physical, technical, and tactical components (Sarmento et al., 2014). Thereby, the physical and technical match performance is always embedded in a tactical context (Forcher, Forcher, Jekauc, Woll, et al., 2022; Riboli et al., 2021; Tierney et al., 2016). Tactical factors include the playing position of the player and the tactical formation of the respective team. For example, center backs in formations with three center backs (e.g. 3-5-2) revealed a higher physical demand than in a formation with only two center backs (e.g. 4-4-2) (Forcher, Forcher, Jekauc, Woll, et al., 2022). Hence, the influence of tactical factors on match performance has already been studied frequently (Forcher, Forcher, Wäsche, et al., 2022; Hands & Jonge, 2020).

However, previous studies specifically addressing tactical formation in soccer have some commonalities limiting their findings. In detail, the representation of the tactical formation as a rigid system (in offensive, defensive, and transition phases) is a simplification that limits the transfer of scientific findings into practice (Garganta, 2009). Furthermore, most studies focusing on tactical formation and match performance have small samples (e.g. 15-20 matches) or considered case studies (Baptista et al., 2019a; Bradley et al., 2011; Modric et al., 2020a; Vilamitjana et al., 2021). As a result, the studies feature low generalizability.

Furthermore, possible changes in tactical formation that occurred during matches [in-game] were either not considered (Aquino et al., 2019; Borghi et al., 2020; Modric et al., 2020; Palucci Vieira et al., 2018; Riboli et al., 2021; Vilamitjana et al., 2021) or the studies that did address in-game formation changes have invariably excluded matches with such changes (Aquino, Palucci Vieira, et al., 2017a; Arjol-Serrano et al., 2021; Baptista et al., 2019a; Bradley et al., 2011; Tierney et al., 2016a). On the one hand, disregarding in-game formation changes leads to the inclusion of matches into the investigations, where the changed formation influences the outcomes while only the starting formation was recorded. For example, a previous study revealed that in-game formation changes can have a large impact on acute match performance (Forcher, Forcher, Jekauc, Wäsche, et al., 2022). On the other hand, findings from studies that exclude matches with in-game formation changes cannot be applied to the matches with in-game formation changes.

Moreover, none of the above-mentioned studies implemented a distinction between offensive and defensive formation which might differ based on the coaches' preferences. Hence, the lacking distinction between formations in offensive and defensive match phases is neglected. Since the tactical objective differs significantly between the offensive and defensive match phases, it seems reasonable to distinguish between the formations played in these phases (Goes et al., 2018).

Summarizing, the studies did not address the frequency of in-game formation changes and the distinction between offensive and defensive formation. The presented features in the methodology limit the overarching outcomes of the mentioned studies. Consequently, to date the frequency of in-game formation changes and differences in offensive and defensive formations remain unknown. Furthermore, the contextualization of data in soccer is important in order to obtain interpretable and meaningful results (Barrera et al., 2021; Ju et al., 2022). A tactical contextualization shows, for example, that outside offensive players cover more distance at high-intensity speed with the ball at their feet than other positions (Ju et al., 2022). Furthermore, studies revealed that defeated teams ran less distance in a whole match (Barrera et al., 2021). Therefore, in addition to surveying the frequency of in-game formation changes, it would also be desirable to investigate the contextual factors associated with those changes.

Hence, the aims of this study were to investigate (i) How frequently do in-game formation changes occur? (ii) What contextual factors are associated with these changes? (iii) How often do defensive and offensive formations differ? For researchers, the results could highlight the importance of considering in-game formation changes and distinguishing between defensive and offensive formations. This information is especially important for planning new high-quality research in the research field of tactical formation in soccer. In practice, the insights gained could help coaches to understand which contextual factors are related to in-game formation changes and consequently, support anticipating possible adjustments of the opposing team earlier.

5.4 Materials and Methods

5.4.1 Sample

The sample of this study consisted of 81 matches of the 2020/21 Bundesliga season. Therefore, 162 single team cases were investigated (i.e. two team cases per match). In the German Bundesliga a total of 18 teams compete. The teams were numbered according to their position in the table at the end of the season. A balanced sample was used in this study. Consequently, every second matchday of the second half of the 2020/21 season was examined (= 9 matchdays). The data basis consisted of video broadcasting of the matches which were provided by Wyscout (Wyscout, Chiavari, Italy). This study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the local ethics committee (Human and Business Sciences Institute, Saarland University, Germany, identification number: 22-02, 10 January 2022).

5.4.2 Study Design and Procedures

The tactical formation was defined as the distribution of the ten outfield players on the entire pitch and describes the number of players per positional group (i.e. 4-5-1: 4 defenders, 5 midfielders, 1 forward). The tactical formation was investigated solely in controlled build-up play phases. Offensive (own team in possession) and defensive (opposing team in possession) formations were differentiated. In the present investigation, the assessment of tactical formations was based on the procedures of Forcher et al.(Forcher, Forcher, Jekauc, Wäsche, et al., 2022). The tactical formations and in-game formation changes were observed by one experienced analyst. Additionally, the inter-rater reliability was assessed by the observation of 9 matches (=18 formations) by an additional experienced video analyst from a professional soccer team (Cohen's Kappa=0.68). Given the substantial degree of agreement between the two raters, the reliability of the data acquisition is ensured (Landis & Koch, 1977).

An in-game formation change was registered when the new formation was maintained for at least two consecutive build-up-play phases. All in-game formation changes with a temporal connection to a sending-off (=red card) were excluded because the reduction in the number of field players to nine automatically leads to a change in the tactical formation (i.e. 4-4-2 before and 4-4-1 after a red card). For each in-game formation change, the contextual variables time interval, match location, score, substitutions, and goals were recorded. Six different time intervals were distinguished: 0-15 min, 15-30 min, 30-45+ min, 45-60 min, 60-75 min, and 75-90+ min. In addition, the substitutions and goals for both the own and the opposing team were recorded five minutes before the formation change.

To determine whether some teams are more tactically flexible than others, the correlation between the number of formation changes and the number of differences in defensive and offensive formation was examined.

5.4.3 Data analysis

Data was recorded by observation and with a notational analysis. Statistical analyses were executed using IBM SPSS Statistics 27.0 (IBM Corp. Released 2020. IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp). The significance level was set to 0.05.

The frequencies of in-game formation changes, connected contextual factors, and the tactical formation for offensive and defensive match phases were assessed. In addition, a descriptive analysis of the number of in-game formation changes and differences between offensive and defensive formations was conducted based on percentages.

For the ordinal scaled contextual variables time interval and score, a chi square test was conducted in order to reveal possible differences in the frequency of the categories. Regarding possible differences in the dichotomous contextual variables substitutions and goals, a test for binomial distribution was calculated for both variables.

To detect whether there are tactically more flexible teams, spearman correlation coefficient with 95% confidence intervals [95% CI] was determined between the *number of formation changes* and the *number of games with differing offensive and defensive formations*. The magnitude of the correlation coefficient was divided into small ($0.1 \leq \rho \leq 0.3$), moderate ($0.3 \leq \rho \leq 0.5$), large ($0.5 \leq \rho \leq 0.7$), very large ($0.7 \leq \rho < 0.9$), and nearly perfect ($\rho \geq 0.9$) agreement (Hopkins, 2002).

5.5 Results

Descriptive information about each in-game formation changes is presented in Table 5.1. The number of games with an in-game formation change and the number of matches with different offensive and defensive formations for each team, respectively, are presented in Figure 5.1. Information on the percentages with regard to the main research questions can be found in Table 5.2. Starting offensive and defensive formations for every match can be viewed in Paper II. Supplementary Table 1.

Table 5.1. Each in-game formation change with offensive and defensive formation before and after the change. For each individual change, the contextual variables matchday, location, time interval, score, substitutions, and goals are listed.

Team	Match-day	Location (home; away)	Time interval	Current score (3=lead; 1=draw; 0=behind)	Substitution own team	Substitution opposing team	Goal own team	Goal opposing team	Offensive formation before change	Offensive formation after change	Defensive formation before change	Defensive formation after change
Team 7	18	away	75-90	3	2	0	1	0	3-4-3	3-5-2	3-4-3	3-5-2
Team 15	18	home	60-75	0	1	0	0	0	4-4-2	4-3-3	4-4-2	4-2-3-1
Team 9	18	away	75-90	0	0	1	0	0	3-4-3	4-3-3	3-4-3	3-4-3
Team 3	18	away	75-90	0	1	0	1	0	4-2-3-1	4-4-2 diamond	4-2-3-1	3-5-2
Team 8	18	home	30-45	0	0	0	0	1	3-5-2	4-3-3	3-5-2	4-4-2
Team 2	18	away	75-90	0	2	0	0	0	3-5-2	4-4-2	4-2-3-1	4-2-3-1
Team 6	18	home	75-90	0	3	0	0	0	4-3-3	3-5-2	4-3-3	3-5-2
Team 12	20	home	45-60	3	0	0	0	0	3-4-3	3-5-2	3-4-3	3-5-2
Team 7	20	away	60-75	0	2	0	0	0	3-5-1	4-3-2	3-5-1	4-3-2
Team 10	20	home	75-90	3	1	0	0	1	4-2-3-1	3-4-3	4-4-2	3-4-3
Team 3	20	away	60-75	0	2	0	0	0	4-2-3-1	4-4-2	4-2-3-1	4-4-2
Team 8	20	home	60-75	0	3	1	0	1	4-2-3-1	3-5-2	4-2-3-1	4-2-3-1
Team 16	22	home	60-75	0	1	0	0	0	3-4-3	4-3-3	3-5-2	4-3-3
Team 3	22	away	60-75	3	1	0	1	0	4-2-3-1	4-3-3	4-2-3-1	4-3-3
Team 17	22	away	45-60	0	1	0	0	1	3-5-2	4-3-3	3-5-2	4-3-3
Team 6	22	away	45-60	0	2	0	0	0	4-3-3	4-4-2	4-3-3	4-4-2
Team 6	22	away	60-75	0	1	2	0	0	4-4-2	3-5-2	4-4-2	3-5-2
Team 10	22	home	45-60	1	1	0	0	0	4-3-3	3-4-3	4-4-2	3-4-3
Team 15	22	home	60-75	0	3	0	0	1	4-3-3	4-4-2	4-4-2	4-4-2
Team 10	24	home	45-60	0	0	0	0	1	4-4-2	3-5-2	4-4-2	3-5-2
Team 15	24	home	45-60	0	0	0	0	0	4-4-2 diamond	4-2-3-1	4-4-2 diamond	4-4-2
Team 16	26	home	75-90	3	0	1	0	0	4-4-2	4-3-3	4-4-2	4-4-2
Team 15	26	home	0-15	1	0	0	0	0	4-4-2 diamond	4-2-2-2	4-4-2 diamond	4-2-2-2
Team 15	26	home	45-60	1	0	0	0	0	4-2-2-2	4-3-3	4-2-2-2	4-3-3
Team 14	26	home	60-75	3	1	0	0	0	3-4-3	3-5-2	3-4-3	3-5-2
Team 6	26	away	45-60	0	2	0	0	0	4-2-3-1	3-5-2	4-2-3-1	3-5-2
Team 11	26	home	75-90	0	2	0	0	0	3-4-3	4-3-3	3-4-3	4-2-3-1

Team	Match-day	Location (home; away)	Time interval	Current score (3=lead; 1=draw; 0=behind)	Substitution own team	Substitution opposing team	Goal own team	Goal opposing team	Offensive formation before change	Offensive formation after change	Defensive formation before change	Defensive formation after change
Team 9	28	home	60-75	0	2	0	0	0	3-4-3	4-4-2 diamond	3-4-3	4-4-2 diamond
Team 17	28	home	45-60	0	3	1	0	1	3-4-3	4-2-3-1	3-4-3	4-2-3-1
Team 2	28	away	45-60	3	1	3	1	0	4-3-3	3-5-2	4-2-3-1	3-5-2
Team 14	28	home	45-60	0	3	0	0	0	3-4-3	3-4-3	3-4-3	3-5-2
Team 4	28	away	60-75	0	2	0	0	1	4-2-3-1	4-4-2	4-2-3-1	4-4-2
Team 13	28	away	60-75	0	2	0	0	0	3-4-3	3-4-3	4-4-2	3-5-2
Team 10	30	away	45-60	0	2	0	0	0	3-4-3	4-4-2	3-4-3	4-4-2
Team 2	30	away	60-75	0	2	0	1	1	4-2-2-2	3-4-3	4-2-2-2	3-4-3
Team 8	30	away	60-75	0	3	1	0	1	4-4-2	3-4-3	4-4-2	3-4-3
Team 8	32	away	45-60	0	2	0	0	1	4-4-2	4-2-3-1	4-4-2	4-2-3-1
Team 17	32	home	45-60	1	0	2	0	0	4-3-3	4-4-2	4-3-3	4-2-3-1
Team 7	32	away	60-75	0	3	0	0	1	3-5-2	4-3-3	3-5-2	4-2-3-1
Team 14	32	home	45-60	1	1	0	0	0	3-5-2	4-4-2	3-5-2	4-4-2
Team 13	34	away	45-60	0	2	0	1	0	4-2-3-1	3-5-2	4-4-2	3-5-2
Team 15	34	away	45-60	1	0	0	0	0	4-3-3	4-4-2	4-2-3-1	4-4-2

Table 5.2. Percentage and frequency data for in-game formation changes, contextual factors related to in-game formation changes, and differences between defensive and offensive formations.

	Percentage (quantity)
Frequency of in-game formation changes	
In-game formation changes	29.6 % *(42 in-game formation changes in 162 single team cases)*
Teams that changed their formation in at least one third of the games (>3 games)	44.4 % *(8 teams)*
Teams that changed their formation in less than one third of the games (<3 games)	56.6 % *(10 teams)*
Contextual factors related to in-game formation changes	
Time interval 0-15	2.4 % *(1 in-game formation change)*
Time interval 15-30	0.0 % *(0 in-game formation changes)*
Time interval 30-45	2.4 % *(1 in-game formation change)*
Time interval 45-60	40.5 % *(17 in-game formation changes)*
Time interval 60-75	35.7 % *(15 in-game formation changes)*
Time interval 75-90	19.0 % *(8 in-game formation changes)*
Current score = lead	16.7 % *(7 in-game formation changes)*
Current score = draw	14.3 % *(6 in-game formation changes)*
Current score = behind	69.0 % *(29 in-game formation changes)*
Substitution own team	76.2 % *(32 in-game formation changes)*
Substitution opposing team	19.0 % *(8 in-game formation changes)*
Goal own team	14.3 % *(6 in-game formation changes)*

	Percentage (quantity)
Differences between defensive and offensive formations	
Differing offensive and defensive formations	25.3 % *(41 cases in 162 single team cases)*
Teams that revealed differing offensive and defensive formations in at least two matches	66.7 % *(12 teams)*
Teams that revealed differing offensive and defensive formations in less than two matches	33.3 % *(6 teams)*

	Percentage (quantity)	
Match location		
	home	**away**
Proportion of formation changes	50.0 % *(21 formation changes)*	50.0 % *(21 formation changes)*
Time interval 0-15	4.8 % *(1 formation change)*	0.0 % *(0 formation changes)*
Time interval 15-30	0.0 % *(0 formation changes)*	0.0 % *(0 formation changes)*
Time interval 30-45	4.8 % *(1 formation change)*	0.0 % *(0 formation changes)*
Time interval 45-60	42.9 % *(9 formation changes)*	38.1 % *(8 formation changes)*
Time interval 60-75	28.6 % *(6 formation changes)*	42.9 % *(9 formation changes)*
Time interval 75-90	19.0 % *(4 formation changes)*	19.0 % *(4 formation changes)*
Current score = lead	19.0 % *(4 formation changes)*	14.2 % *(3 formation changes)*
Current score = draw	23.8 % *(5 formation changes)*	4.8 % *(1 formation changes)*
Current score = behind	57.1 % *(12 formation changes)*	81.0 % *(17 formation changes)*
Substitution own team	61.9 % *(13 formation changes)*	90.5 % *(19 formation changes)*
Substitution opposing team	19.0 % *(4 formation changes)*	19.0 % *(4 formation changes)*
Goal own team	0.0 % *(0 formation changes)*	28.6 % *(6 formation changes)*
Goal opposing team	28.6 % *(6 formation changes)*	28.6 % *(6 formation changes)*

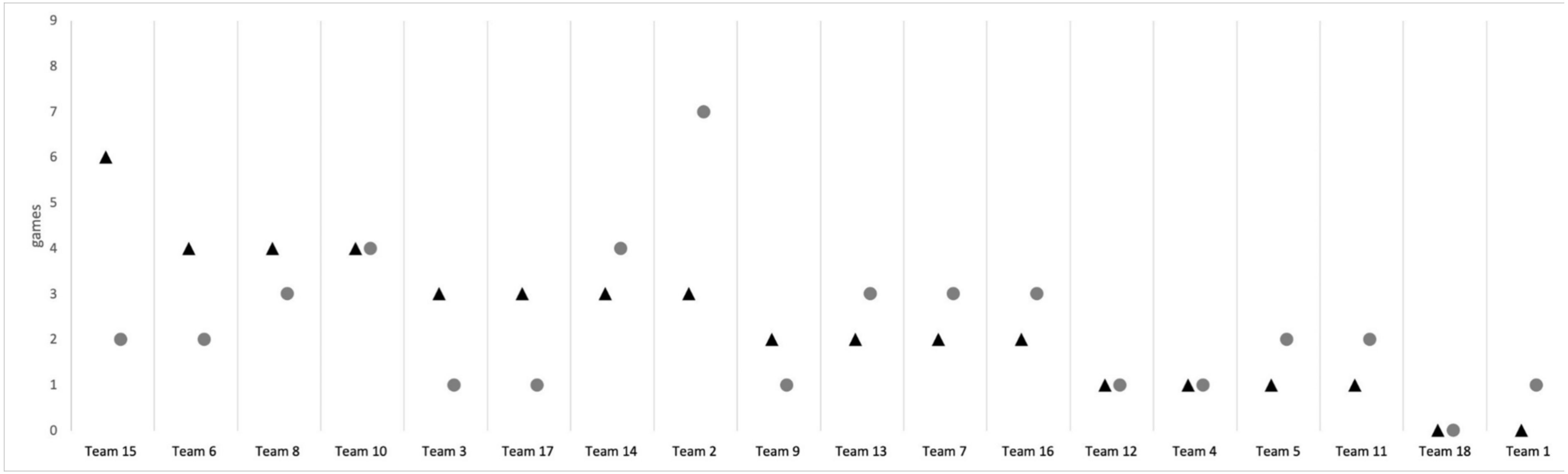

Figure 5.1. For each team, the number of in-game formation changes (black triangles) and the number of matches with different offensive and defensive formations (grey circles) are reported. The teams were sorted according to the number of in-game formation changes (i.e. the team with the most in-game formation changes on the left) and were numbered according to their position in the table at the end of the season.

In the investigated 81 games and, therefore, in 162 single team cases, 48 in-game formation changes were recorded. Because in-game formation changes as a result of red cards were excluded (6), 42 changes remained. Therefore, teams in the German Bundesliga changed their tactical formation in 29.6% of the investigated cases. While 44.4% of the investigated teams changed their formation in at least one third of the games, 56.6% of the teams changed their formation in less than one third of the games. With six changes during nine recorded games, team 15 changed their formation most frequently. Only for team 1 and 18, no in-game formation change was revealed. Identical numbers of in-game formation changes (=21) were observed for home and away matches.

Furthermore, information about the context of the in-game formation changes can be found in Table 5.1. The chi square test revealed significant differences regarding the time interval ($p<0.01$, mean = 62.38, SD = 14.67) and the score ($p<0.01$, mean = 0.64, SD = 1.11). 95.2% of the in-game formation changes were recorded in the second half (=40 changes). Most changes were recorded for the time interval 45-75 min (76.2%). The match location had no influence on the time of the change. Moreover, regarding the context of the formation changes, there were more changes when the opposing team was leading (69.0%), while there were less changes recorded for leading teams (16.7%) and tied matches (14.3%). The statistical tests for binomial distribution indicated that there were more substitutions by the own team ($p<0.01$, mean = 1.43, SD = 1.03), less substitutions by the opposing team ($p<0.01$, mean = 0.29, SD = 0.67), less own goals ($p<0.01$, mean = 0.14, SD = 0.35), and less opposing goals ($p<0.01$, mean = 0.29, SD = 0.45) in the five minutes before the formation change than expected with a binomial distribution. 76.2% of the changes were preceded by a substitution of the own team. An opposing team substitution before a formation change was observed in 19.0% of the cases. The formation was changed after a goal of the opposing team more frequent (28.6%) than after a goal for the own team (14.3%). For home matches, more changes were observed when the current score was a draw. For away matches more formation changes were observed if the team was trailing, there was a substitution of the own team, and a goal of the respective team was scored in the five minutes before the change.

Teams started with different offensive and defensive formations 41 times (=25.3%). Only one team (= team 18) played all nine investigated matches with identical offensive and defensive formations. Moreover, team 2 was the only team that played with differing offensive and defensive formations in more than half of the matches (= 7 matches).

The Spearman correlation revealed a significant and large correlation between the *number of formation changes per team and games with different offensive and defensive formations* per team (ρ=0.52, p= 0.03, 95% CI= 0.05-0.80).

5.6 Discussion

This study aimed to shed some light on tactical formations in the German Bundesliga by investigating (i) the frequency of in-game formation changes, (ii) which contextual factors are related to the in-game formation changes, and (iii) how often defensive and offensive formations differed at the beginning of a match. In-game formation changes were observed in 29.6% of the investigated matches. Only two teams did not change their formation in any investigated match. Furthermore, in 25.3% of all observed matches, defensive and offensive formations of a team differed at the beginning of a match. Only one team started with identical offensive and defensive formations across all investigated matches.

5.6.1 Frequency of In-game Formation Changes

Large differences were found between the teams regarding the frequency of in-game formation changes. For almost half of the teams studied (44.4%), an in-game formation change in at least one third of the matches was revealed. While team 15 even changed their formation six times, for seven other teams (= teams 2, 3, 6, 8, 10, 14, and 17) three or four in-game formation changes were recorded. In contrast, for the remaining 55.6% of the teams, a change of formation was observed in less than one third of the matches. One or two formation changes were found for eight teams (= teams 4, 5, 7, 9, 11, 12, 13, and 16). Teams 1 and 18 did not change their formation in any of the matches examined. Accordingly, the teams can be divided into two approximately equal categories in terms of the frequency of formation changes. First, teams that change their formation more frequently (i.e. in at least 1/3 of the matches = 44.4%) and teams that change their formation rarely or not at all (i.e. in less than 1/3 of the matches = 55.6%). Furthermore, the match location had no influence on the number of in-game formation changes.

A previous study analyzing one team over three seasons with three different coaches revealed that the frequency of in-game formation changes depended on the coach (Forcher, Forcher, Jekauc, Wäsche, et al., 2022). As the investigated teams show strong differences in the frequency of in-game formation changes, one could conclude that the present study also supports the aforementioned suggestion. It can therefore be assumed that the coach (or the coaching staff) is largely responsible for the tactical flexibility of a team during a game. Furthermore, comparisons with other studies were not possible because they did not provide comparable data.

5.6.2 Contextual Factors Related to In-game Formation Changes

Furthermore, important information could be extracted regarding the contextual factors related to the in-game formation changes. The in-game formation changes were mostly recorded for the second half, linked with a substitution, and when the team was trailing. Almost all in-game formation changes were observed in the second half (95.2%). The late timing may be related to several processes. First, a team needs to adjust to the opponent and their style of play over a specific time. Only after a certain period of time repetitive patterns in the game can be identified. After this timespan, the coaching staff can then think about possible adjustments regarding the tactical formation. Second, most of the changes took place in the time interval 45-60 minutes. This time interval has several advantages. On the one hand, a formation change can be explained to the team in a restful environment during the half-time break. On the other hand, an adjustment at this time is promising because there is still a relatively long time left in the match to enable the players to adapt their behavior to the new formation.

Furthermore, most in-game formation changes are linked to a substitution relating to the formation changing team (76.2%). A substitution allows a player to take on a new role in the tactical team formation and thus replace another. In addition, the short interruption during the substitution can be used to give instructions to the players and, therefore, to adjust the tactical formation. Finally, most in-game formation changes occur when the opposing team was leading (69.0%). Furthermore, in-game formation changes were observed more frequently after an opposing team goal (28.6%) than after a goal of the own team (14.3%). It has already been shown that when a team loses, the likelihood to change the formation between matches increases (Tamura & Masuda, 2015). This is known as the Win-Stay-Loose-Shift strategy. The aforementioned results suggest that the Win-Stay-Loose-Shift strategy should also be considered within a game. Consequently, when a team is trailing, it can be assumed that the likelihood of an in-game formation change increases. Accordingly, when a team is behind, the willingness of the coaching staff to make changes to tactics (e.g. change in formation) increases. Conversely, the likelihood of an in-game formation change decreases when a team is leading. Hence, the coaching staff wants to bring home the victory safely and avoid giving away a lead by changing the tactical formation throughout the game. A previous investigation focusing on solely one team over three seasons in the German Bundesliga also revealed more in-game formation changes after goals for the opposing team (Forcher,

Forcher, Jekauc, Wäsche, et al., 2022). Hence, the results of the previous study support the aforementioned conclusions.

Regarding the match location there were only small differences between home and away teams. However, for home teams, more changes were observed when the current score was a draw. However, coaches of away teams, acted more conservatively, because they changed the formation almost exclusively when trailing. Therefore, one could conclude that coaches of home teams are more decisive in terms of in-game formation changes.

5.6.3 Differences Between Defensive and Offensive Formations

In addition, the distinction between offensive and defensive formations needs to be considered to answer the third part of the research question. While Team 18 played with identical offensive and defensive formations in every match, six teams (= teams 1, 3, 4, 9, 12, and 17) revealed different offensive and defensive formations in only one of the games studied. Furthermore, for another eight teams (= teams 5, 6, 7, 8, 11, 13, 15, and 16), two to three games with different offensive and defensive formations were observed. Lastly, teams 1, 10, and 14 revealed differing defensive and offensive formations at least four times. Across all investigated teams, the Spearman correlation revealed that teams with fewer in-game formation changes also appeared less often with different offensive and defensive formations ($\rho=0.52$). One could conclude that teams that often change formations also seem to be those that often have different defensive and offensive formations, and are thus to be assessed as tactically flexible (Praça et al., 2022).

5.6.4 Limitations

Although the study provides a general overview of in-game formation changes in professional soccer, there are some limitations that need to be considered when interpreting the findings of this study in a broader context. While including more matches than many previous studies in this field, still only one part of a single season was studied. It is possible that the frequency of formation changes or differences between defensive and offensive formations may change over time. Hence, it could be worthwhile investigating a whole competitive season. Furthermore, only the frequency of in-game formation changes was investigated. A logical next step in future studies would be to investigate the influence of these in-game formation changes on match performance (e.g. technical or physical performance). Moreover, future studies could try to predict in-game formation changes based on even more contextual factors (e.g. opposition quality) by using a linear mixed model. To implement this, for example, all five-minute periods of the sample would have to be analyzed (i.e. also those in which no in-game formation change took place). Such a prediction could give coaches a decisive competitive advantage in practice.

5.7 Conclusion

The teams in the German Bundesliga changed their tactical formations during a match in 29.6% of the investigated cases. Furthermore, the teams played with different defensive and offensive formations in 25.3% of the analyzed matches. Therefore, the present study revealed essential information for planning new studies on tactical formation in soccer because by using only one formation throughout a match and without differentiating offensive and defensive game phases the important information is lost and results cannot be generalized. Accordingly, in-game formation changes and the differentiation between offensive and defensive formations need to be considered in future investigations. This approach would represent an advance in knowledge that is essential for future research in professional soccer, thus leading to a better methodology and, at the same time, more robust and practically relevant results.

Moreover, teams in the German Bundesliga changed formation more often in the second half, when they were trailing, and substituted players beforehand. From a practical perspective, coaches can use these contextualized results to earlier anticipate possible formation changes of opposing teams in the future. This, in turn, allows them to better react to these opponent adjustments to support their team as best as possible. These adjustments are especially necessary for modern professional soccer, which has become more and more flexible.

6 How Coaches Can Improve Their Teams' Match Performance - The Influence of In-Game Changes of Tactical Formation in Professional Soccer (Paper III)

Published version of the original research article

Forcher, **L.**, Forcher, L., Jekauc, D., Wäsche, H., Woll, A., Gross, T., & Altmann, S. (2022). How Coaches can Improve their Teams' Match Performance - The Influence of in-game Changes of Tactical Formation in Professional Soccer. Frontiers in Psychology, 13, 1-11. https://doi.org/10.3389/fpsyg.2022.914915

6.1 Abstract

The tactical formation has been shown to influence the match performance of professional soccer players. This study aimed to examine the effects of in-game changes in tactical formation on match performance and to analyze coach-specific differences.

We investigated three consecutive seasons of an elite team in the German Bundesliga which were managed by three different coaches, respectively. For every season, the formation changes that occurred during games were recorded. The match performance was measured on a team level using the variables 'goals', 'chances', and 'scoring zone' entries (≙successful attacking sequence) for the own/opposing team.

Non-parametric tests were used to compare the ten minutes before with the ten minutes after the formation change, as well as games with and without formation change.

In the ten minutes after the formation change, the team achieved more goals/chances/scoring zone entries than in the ten minutes before the formation change (mean ES=0.52). Similarly, the team conceded fewer opposing goals/chances/scoring zone entries in the ten minutes after the formation change (mean ES=0.35). Furthermore, the results indicate that the success of the respective formation change was dependent on the responsible coach. Depending on the season, the extent of the impacts varied (season 1: mean ES=0.71; season 2: mean ES=0.26; season 3: mean ES=0.22).

Over all three seasons, the formation changes had a positive effect on the match performance of the analyzed team, highlighting their importance in professional soccer. Depending on the season, formation changes had varying impacts on the performance, indicating coach-specific differences. Therefore, the quality of the formation changes of the different coaches varied. The provided information can support coaches in understanding the effects of their in-game decisions.

Keywords: football, tactics, game analysis, video, scouting, trainer

6.2 Introduction

In recent years, scientific interest in soccer match performance has markedly increased. Physical and technical match performance has been investigated frequently (Dolci et al., 2020; Forcher, Forcher, Wäsche, et al., 2022). Furthermore, since computer technology and science allowed researchers to deal with larger data sets, the construct of the tactical soccer performance received increasing attention (Sarmento et al., 2018). Particularly, current reviews highlight the offensive and defensive tactical performance of single players, groups, and whole teams, thus pointing to the great opportunities in-game analysis research (Forcher, Altmann, et al., 2022; Goes et al., 2020; Lepschy et al., 2018). Similarly, the interest in the influence of tactical factors on soccer performance has also increased recently (Modric et al., 2020; Vilamitjana et al., 2021).

Typical tactical factors that influence the match performance of soccer players are the playing position or the tactical formation. It is widely accepted that the playing position has a large impact on technical as well as physical match performance (Dolci et al., 2020). For example, central midfielders indicate more ball-possessions than other positions (Dellal et al., 2010) and wide positions (defenders & midfielders) run the greatest distances at high-intensity and sprinting speed zones (Aquino, Carling, Palucci Vieira, et al., 2020; Paraskevas et al., 2020; Rivilla-Garcia et al., 2018). Similarly, the tactical formation of a soccer team impacts the match performance of a single player and the whole team. Teams playing in a formation with three central defenders (e.g. 3-5-2) tend to be more physically demanded in comparison to teams with two central defenders (e.g. 4-4-2) (Forcher, Forcher, Wäsche, et al., 2022). By contrast, looking at the technical performance, players in a 4-4-2 formation display more passes than in other formations (Arjol-Serrano et al., 2021; Bradley et al., 2011). Lastly from a tactical perspective, teams in a 3-5-2 formation can be more compact and, therefore, can put more pressure on the opposing attacking team than teams in a 4-4-2 formation (Memmert et al., 2019). To summarize, both tactical factors (i.e. playing position and tactical formation) have an influence on soccer match performance.

Nevertheless, the studies that examined the effects of tactical formation on match performance have some distinctive features. Specifically, all the mentioned studies that investigated tactical formations focused on the effects of tactical formation changes that occurred *between* two or more games. Besides substitutions, such changes in tactical formation within a game are one way for the coach to potentially influence the running of the game (Bradley et al., 2014a). To the best of the authors' knowledge, until today no studies analyzed the effects of changing the tactical formation *within* one game.

Apart from this, the studies mentioned above have common features that differ from the approach taken in this study. The majority of studies investigated physical and technical parameters (Bradley et al., 2011; Paraskevas et al., 2020a; Rivilla-Garcia et al., 2018a) to describe soccer performance. Incidentally, most of the previous studies focused on individual match performance metrics and have not studied parameters that are directly linked to success. In contrast, the parameters investigated in the current study are linked in a more direct way to success (Lepschy et al., 2020). In addition, most of the investigations dealt with single players' game performances. As suggested in previous studies, we divided the game into individual attacking sequences (Forcher et al., 2021). Subsequently, we assessed the success of each individual ball possession for the own as well as for the opposing team.

In conclusion, it seems worthwhile to investigate the effects of in-game formation changes using outcome variables that are linked to success in soccer such as goals, chances, and last-plane entries. Accordingly, the current study aimed to examine the effects of such in-game changes in the tactical formation on match performance by analyzing both the own team's and opposing team's attacking sequences. In addition, we sought to identify possible coach-specific differences regarding these effects. The results of our study could help to detect the impact of in-game formation changes and evaluate coach-specific differences on these dynamics.

6.3 Materials and Methods

6.3.1 Study Design

In the present study, three consecutive seasons of a German Bundesliga team were analyzed (season 1 =2021/22; season 2 = 2019/20; season 3 = 2018/19). To detect changes in tactical formation that occurred within games [in-game], we analyzed each game by observation. To quantify if and to which extent the in-game formation change influenced the match performance, we conducted two comparisons. First, we analyzed the effects of in-game formation changes by comparing games with at least one formation change in contrast to games without a formation change. Second, we analyzed the in-game effects of formation changes by comparing the ten minutes before [10-min-pre] to the ten minutes after [10-min-post] the formation change. The ten-minute period represents a compromise between an acceptable number of attacking sequences and an exclusion of other impacts.

In order to quantify the effects of the in-game formation changes on an attacking sequence level, goals, chances, and scoring zone entries were analyzed for the own as well as for the opposition team, leading to a total of six different variables.

6.3.2 Sample

In this study, official video data of three consecutive seasons of a German elite team in the Bundesliga were analyzed, which were provided by Wyscout (Wyscout, Chiavari, Italy). During this period, the club participated in international competitions (UEFA Champions League & UEFA Europa League) in two of the three seasons and was managed by three different coaches. In the second season, the coach was replaced after the 30th matchday and, therefore, only 30 of 34 possible games of this season were analyzed. The other two seasons consisted of 34 games each. Accordingly, the sample comprised a total of 98 games. Since each season was trained by a different coach, differences between the seasons may be due to differences between the coaches. The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the local ethics committee (Human and Business Sciences Institute, Saarland University, Germany, identification number: 22-02, 10 January 2022).

6.3.3 Procedures

The tactical formation was defined as the distribution of the players on the pitch and was only observed in controlled build-up play from either their own or opposing team. Defensive (opposing team in ball possession) and offensive (own team in ball possession) tactical formations were distinguished. A tactical formation is defined by the number of players that play as defenders, midfielders, and forwards (i.e. 4-4-2: 4 defenders, 4 midfielders, 2 forwards). Two experienced video analysts independently recorded every formation change by observation and when differences arose they were discussed until a consensus was reached.

A formation change was recorded if the analyzed team either changed solely their offensive formation, changed solely their defensive formation, or changed both formations simultaneously. A change in the tactical formation (e.g. number of players per playing position: i.e. defenders, midfielders, forwards) was counted when the new tactical formation was maintained throughout a minimum of two consecutive build-up play phases. The defensive formation was monitored when the opposing team was in ball possession whereas the offensive formation was monitored when the own team was in ball possession. The opposing teams' tactical formation was not considered in this study. Afterward, the exact time point for every single formation change was identified. The time point was defined as the first build-up play phase in which the change of the tactical formation was observed.

To detect the effects of in-game formation changes on goals, chances, and scoring zone entries, we analyzed *games with at least one formation change* in comparison to *games without a formation change*. In addition, the ten minutes before the formation change [*10-min-pre*] were compared to the ten minutes afterward [*10-min-post*]. The ten-minute period was chosen because it represents a compromise between an acceptable number of attacking sequences and an exclusion of possible impacts by an opposing adaption to the formation change.

The match performance on a team level was analyzed using six different key performance variables that assess the success of individual attacking sequences. For the own teams as well as for the opposition team, goals, chances, and scoring zone entries were recorded. As the main goal of an attacking sequence is to score, goals and chances were recorded in order to quantify the success of an individual attacking sequence (González-Rodenas et al., 2019; Tenga, Ronglan, et al., 2010). Additionally, by recording scoring zone entries, a further key performance variable was considered. Scoring zone entries are an expressive variable when looking at the match performance of a whole team and evaluating the success of an individual attacking sequence (Guimarães et al., 2021). Every goal and every chance arises after a scoring zone entry.

Similar to Tenga et al. (Tenga, Ronglan, et al., 2010), we defined chances as every shot or header that was executed in the penalty area. Additionally, every shot from outside the penalty area that led to a goalkeeper save was counted as a *chance*.

The scoring zone is a zone on the pitch that spreads in front of the opposition goal (Figure 6.1). The area starts at the goal line up to the corners and continues with a semicircle from side-line to side-line. Since Guimaraes et al. (Guimarães et al., 2021) revealed that attacks via the central zone of the final third are more promising than attacks via the outside lanes, the *scoring zone* area is larger in the center than on the outside. Therefore, on the side-lines, the semicircle originates with a horizontal distance of 16.5 m to the goal line. At its most distant point, the center of the goal-line, the distance between the semicircle and the goal-line constitutes 25 m. A scoring zone entry was counted if a player of the attacking team has a ball contact in the scoring zone area and is facing towards the goal. Further, a scoring zone entry was counted if the player in ball possession faced the opposing goal even if he was not in the scoring zone area and a maximum of six players of the defending team were in front of the ball. Therefore, in addition to chances and goals, scoring zone entries were considered as a successful attacking sequence.

In Figure 6.2, a visual presentation of one game is provided. The six different variables were listed throughout every minute of the whole game time. Further, the moment of the in-game formation change of the own team was tagged and the 10-min-pre and 10-min-post phases were outlined.

Moreover, to investigate the inter-rater reliability of the key performance variables studied (goals, chances, scoring zone), a game from the first season was evaluated by two experienced analysts (see Paper III. Supplementary Table 1). Given the high agreement between the results of both analysts (mean Cohen's Kappa=0.94; mean p=0.02), the applied procedure can be considered reliable (Landis & Koch, 1977).

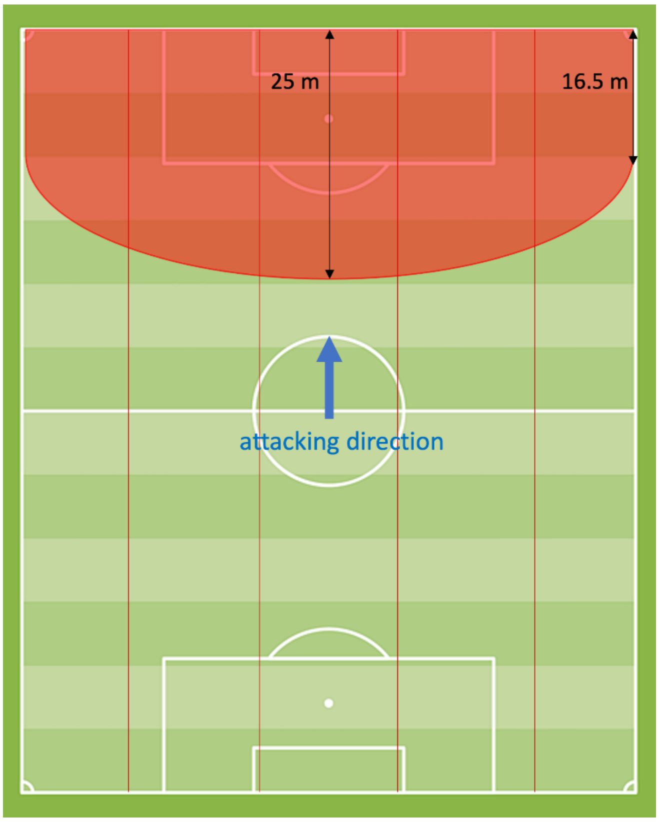

Figure 6.1. Scoring zone.

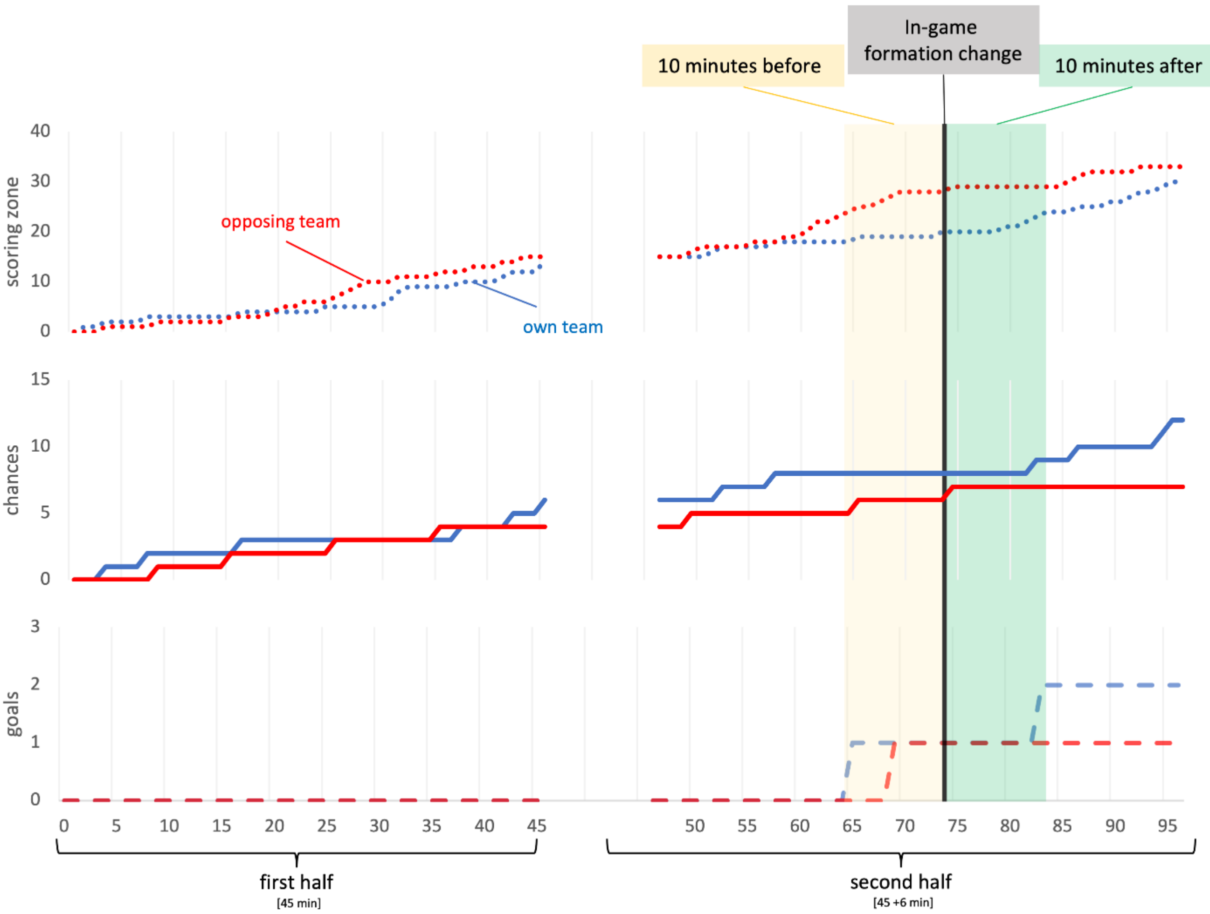

Figure 6.2. Example.

6.3.4 Statistical Analysis

To detect the impact of in-game formation changes, mean values and standard deviations [SD] for goals, chances, and scoring zone entries were calculated for *games with at least one formation change* and *games without formation change*. In addition, for all games with at least one formation change, these variables were examined *10-min-pre formation change* and *10-min-post formation change*.

All variables were checked for normal distribution with the help of Kolmogorov-Smirnov tests. Since not all variables were normally distributed, we performed the statistical analysis with non-parametric tests (see Paper III. Supplementary Table 2).

Moreover, to evaluate the differences between the three coaches, we considered each season separately.

First, we compared games with and games without formation change. The number of games was not equally distributed throughout the two groups (i.e. games with and without formation change).

Therefore, to detect possible differences between the games with and without formation change, Mann-Whitney-U-tests were conducted.

Second, data from 10-min-pre formation change were compared to 10-min-post formation change. Specifically, for each formation change detected, data were collected for the 10-min pre- and 10-min post-phases so that paired samples were provided. Therefore, to determine whether the measured variables increase or decrease in the 10-min-post phase compared to the 10-min-pre phase, sign-tests were executed.

To determine the magnitude of the group differences, Cohen's d effect sizes [ES] were calculated for every group comparison. In detail, small ($0.2 \leq ES < 0.5$), medium ($0.5 \leq ES < 0.8$) and large ($ES \geq 0.8$) ES were distinguished (Cohen, 1988).

All statistical analyses were executed using IBM SPSS Statistics 25.0.0.0 (IBM Co., New York, USA). Due to the expected low number of formation changes per season, we mainly referred to effect sizes when interpreting the results instead of p values.

6.4 Results

Season 1 (Figure 6.3) included nine games with a formation change, resulting in nine single formation changes that were investigated. Of the nine changes, eight were recorded in the second half leading to an average game minute of 64.11(±15.57). Seven changes concerned both offensive and defensive formation, while only one change concerned solely defensive or offensive formation, respectively.

Season 2 (Figure 6.4) included 10 games with a formation change, resulting in 11 single formation changes that were investigated (one game with 2 formation changes). All eleven changes were recorded in the second half leading to an average game minute of 55.82 (±13.20). Five changes concerned both offensive and defensive formation, two changes only defensive formation, and four changes only offensive formation.

Season 3 (Figure 6.5) included 22 games with a formation change, resulting in 28 single formation changes that were investigated (6 games with 2 formation changes). 23 of the 28 changes were recorded in the second half leading to an average game minute of 55.46(±17.45). 16 changes concerned both offensive and defensive formation, eight changes only defensive formation, and four changes only offensive formation.

Descriptive statistics (mean ± SD) of every season separately and all seasons taken together and for every variable (goals, chances, scoring zone) are reported in Figures 6.3-6.6. Numerical values can be taken from the Paper III. Supplementary Table 3 and Paper III. Supplementary Table 4. Detailed information on each in-game formation change including defensive and offensive formations before and after the change can be found in Paper III. Supplementary Table 6.

The Mann-Whitney-U-tests (see Figures 6.3-6.6), comparing games with formation change and without formation change, revealed that the analyzed team in season 2 conceded more goals in games with at least one formation change compared to games without a formation change ($p=0.02$; $ES=0.46$; $U=49$; $Z=-2.36$). Although the ES were mainly trivial and small they reveal more detailed information (see Paper III. Supplementary Table 3). In season 1, games with a formation change were associated with fewer opposing chances and opposing scoring zone entries ($ES=0.26$). In Season 2, games with a formation change had more own scoring zone entries and opponent goals and fewer own and opponent chances than games without a formation change (mean $ES=0.31$). In season 3, the team created more scoring zone entries in games with formation change than in games without formation change ($ES=0.29$).

The sign-tests (see Figures 6.3-6.6) revealed that the analyzed team allowed fewer opposing scoring zone entries in the 10-min-post formation change period compared to the 10-min-pre formation change period in season 1 (p=0.02; ES=1.29; positive spread=7; negative spread=0; tie=2). Further, the analyzed team created more chances in the 10-min-post formation change period compared to the 10-min-pre formation change period in all seasons (p=0.03; ES=0.54; positive spread=10; negative spread=24; tie=14). Subsequently, the results regarding ES reveal more detailed information (see Paper III. Supplementary Table 4). Over all three seasons, the analyzed team created more goals, chances, and scoring zone entries in the 10-min-post formation change period compared to the 10-min-pre formation change period (mean ES=0.52). Furthermore, the analyzed team prevented more opposing goals, chances, and scoring zone entries in the 10-min-post formation change period compared to the 10-min-pre formation change period (mean ES=0.28).

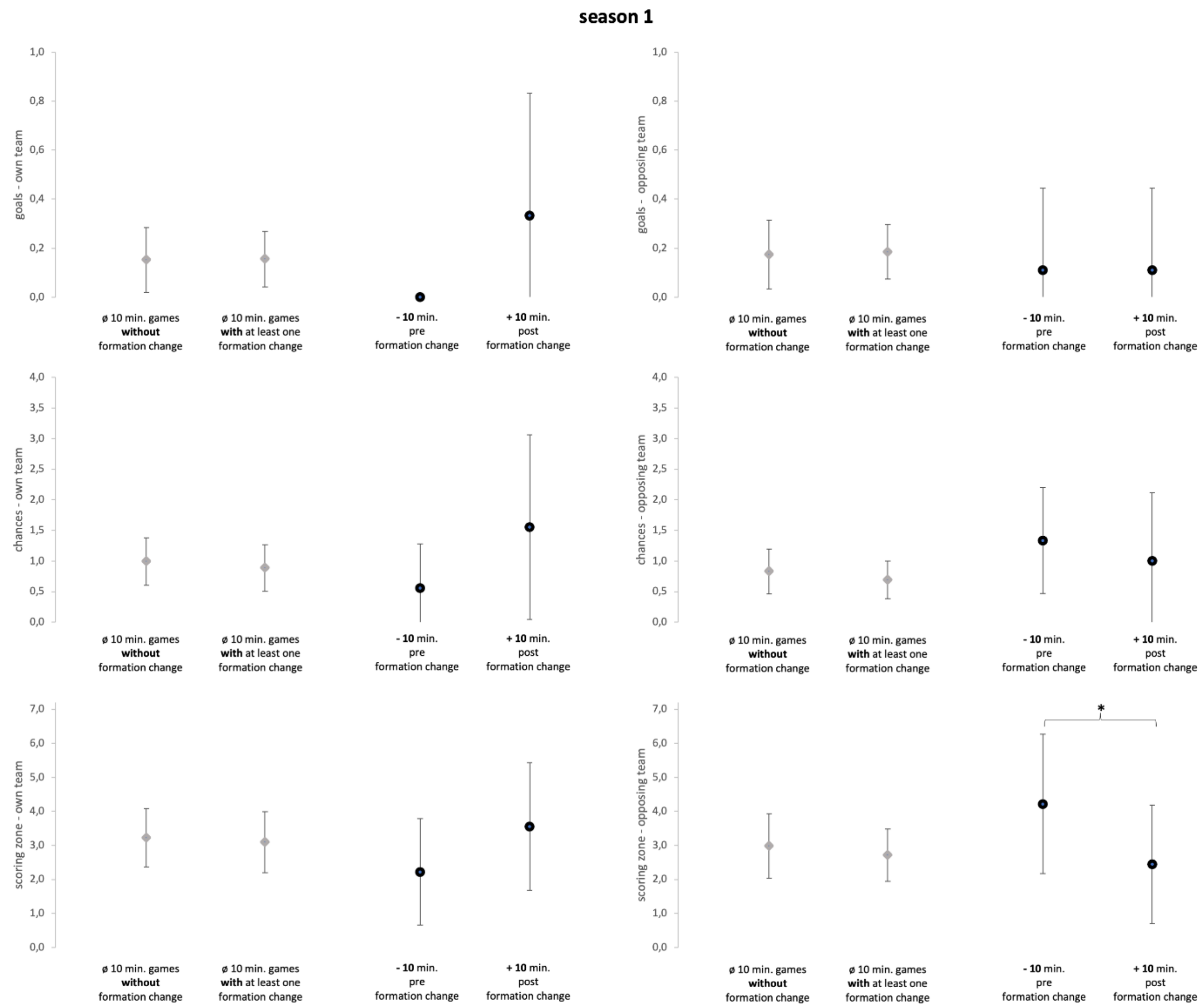

Figure 6.3. Season 1. Data of season 1 are presented as mean values ± SD. Black parentheses indicate significant differences (p<0.05).

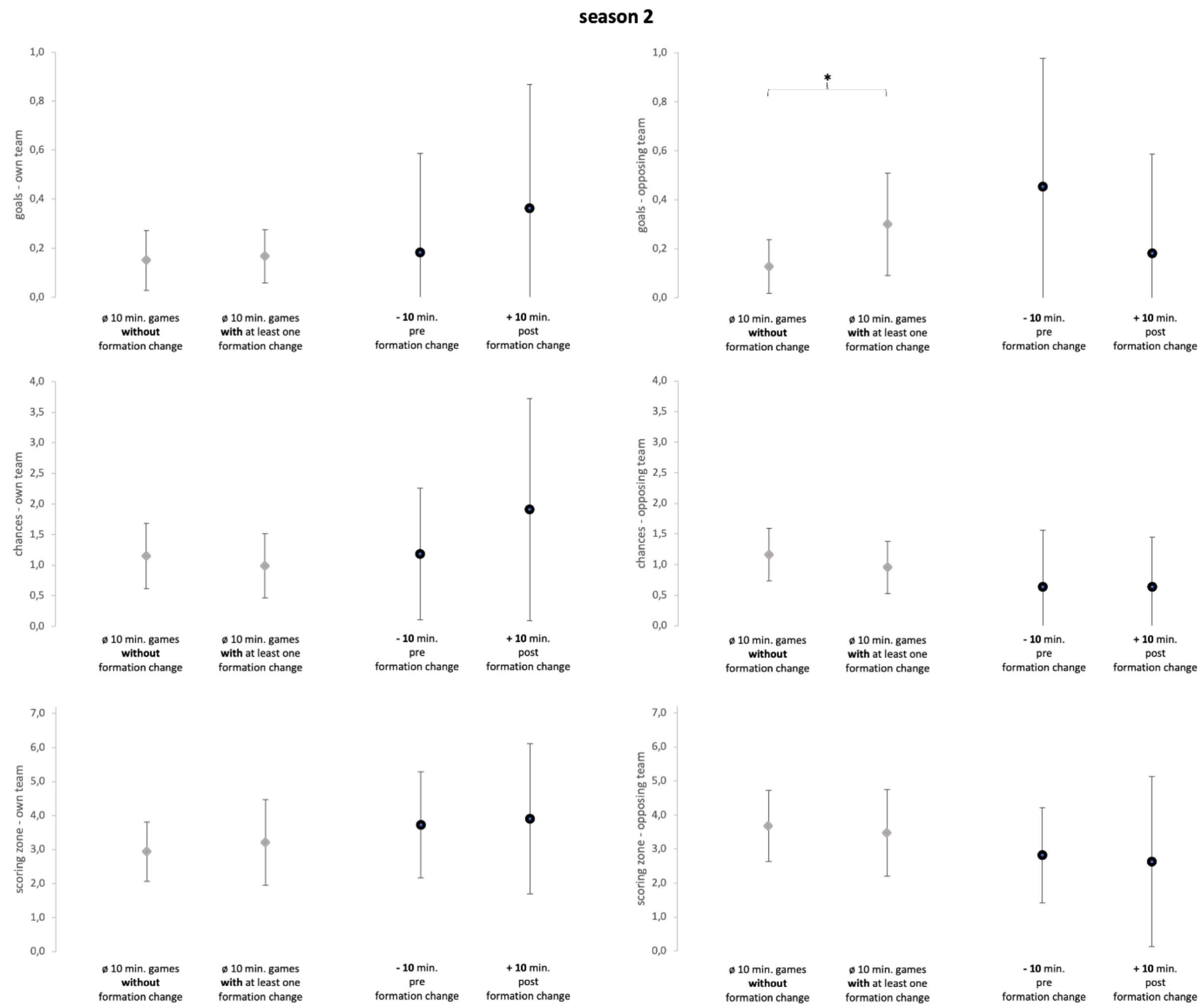

Figure 6.4. Season 2. Data of season 1 are presented as mean values ± SD. Black parentheses indicate significant differences (p<0.05).

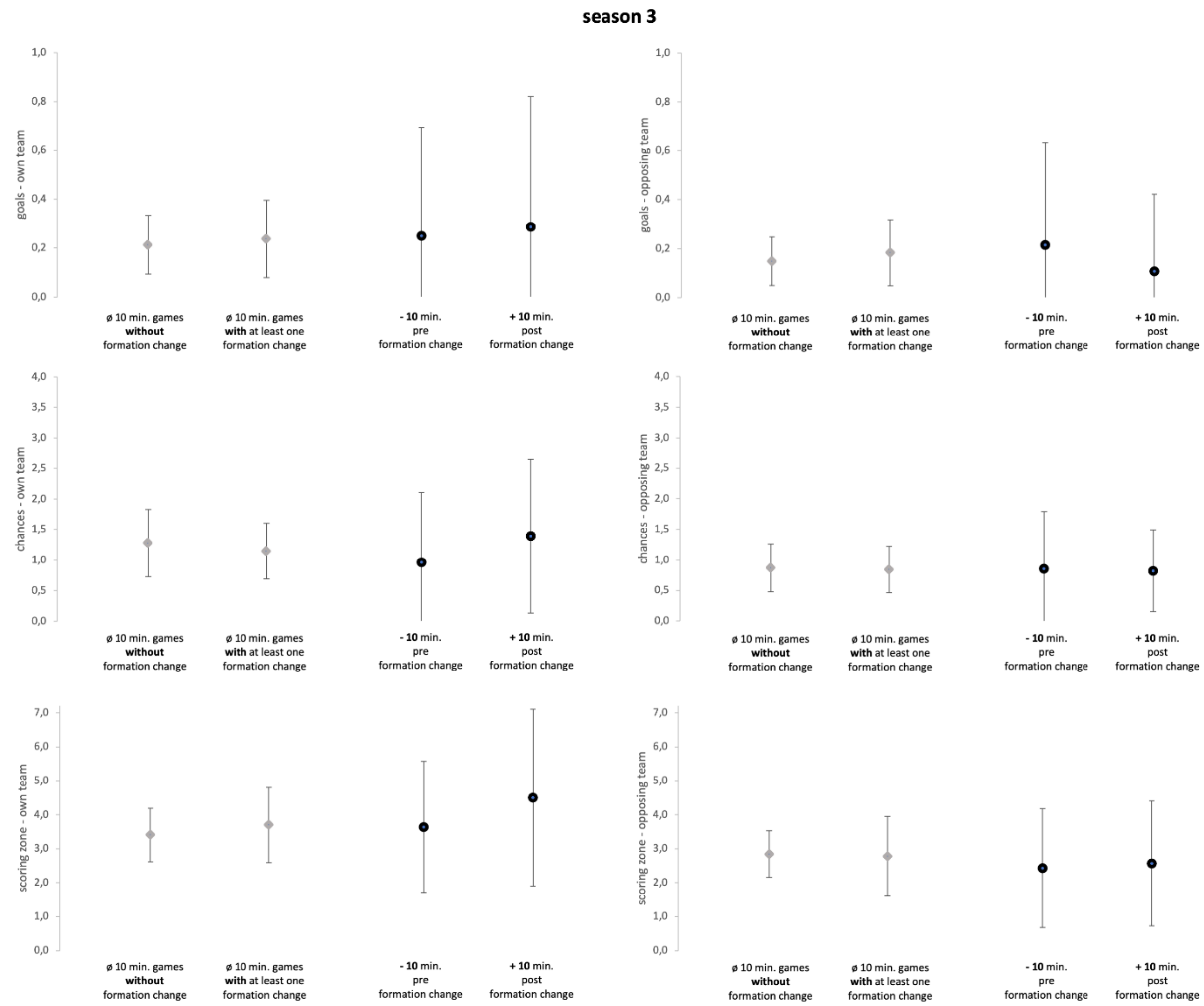

Figure 6.5. Season 3. Data of season 1 are presented as mean values ± SD. Black parentheses indicate significant differences (p<0.05).

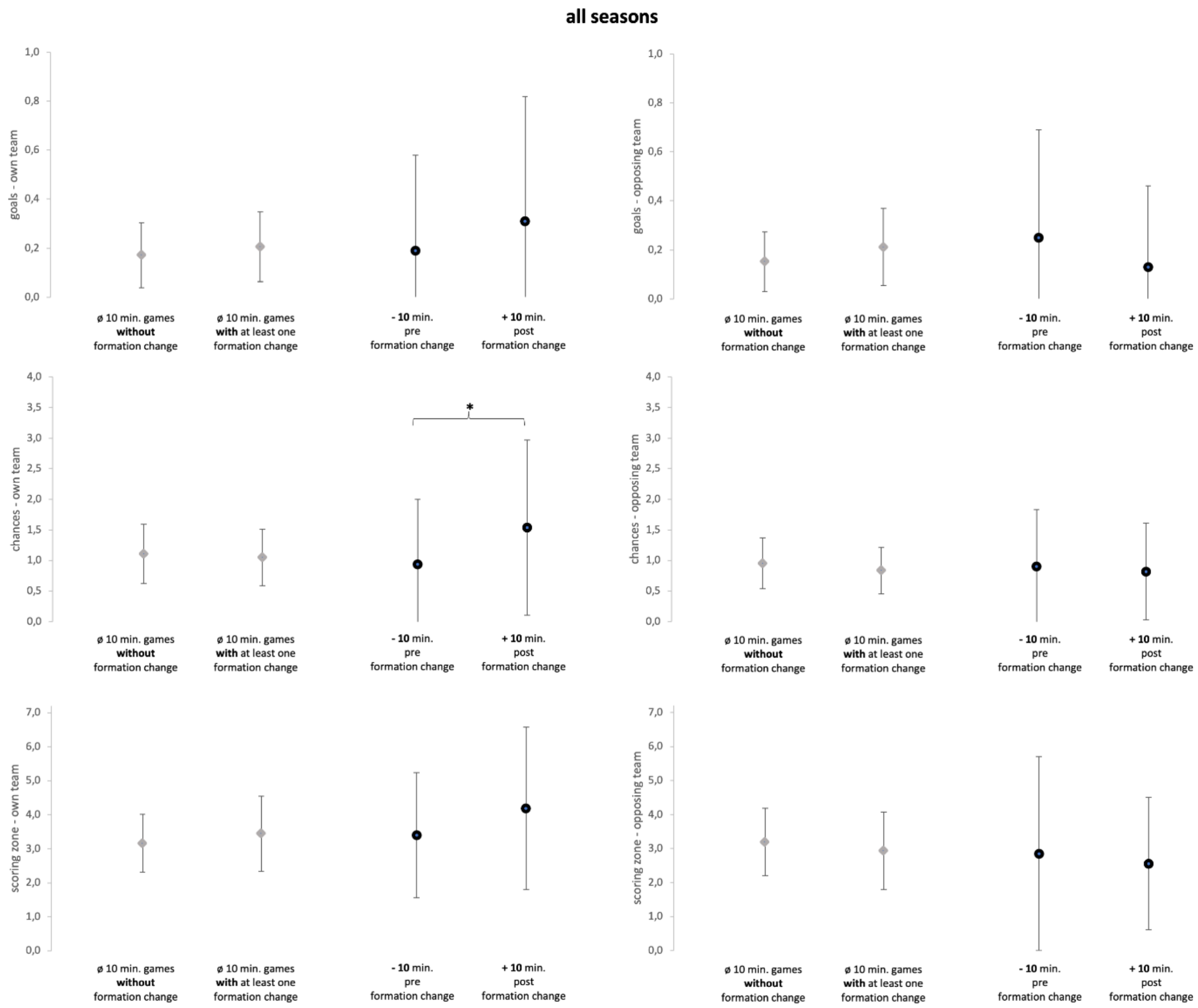

Figure 6.6. All seasons. Data of season 1 are presented as mean values ± SD. Black parentheses indicate significant differences (p<0.05).

6.5 Discussion

The current study aimed to examine the effects of in-game changes in the tactical formation on goals, chances, and scoring zone entries of one team in the German Bundesliga and to analyze potential coach-specific differences regarding these effects. Generally, over all three investigated seasons, the in-game changes of tactical formation led to an improvement in the match performance of the analyzed team. In season 1, the positive effects of the in-game formation changes were the most pronounced. Therefore, the magnitude of the influence of in-game formation changes on the match performance was dependent on the season and, hence, on the coach. While the coaches in seasons 1 and 2 changed the formation when their team performed poorly, the coach in season 3 used tactical formation changes regardless of the performance of his team.

6.5.1 Effects of In-game Formation Changes

The first objective of the study was to investigate whether in-game formation changes impacted match performance. Subsequently, comparing the 10-min-pre and 10-min-post formation change periods, the changes in tactical formation had a medium positive effect on every key performance variable of attacking play (see Figures 6.3-6.5; mean ES=0.40). All seasons combined, the variable which was affected the most by the in-game formation changes was chances of the own team (mean ES=0.65). In conclusion, these findings suggest that in-game changes of the tactical formation helped to increase the match performance of the analyzed team in the period after the formation change. A change in the formation inevitably leads to a new tactical orientation of the team. Therefore, the opposing team is presented with new defensive and offensive tasks. Since the opponent is impaired by this change of the game, the formation change can then lead to an improvement in the offensive and defensive performance of the own team. However, since this is the first study on the effect of in-game formation changes, the results should be viewed with caution.

The improved performance after the formation change leads to an increase in own chances and a decrease in opposing chances. Lepschy et al. (Lepschy et al., 2020) revealed that one critical factor determining the success in the investigated German Bundesliga is the number of shots. Regarding the present study, the key performance variable chances include shots. Summarizing, considering the results of Lepschy et al., reducing the opponent's chances and increasing the own team's chances leads to a higher probability of success. Since the investigated in-game formation changes lead to this phenomenon, it is reasonable to conclude that the investigated formation changes increased the probability of success.

6.5.2 Differences Between the Coaches

The second study aim, to analyze the differences between the coaches, will be addressed in the following. Subsequently, every single season will be discussed individually.

First, the coach in season 1 was able to contribute substantially to the improvement of the performance by applying in-game formation changes. The analyzed team could increase the number of goals, chances, and scoring zone entries in the ten minutes after the formation change (mean ES=0.88). Similarly, the formation changes led to fewer chances and scoring zone entries of the opposing team in the ten minutes after the change (mean ES=0.81). Moreover, the opposing team created fewer chances and scoring zone entries in games with a formation change underlining the improvement in match performance with an in-game formation change (mean ES=0.26). Therefore, the in-game formation changes increased the match performance of the analyzed team. Previous studies revealed that different tactical formations can lead to varying offensive and defensive tactical performances (Low et al., 2021; Memmert et al., 2019). Based on those findings, if a coach wants to influence the unsatisfactory performance of his players, the change of the tactical formation is one possible tool to influence the match performance. Concluding, the formation changes of coach 1 can be valued as suitable and very effective in consideration of the respective game situation.

Second, the in-game formation changes in season 2 reveal a smaller effect on the performance of the analyzed team. On the one hand, the team scored more goals, created more chances, and conceded fewer goals in the ten minutes after the formation change compared to the ten minutes before (mean ES=0.42), indicating a positive influence on performance. Furthermore, the team created more scoring zone entries and prevented more opposing chances in games with a formation change (mean ES=0.29). On the other hand, the own scoring zone entries, opposing scoring zone entries, and opposing chances stayed rather unaffected in the ten minutes after the formation change (mean ES=0.09). Moreover, the team created fewer chances and conceded more opposing goals in games with a formation change (mean

ES=0.34). Concluding, the formation changes of the coach in season 2 improved the match performance of the analyzed team concerning opposition goals, own goals, and own chances. In contrast to season 1, the changes in tactical formation were overall less effective.

Third, in season 3 the effects of in-game changes of formation on performance were further diminished. Formation changes in this season did not affect the parameters' own goals, opposing scoring zone entries, opposing chances, and opposing goals in the 10-min post formation change (mean ES=0.20). Only own scoring zone entries and own chances indicate a positive alternation in the ten minutes after the formation change (mean ES=0.48). One potential conclusion could be that the coach in season 3 was focused more on the own offensive performance. Overall, the effects of in-game formation changes on the overall performance in season 3 were small. The behavior regarding and scenarios leading to formation changes differed between coaches which can partly explain the differing effectiveness of formation changes between coaches. These aspects will be further discussed in the following.

6.5.3 Scenarios Leading to a Formation Change

In team sports, coaches are a crucial factor in influencing player interaction during the game (Keatlholetswe & Malete, 2019). Nevertheless, coaching decisions regarding tactical formation in soccer have not yet been studied. In contrast, one investigation focusing on handball revealed that the situations in which coaches change the tactical formation during running games differed (Debanne & Laffaye, 2015). The results of this study reveal that the motivation of coaches to change a formation is influenced by different scenarios (e.g. lead) that occur in the game. Consequently, in the present study, different scenarios that motivated the respective coach to make an in-game formation change will be addressed in the following. First, the coach in season 1 preferred to change his team formation in games where his team was less successful (Ø points in games without formation change: 1.32±1.35; Ø points in games with formation change: 1.11±1.17). Another finding supporting this assumption is that the team scored fewer goals, created fewer chances, and realized fewer scoring zone entries in the ten minutes before the formation change (goals = 0.00 ±0.00; chances = 0.56 ±0.73; scoring zone entries = 2.22 ±1.56) compared to the average ten minutes in games with and without a formation change ([with formation change: goals = 0.17 ±0.13; chances = 0.89 ±0.38;

scoring zone entries = 3.10 ±0.89], [without formation change]: goals = 0.17 ±0.15 ; chances = 1.00 ±0.39; scoring zone entries = 3.22 ±0.86]). Furthermore, the opposing team earned more chances and scoring zone entries in the ten minutes before a change than average in the games with and without a formation change. Concluding, throughout the nine formation changes recorded in season 1, the coach changed formations when the team underperformed compared to the team average.

Second, the decision for an in-game formation change of the coach in season 2 seemed to be dependent mainly on the parameter opposing team goals. In the ten minutes previous to the formation change (goals = 0.45 ±0.52) the opposing team scored more goals than in average ten minutes in games with and without formation change ([with formation change: goals = 0.30 ±0.21], [without formation change: goals = 0.13 ±0.11]). Moreover, the team conceded more goals in games with a formation change compared to games without a formation change (ES= 0.46). Concluding, the coach changed the tactical formation in games where his team conceded more goals and in situations when the opposing team scored.

Third, and in contrast to the other seasons, the unclear results in season 3 do not allow a conclusion on a trigger scenario. Season 3 revealed by far the largest number of in-game formation changes (=28). Therefore, one possible explanation could be that the coach in season 3 used in-game changes of tactical formation as a tactical rationale and the effects were blurred due to the high number of formation changes. In contrast, the coaches in seasons 1 and 2 did change the tactical formation when the team showed a bad performance. However, referring to the high point averages per game (see Paper III. Supplementary Table 3) the in-game decisions of the coach (changing or not changing the formation) in season 3 can still be valued as suitable. In summary, it can be said that the decision to change the formation is highly dependent on the coach and that there are interindividual differences. However, the two coaches in seasons 1 and 2 changed formation mainly when the team performed poorly, which might partially explain the higher effectiveness of formation changes during these two seasons.

In the following, the limitations of the study will be addressed. In the current investigation, the tactical formation of the opponent was not considered. As the 20 outfield players interact with each other during the game, the opposing team's tactical formation can impact the match performance (Carling, 2011). In addition, science has already proven that the final result and the goal difference of a match have an influence on match performance (Lupo &

Tessitore, 2016). However, the present study did not include the current score and final result of the investigated matches in the evaluation of the results, but only reported them in Paper III. Supplementary Table 6. Science Furthermore, it is necessary to address that this study only investigated the effects of in-game formation changes regarding one single team. Therefore, the generalization of the findings and conclusions to other coaches, teams, and leagues is hardly possible (Dellal et al., 2011; Rampinini et al., 2007). Moreover, because in-game formation changes are rare and we divided the results by season the sample sizes of formation changes were small. However, three full seasons of a professional soccer team were analyzed in this study. As mentioned above, the investigated team reached European competitions in two of the three analyzed seasons. The transfer towards teams with players that do not have a comparable performance quality as the players in the current study has to be questioned (Aquino, Palucci Vieira, et al., 2017). With the above-mentioned facts (e.g. small sample size) and the additional information that only non-parametric tests were calculated, it can be assumed that the results presented in this study are very conservative.

In contrast to the above-mentioned limitations, the present study also possesses significant strengths. First of all, the current approach is the first to evaluate the effect of in-game formation changes in soccer. Moreover, a key strength is that the tactical formations and changes in formation were observed independently by two experienced video analysts and results of both raters were reviewed until consensus was reached. Moreover, the reliability of the investigated key performance variables was checked to substantiate the significance of the results. Furthermore, the current study analyzed a professional soccer team that played on the highest level in national (i.e. Bundesliga) and international (i.e. Champions League, Europa League) competitions during the study period.

Fruitful avenues for future investigations could be to investigate the effects of in-game formation changes in other leagues and for other teams. Furthermore, addressing the opposing formation would generate additional added value to the results. Moreover, a future study could also consider longer periods after the formation change to investigate the long-term effects of the in-game changes. Furthermore, future studies could investigate other factors that potentially lead to an in-game formation change (e.g. substitutions). In addition, it is desirable to investigate a team with the same coach over a longer time. Hence, the sample sizes of in-game formation changes should get larger and, therefore, the results get more robust. Moreover, qualitative analysis (e.g. interviewing coaches) could help to put the results in a broader context. Therefore, the initial motivation of coaches to change the formation could be revealed. In addition, the psychological effects of changing the tactical formation could be studied in the future.

6.6 Conclusion

The results of this study provide novel information about the effects of in-game formation changes in professional soccer (German Bundesliga). In-game formation changes were recorded for 43% of the games studied. Formation changes were used by different coaches for different purposes and with varying degrees of success. Across all three investigated seasons, the in-game formation changes helped the team to turn an average or below-average performance into better performance during the 10 min after the formation change. Further, the comparison between the investigated seasons indicates that the effect of the respective formation changes was dependent on the responsible coach. Different trigger scenarios were revealed that led the coaches to the in-game formation changes.

The results of the present study underpin the enormous importance of in-game decision-making of coaches. Additionally, the results reinforce the importance of coaches and their individual qualities.

7 Center Backs Work Hardest When Playing in a Back Three: The Influence of Tactical Formation on Physical and Technical Match Performance in Professional Soccer (Paper IV)

Published version of the original research article

Forcher, **L.**, Forcher, L., Jekauc, D., Woll, A., Gross, T., & Altmann, S. (2022). Center backs work hardest when playing in a back three: The influence of tactical formation on physical and technical match performance in professional soccer. PLOS ONE, 17(3), 1-17. https://doi.org/10.1371/journal.pone.0265501

7.1 Abstract

The purpose of this study was to investigate whether tactical formation affects the physical and technical match performance of professional soccer players in the first German Bundesliga.

From official match data of the Bundesliga season 2018/19, physical (total distance, high-intensity distance, sprinting distance, accelerations, maximum velocity) and technical performance (short/middle/long passes, dribblings, ball-possessions) of players were analyzed. Players were categorized into five playing positions (center back, full back, central midfielder, wide midfielder, forward) and teams into eight different tactical formations (4-4-2, 4-4-2 diamond, 4-2-2-2, 4-3-3, 4-5-1, 4-2-3-1, 3-4-3, 3-5-2).

Results revealed that the degree to which tactical formation affects match performance is position dependent. In terms of physical performance, center backs and full backs showed highest sprinting distances when playing in a formation with only three defenders in the back row (3-4-3, 3-5-2) compared to all other formations (ES range: $0.13 \leq ES \leq 1.27$). Regarding technical performance, all positions except forwards displayed fewer short passes, middle passes and ball-possessions in the formations 4-3-3 and 4-2-3-1 compared to all other formations ($0.02 \leq ES \leq 1.19$).

In conclusion, physical and technical performance of center backs, full backs and wide midfielders differed markedly between the tactical formations. Conversely, the physical and technical performance of central midfielders and forwards only showed small differences between the different tactical formations. These findings can help coaches scheduling their practice. For example, if a coach wants to change the playing formation, he can anticipate the physical and technical match performance changes depending on the respective playing position.

Keywords: team sports, football, tactics, passing, running performance

7.2 Introduction

The intensity and the speed of professional soccer have increased in recent years (Barnes et al., 2014). In favor of this development, the physical match performance of a player in a single match has risen significantly (Dolci et al., 2020). Further, the technical skills that are required to compete on a professional level, have increased similarly (Barnes et al., 2014; Bush, Barnes, et al., 2015).

Looking at the performance of a soccer player, besides physical and technical parts, performance is also determined by mental and especially tactical aspects (Sarmento et al., 2014). Among the most important tactical factors rank the playing position and the tactical formation.

The playing position has a large impact on the physical and technical match performance of a player (Dellal et al., 2010; Rivilla-Garcia et al., 2018). From a physical perspective, central midfielders show the highest total running distance compared to other positions (Aquino, Palucci Vieira, et al., 2017; Dellal et al., 2010; Di Salvo et al., 2007; Paraskevas et al., 2020; Rivilla-Garcia et al., 2018; Vigh-Larsen et al., 2017). Looking at the distances covered at high-intensity speed and sprinting speed, wide midfielders and full backs display greater distances than the other positions (Aquino, Carling, Palucci Vieira, et al., 2020; Dellal et al., 2010; Paraskevas et al., 2020; Rivilla-Garcia et al., 2018; Tierney et al., 2016; Vardakis et al., 2019; Vigh-Larsen et al., 2017). Regarding technical performance, Dellal et al. (2010) revealed that forwards lose more duels and have more turnovers than other positional groups. Further, midfielders (central & wide) displayed the most ball-possessions.

The effect of tactical formation on match performance seems to be lower than the effect of playing position, however differences between formations have been revealed (Baptista et al., 2019; Carling, 2011). One investigation showed higher amounts of passes played and success rate of passes for teams in a 4-4-2 formation compared with teams in a 4-3-3 or 4-5-1 formation (Bradley et al., 2011). Baptista et al. (2019) revealed that players playing in a 4-5-1 formation covered more distance in high-intensity and sprinting speeds than in a 3-5-2 formation.

A drawback of the abovementioned studies is that they investigated the effects of tactical formation and playing position on match performance in isolation. Conversely, the combination of tatical formation and playing position seems more promising to explain match performance (Aquino, Palucci Vieira, et al., 2017; Sarmento et al., 2018).

Hence, some investigations tried to investigate the effects of the combination of the factors tactical formation and playing position on soccer match performance. A study that distinguished between the three positional groups defenders, midfielders, and attackers found that defenders showed lower total distance and high-intensity distance when playing in a 4-4-2 formation, compared to defenders in a 4-3-3 or 4-5-1 formation (Bradley et al., 2011). In addition, strikers cover a larger high-intensity distance when playing in a 4-3-3 formation, compared to strikers in a 4-4-2 or 4-5-1 formation. Building on these results, Tierney et al. (Tierney et al., 2016) differentiated between five playing positions. Their findings revealed that central midfielders accelerate more often in the 4-2-3-1 formation and cover higher total and high-intensity distances in the 4-4-2 formation than central midfielders in other formations. Differentiating between center backs and wide defenders as well as between central and wide midfielders offered novel insights regarding the effect of tactical formation on soccer match performance. Only one investigation studied the combined effects of formation and position on the technical performance of soccer players (Carling, 2011), thereby analyzing how the tactical formation of the opposing team affects the technical match performance of one single soccer team. For example, it was found that central midfielders and center backs played more direct passes when playing against a team in a 4-2-3-1 formation, compared to opponents playing in a 4-4-2 formation.

While providing first insights into the combined effects of tactical formation and playing position on soccer match performance, the current state of research lacks findings of the influence on technical match performance. Furthermore, only a limited number of tactical formations (maximum 5 formations) have been investigated so far. Therefore, studies that capture all tactical formations used by teams from a whole league could provide a more comprehensive picture on this topic. Moreover, it is well known that the level and the origin of the league can impact the physical and technical match performance of soccer players (Dellal et al., 2011; Rampinini et al., 2007). While there is no investigation addressing the German Bundesliga so far, it seems worthwhile to explore this topic in this league.

Therefore, the current study aimed to investigate whether tactical formation affects the physical and technical performance of professional soccer players of different positions in the first German Bundesliga. Taking the results of other investigations into account (Aquino, Carling, Palucci Vieira, et al., 2020; Aquino, Puggina, et al., 2017; Dolci et al., 2020), we hypothesized that according to the playing position, the formation affects the physical and technical performance.

7.3 Materials and Methods

7.3.1 Sample

In the present study, official match data from the 2018/2019 season of the German Bundesliga were used, since this was the last season that has not been affected by the COVID-19 pandemic. A total of 267 out of 306 games were analyzed, as every match with one player has been sent off was excluded. Since only players that were involved in the whole game time (i.e., full 90 min) of the respective match were included, leading to a maximum of 20 outfield players per match. This results in 3810 separate observations (i.e. a single match performance of one player) that were analyzed. Although data was collected as part of the players' professional employment (Winter & Maughan, 2009), ethical approval was obtained from the local ethics committee (Human and Business Sciences Institute, Saarland University, Germany, identification number: 22-02, 10 January 2022).

7.3.2 Variables and Procedures

Initially, the tactical formation for each team and match, respectively, was identified by using the official match-reports of the Bundesliga which are provided by Deltatre (Deltatre, Turin, Italy). The identified formations are constructed out of the starting eleven and are checked by observation after 15 minutes of each game. To investigate accuracy of the provided tactical formation data, we compared the formations provided for the first game day (18 formations) with the observation of an experienced video analyst of the German Bundesliga team TSG Hoffenheim. Given the high agreement between the results of the provided formations from Deltatre and the observations from the video analyst (Cohen's Kappa: 0.93, $p<0.05$), the data from Deltatre were used for this study (Landis & Koch, 1977).

Additionally, five different playing positions were distinguished (central defender, full back, central midfielder, wide midfielder, forward). Subsequently, 9 different tactical formations differentiated (see Paper IV. Supplementary Table 4). As the formation 3-4-3 diamond was only played once, it was excluded from further analysis.

After identifying the tactical parameters formation and position, the physical and technical performance of the respective players were analyzed. To assess the physical performance, the parameters total distance [km], high-intensity distance [km], sprinting distance [km], the maximum velocity [km/h], and the number of accelerations [quantity] were analyzed.

Considering the underlying data and the used speed zones of other studies (Bradley et al., 2011; Dellal et al., 2010; Di Salvo et al., 2007; Modric et al., 2020; Rampinini et al., 2007a), the speed interval for high-intensity distance was set for 17.00-23.99 km/h and sprinting distance set for ≥24.00 km/h. One acceleration was counted, when there was a positive acceleration score for more than 1,5 sec., implying there had to be an increase of speed compared to the frame before.

Technical performance was analyzed using the parameters number of passes, dribblings, and ball-possession phases. Based on the covered distance of the ball, passes were divided into three categories (short [<10 m], middle [10≥30 m], long [>30 m]). One dribbling was counted when one player in safe ball control tried to dribble past an opponent. One ball-possession phase for one player was counted when he had a ball action in a ball-possession phase of his team.

Finally, contextual factors that have been reported in other studies were analyzed for each match: Quality of the own team (=team ranking at the end of the season), quality of the opponent (=team ranking at the end of the season) (Aquino, Carling, Palucci Vieira, et al., 2020; Paraskevas et al., 2020), result of the game (=points in the respective game) (Aquino, Carling, Palucci Vieira, et al., 2020), percentage of ball-possession (Bradley et al., 2011), venue (home or away) (Aquino, Carling, Palucci Vieira, et al., 2020; Paraskevas et al., 2020), and net playing time (Lago-Peñas & Rey, 2012) were analyzed. These contextual factors were captured as they could possibly explain how tactical, physical, and technical factors interact with each other.

All data are based on the DFL Observed Tracking-Data, which are processed by Deltatre. The data were captured using a Multi-Camera-Tracking System (TRACAB, Chyron Hego, Melville, NY, USA), which can be considered valid (Linke et al., 2020).

7.3.3 Statistical Analysis

To analyze the effect of tactical formation within one playing position, each single playing position was considered independently. Therefore, for every single playing position (center back, full back, central midfielder, wide midfielder, forward) a one-way analysis of variance [ANOVA] was conducted separately for every physical (total distance, high-intensity distance, sprinting distance, max. velocity, accelerations) and technical (ballpossession-phases, dribblings, short/medium/long passes) parameter. In this context, the tactical formation served as the independent variable and the respective physical or technical parameter as the dependent variable. To determine possible differences between tactical formations, Bonferroni post-hoc tests were executed.

Further, the contextual factors were addressed individually. To check if the contextual factors differ according to the tactical formation, for each contextual factor (own team ranking, opposition team ranking, net game time, points per game, ball possession, venue) a one-way ANOVA was conducted. Similarly, the tactical formation served as the independent variable and the respective contextual parameter as the dependent variable. To determine possible differences between tactical formations, Bonferroni post-hoc tests were executed.

To interpret the magnitude of differences, Cohen's d effect sizes [ES] were computed: Small ($0.2 \leq ES < 0.5$), medium ($0.5 \leq ES < 0.8$) and large ($ES \geq 0.8$) ES were distinguished (Cohen, 1988).

A priori, the significance for all tests was set to 0.05. All statistical analyses were executed using IBM SPSS Statistics 25.0.0.0 (IBM Co., New York, USA).

7.4 Results

Means, standard deviations, and results for the ANOVA of the physical and technical parameters for each playing position considering the tactical formation are displayed in figures 7.1-7.5. Descriptive values for each parameter can also be found in Paper IV. Supplementary Table 1, 2 and 3. Overall, ANOVA revealed significant differences between tactical formations for all positions and regarding most physical and technical parameters (Figures 7.1-7.5).

More in detail, the degree to which tactical formation affected physical and technical match performance was position dependent. Relating to physical performance, center backs and full backs demonstrated the largest means for total and high-intensity distance in the 3-4-3 and 3-5-2 formations (Figures 7.1 & 7.2). Wide midfielders showed the highest values for total and high-intensity distance in the 4-4-2 diamond formation and the lowest values in the 3-4-3 formation (Figure 7.4). In addition, central midfielders and forwards displayed less pronounced differences in physical parameters (e.g. high-intensity distance) (Figures 7.3 & 7.5).

Concerning technical performance, full backs showed the highest amount in dribblings in 3-4-3 and 3-5-2 formations (Figure 7.2). By contrast, the number of dribblings for center backs and central midfielders were similar across formations (Figures 7.1 & 7.3). Except forwards, all other positions demonstrated higher values for short passes and ball-possession phases in the formations 4-3-3 and 4-2-3-1 (Figures 7.1, 7.2, 7.3, & 7.4).

Looking at the contextual factors, some of these parameters showed differences according to the tactical formation (Table 7.1). While opposition team ranking and venue were unaffected by the tactical formation, own team ranking and ball-possession differed markedly according to the tactical formation.

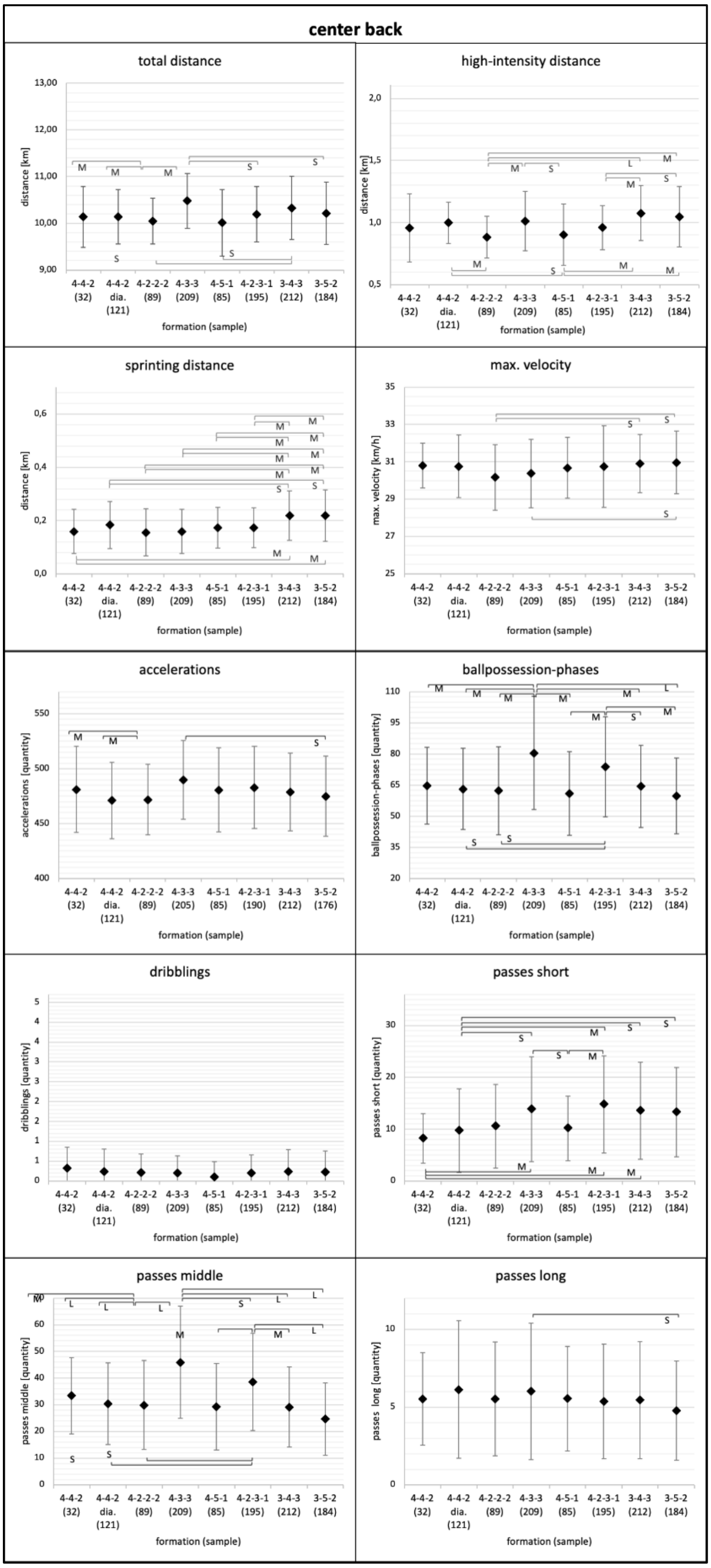

Figure 7.1. Center Back. Data of center backs are presented as mean values ± SD. Anova revealed p<0.05 for each parameter except dribblings (p=0.43). Black parentheses indicate significant differences (p<0.05) between the formations. Each significant group difference is labelled with S for small, M for medium or L for large effect size.

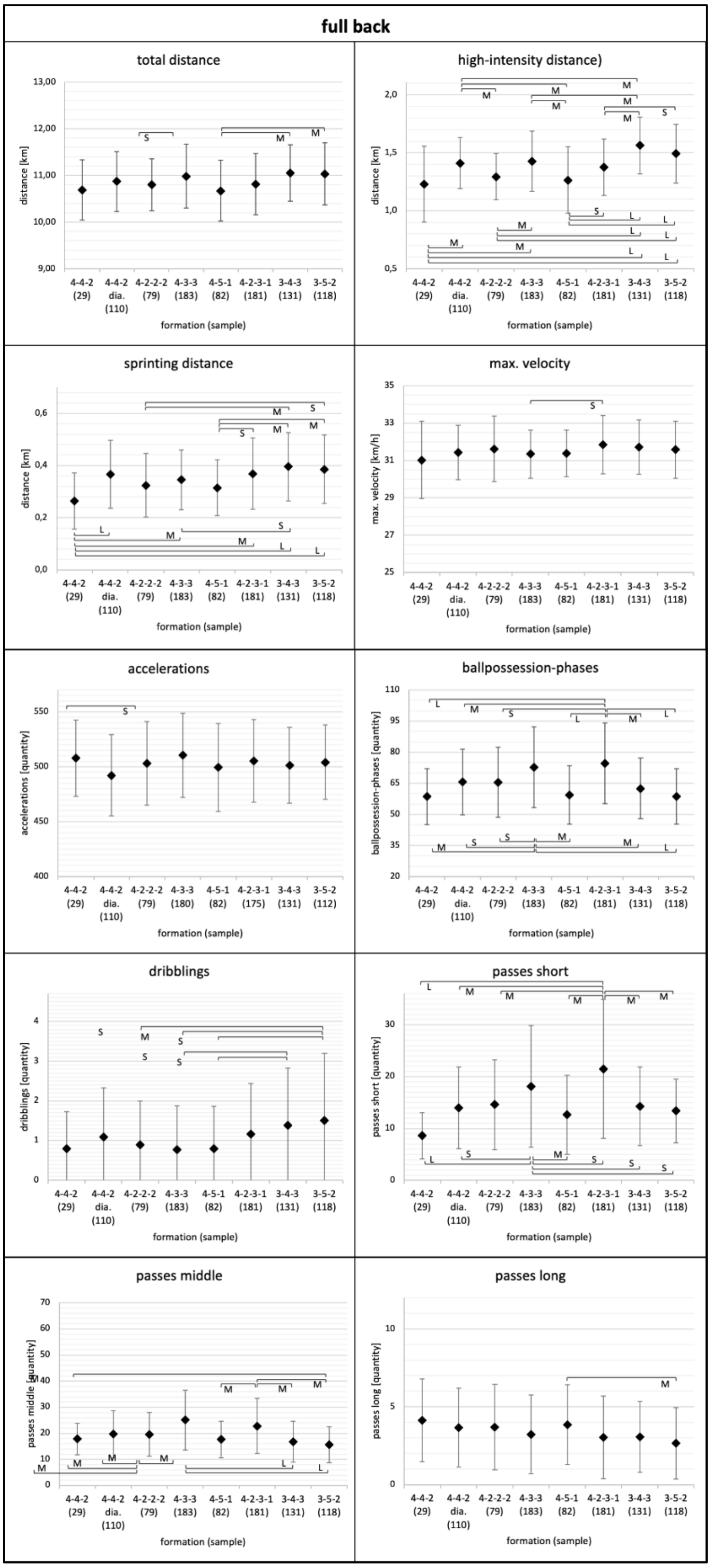

Figure 7.2. Full Back. Data of full backs are presented as mean values ± SD. Anova revealed p<0.05 for each parameter. Black parentheses indicate significant differences (p<0.05) between the formations. Each significant group difference is labelled with S for small, M for medium or L for large effect size.

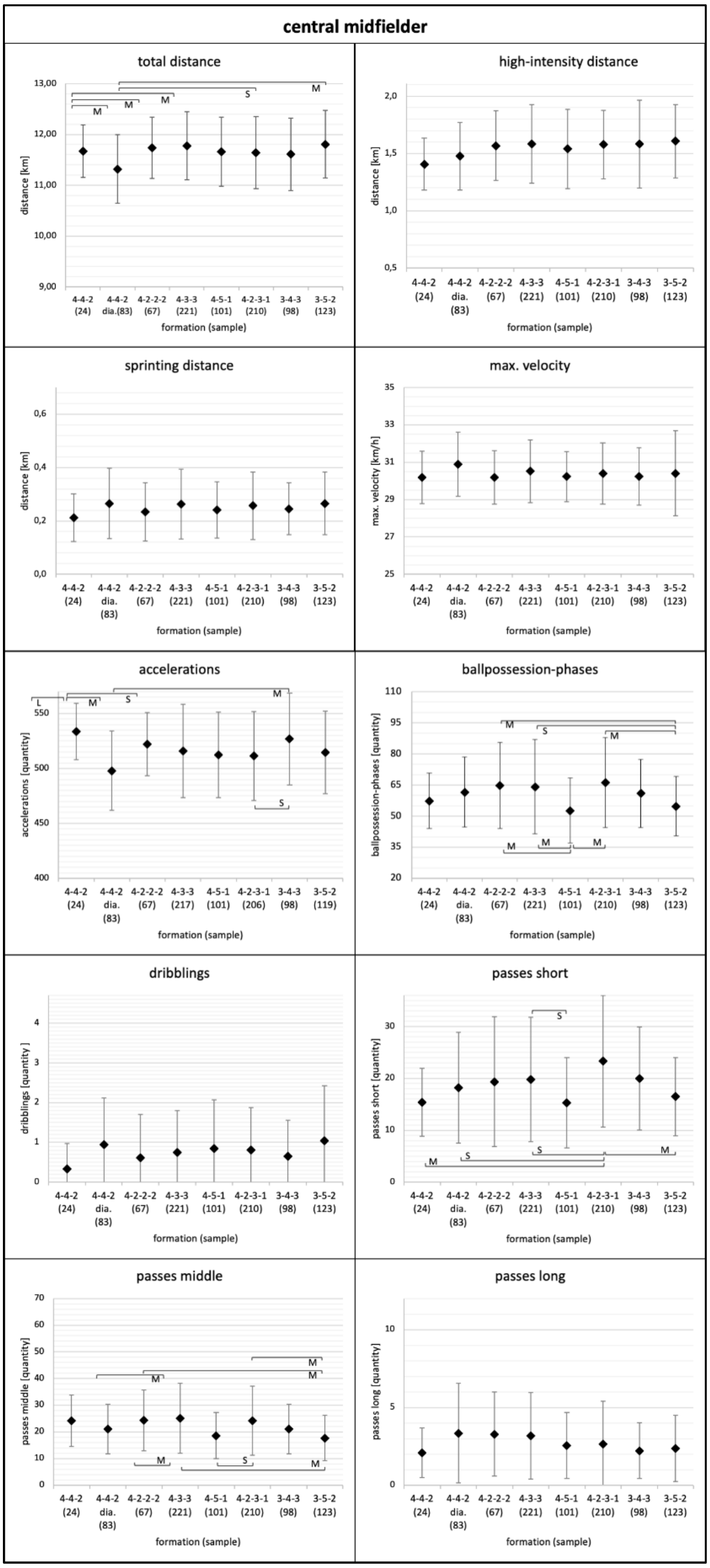

Figure 7.3. Central Midfielder. Data of central midfielders are presented as mean values ± SD. Anova revealed p<0.05 for each parameter except sprinting distance (p=0.20) and maximum velocity (p=0.14). Black parentheses indicate significant differences (p<0.05) between the formations. Each significant group difference is labelled with S for small, M for medium or L for large effect size.

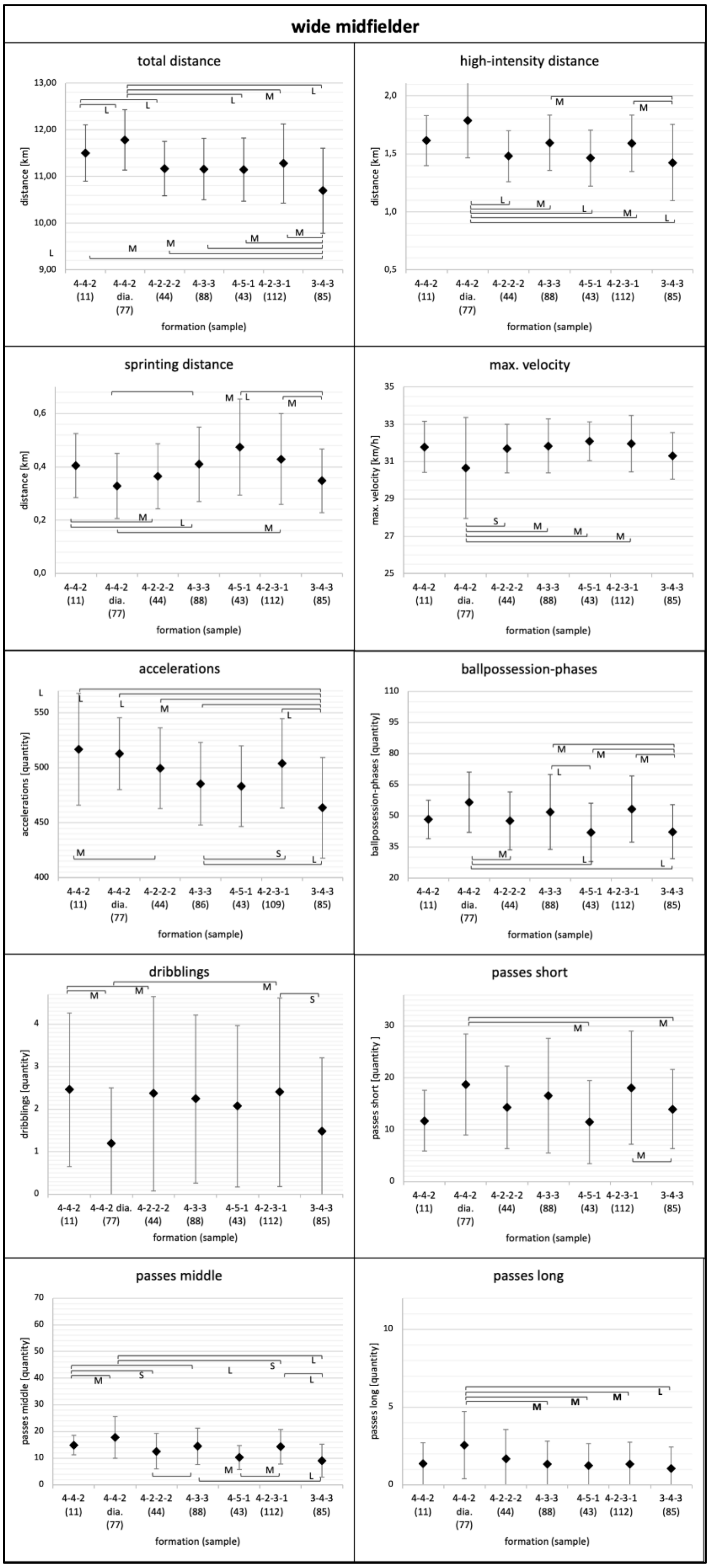

Figure 7.4. Wide Midfielder. Data of wide midfielders are presented as mean values ± SD. Anova revealed p<0.05 for each parameter. Black parentheses indicate significant differences (p<0.05) between the formations. Each significant group difference is labelled with S for small, M for medium or L for large effect size.

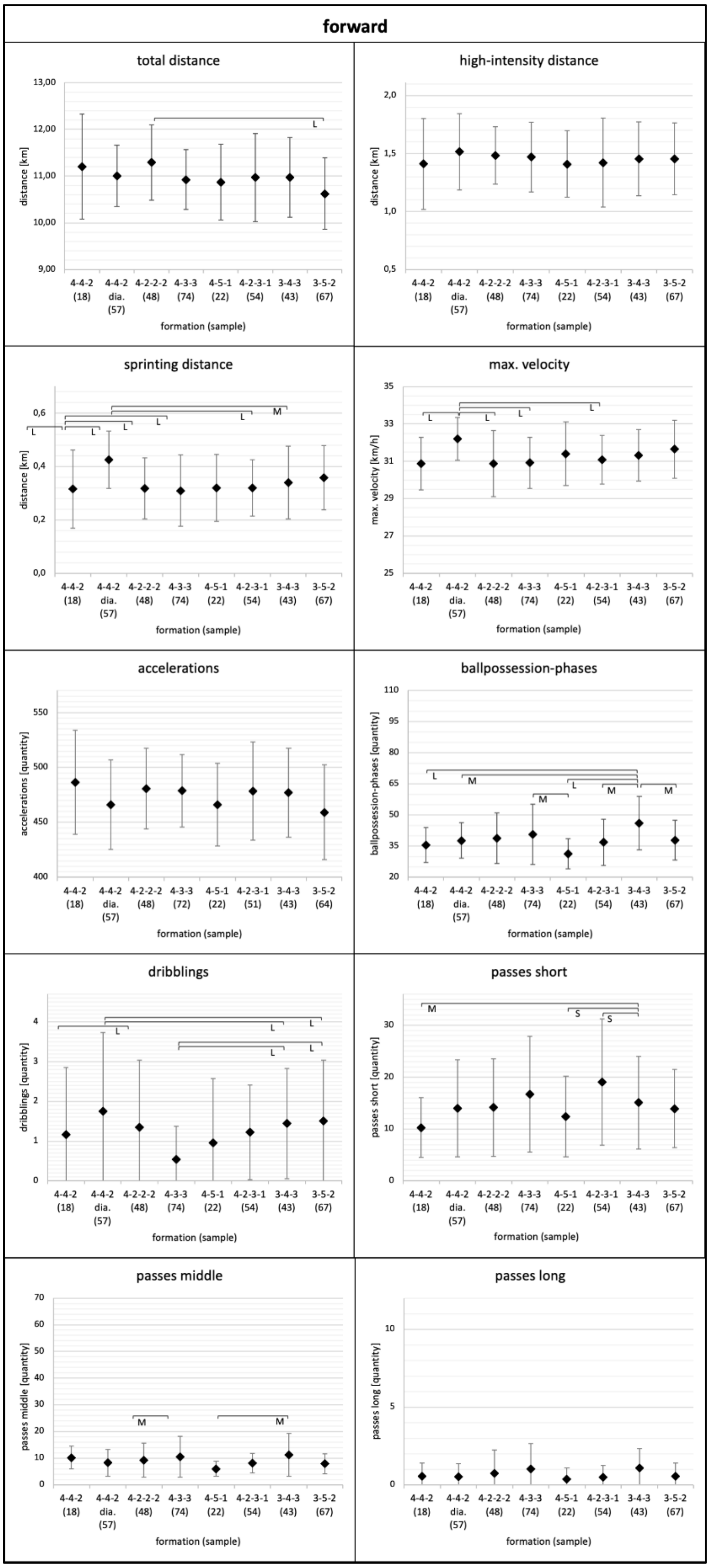

Figure 7.5. Forward. Data of forwards are presented as mean values ± SD. Anova revealed p<0.05 for each parameter except high-intensity distance (p=0.80). Black parentheses indicate significant differences (p<0.05) between the formations. Each significant group difference is labelled with S for small, M for medium or L for large effect size.

Table 7.1. Data of contextual factors are presented as mean values ± SD. Significant group differences (p<0.05) are presented with small effect size *, medium effect size** and large effect size ***.

Formation	games	mean	SD	anova	group comparisons
own team ranking (end of the season)					
4-4-2	16	13.50	2.48	p<0.01	[***vs. 4-3-3]; [***vs. 4-2-3-1]
4-4-2 dia.	63	9.70	3.99		[**vs. 4-3-3]; [***vs. 4-5-1];
4-2-2-2	46	10.50	5.72		[***vs. 4-3-3];
4-3-3	109	6.38	4.50		[***vs. 4-4-2]; [**vs. 4-4-2 dia.]; [***vs. 4-2-2-2]; [**vs. 4-2-3-1]; [***vs. 4-5-1]; [***vs. 3-4-3]; [***vs. 3-5-2]
4-5-1	46	13.43	4.01		[***vs. 4-4-2 dia.]; [***vs. 4-3-3]; [***vs. 4-2-3-1]; [**vs. 3-5-2]
4-2-3-1	106	7.53	5.63		[***vs. 4-4-2]; [**vs. 4-2-2-2]; [***vs. 4-5-1]; [**vs. 3-4-3]; [**vs. 3-5-2]
3-4-3	78	11.12	4.16		[***vs. 4-3-3]; [***vs. 4-2-3-1]
3-5-2	69	10.55	4.37		[***vs. 4-3-3]; [**vs. 4-5-1]; [***vs. 4-2-3-1]
opposition team ranking (end of the season)					
4-4-2	16	8.44	5.27	p=0.16	no significant differences between formations
4-4-2 dia.	63	9.70	4.78		no significant differences between formations
4-2-2-2	46	10.67	4.94		no significant differences between formations
4-3-3	109	9.71	5.09		no significant differences between formations
4-5-1	46	7.70	5.41		no significant differences between formations
4-2-3-1	106	9.86	5.09		no significant differences between formations
3-4-3	78	9.55	5.15		no significant differences between formations
3-5-2	69	8.83	5.68		no significant differences between formations
net game time [min]					
4-4-2	16	58.91	4.38	p<0.01	no significant differences between formations
4-4-2 dia.	63	56.23	3.94		[**vs. 4-3-3]
4-2-2-2	46	56.98	4.19		no significant differences between formations
4-3-3	109	58.73	4.25		[**vs. 4-4-2 dia.]; [**vs. 3-4-3]; [**vs. 3-5-2]
4-5-1	46	57.84	3.90		no significant differences between formations
4-2-3-1	106	58.30	4.65		no significant differences between formations
3-4-3	78	56.46	4.00		[**vs. 4-3-3]
3-5-2	69	56.32	3.91		[**vs. 4-3-3]
points per game [quantity]					
4-4-2	16	1.00	1.26	p<0.01	no significant differences between formations
4-4-2 dia.	63	1.71	1.33		[**vs. 4-5-1]; [**vs. 3-4-3]
4-2-2-2	46	1.67	1.38		no significant differences between formations
4-3-3	109	1.51	1.33		no significant differences between formations
4-5-1	46	0.87	1.20		[**vs. 4-4-2 dia.]; [**vs. 4-2-3-1]
4-2-3-1	106	1.68	1.35		[**vs. 4-5-1]; [**vs. 3-4-3]
3-4-3	78	0.97	1.23		[**vs. 4-4-2 dia.]; [**vs. 4-2-3-1]
3-5-2	69	1.17	1.21		no significant differences between formations
ball-possession [%]					
4-4-2	16	45.55	6.37	p<0.01	[***vs. 4-3-3]
4-4-2 dia.	63	50.05	7.35		[**vs. 4-5-1]
4-2-2-2	46	48.09	8.17		[**vs. 4-3-3]
4-3-3	109	53.92	9.13		[***vs. 4-4-2]; [**vs. 4-2-2-2]; [***vs. 4-5-1]; [***vs. 3-5-2]
4-5-1	46	44.32	8.32		[**vs. 4-4-2 dia.]; [***vs. 4-3-3]; [***vs. 4-2-3-1]; [**vs. 3-4-3]
4-2-3-1	106	51.98	8.99		[***vs. 4-5-1]; [**vs. 3-5-2]
3-4-3	78	50.09	8.01		[**vs. 4-5-1]
3-5-2	69	46.63	7.65		[***vs. 4-3-3]; [**vs. 4-2-3-1]
venue (home [1] / away [2])					
4-4-2	16	1.50	0.52	p>0.99	no significant differences between formations
4-4-2 dia.	63	1.49	0.50		no significant differences between formations
4-2-2-2	46	1.50	0.51		no significant differences between formations
4-3-3	109	1.50	0.50		no significant differences between formations
4-5-1	46	1.46	0.50		no significant differences between formations
4-2-3-1	106	1.52	0.50		no significant differences between formations
3-4-3	78	1.50	0.50		no significant differences between formations
3-5-2	69	1.51	0.50		no significant differences between formations

dia. = diamond

7.5 Discussion

The study aimed to investigate whether tactical formation affects the physical and technical performance of professional soccer players of different positions in the first German Bundesliga.

The main finding was that the degree to which tactical formation affects match performance is position dependent. In this context, on the one hand, technical and physical performance of center backs, full backs and wide midfielders differed markedly between the tactical formations. On the other hand, the physical and technical performance of central midfielders and forwards only showed small differences between the different tactical formations. Therefore, the hypothesis that the tactical formation affects the physical and technical performance according to the playing position can be generally confirmed.

In the following, the results for each playing position will be discussed individually. Center backs demonstrated higher values for total distance and accelerations for the 4-3-3 formation compared to other formations (ES range: 0.19≤ effect size [ES] ≤0.78). This finding contradicts other investigations, which identified lower total distance and accelerations for center backs in 4-3-3 compared to other formations (Borghi et al., 2020; Bradley et al., 2011; Tierney et al., 2016a). However, it should be noted, that these investigations used relatively small sample sizes which might limit their explanatory power. Further, considering the high-intensity distance, center backs showed the highest values in 4-3-3, 3-4-3, and 3-5-2. Compared to other formations, there was a range from small to large differences (0.06≤ES≤0.93). Similarly, center backs covered more sprinting distance in 3-4-3 and 3-5-2 compared to all other formations (0.38≤ES≤0.70). Other researchers also found higher sprinting distances for center backs in a 3-5-2 formation (Baptista et al., 2019; Modric et al., 2020). The results could be associated with the assumption that in 3-4-3 and 3-5-2 formations, full backs can be more offensive as three center backs ensure higher defensive protection compared to formations with only two center backs. Therefore, only three center backs have to cover the length and the width of the field, while in other formations (e.g. 4-4-2) there are four players to do so.
Concerning the technical performance, center backs showed higher values for ball-possession phases, short passes, and middle passes for 4-3-3 und 4-2-3-1 compared to other tactical formations (0.03≤ES≤1.19). A possible explanation for the increased ball-possession phases of center backs might be that in the 4-3-3 and 4-2-3-1 formations, the contextual factor ball-

possession per team was higher than in other formations (see Table 7.1). Moreover, a higher percentage of ball-possession enables the respective players (e.g. center backs) to complete more passes.

Full backs, in general, showed a more straightforward response in physical performance between tactical formations. On the one hand, lowest total distance, high-intensity distance, and sprinting distance were observed in the formations 4-4-2 and 4-5-1. On the other hand, greatest total, high-intensity, and sprinting distances were found for 3-4-3 and 3-5-2 with up to large effect sizes in comparison with other formations (0.13≤ES≤1.27). Supporting these results, a study by Modric et al. (Modric et al., 2020) revealed highest values for total, high-intensity, and sprinting distances for full backs in a 3-5-2 formation. Therefore, based on our and Modric and colleague's (Modric et al., 2020) findings, full backs show a higher running performance (i.e. total distance, high-intensity distance, sprinting distance) in formations with three center backs compared to formations with four defenders (e.g. 4-4-2 or 4-5-1). An explanatory approach could be that full backs receive more defensive support in 3-4-3 and 3-5-2 formations by the three center backs and therefore can focus more on their offensive duties. This results in more running output for the full backs to fulfill their offensive and defensive responsibilities.

Looking at the technical performance, full backs displayed more dribblings in 3-4-3 and 3-5-2 compared with other formations (0.16≤ES≤0.54). This could be related to the explanatory approach that full backs have more offensive responsibilities in formations with three center backs. Full backs in 3-4-3 and 3-5-2 act in more offensive positions and therefore can attempt more dribblings. Full backs also show higher values for ball-possession phases, short passes, and middle passes in 4-3-3 and 4-2-3-1 compared to other formations (0.31≤ES≤1.02). As mentioned earlier, these results can be related to the contextual factor of ball-possession. Further, the teams playing 4-3-3 and 4-2-3-1 had a higher team ranking compared to other formations (see Table 7.1). In this context, an investigation revealed that better teams more often played a ball-possession-based style (Kempe et al., 2014). These findings indicate that the results of ball-possession percentage and quality of a team can be related to each other.

Considering the physical performance of central midfielders, only a few differences occur between formations. Central midfielders in 4-4-2 diamond exhibit a lower running performance (i.e. total distance, high-intensity distance, sprinting distance) compared to other formations. Other investigations revealed more pronounced differences for central midfielders between formations. However, these studies only looked at data of one or two teams with relatively small sample sizes, therefore restricting their findings (Baptista et al., 2019; Tierney et al., 2016).

Similarly, there only occurred a few differences between formations in technical parameters. As mentioned above, central midfielders are more involved in ball possessions in 4-3-3 and 4-2-3-1 formations. Therefore, they exhibited more short and middle distance passes in these formations. Again, this could be related to the contextual factors of team ranking and ball-possession. Due to the central positioning in all formations, central midfielders potentially do not have to adapt their physical and technical performance as much as other positions (center back, full back) when changing the tactical formation.

Regarding the position wide midfielder, more differences than for central midfielders were discovered. Higher values were found for wide midfielders in 4-4-2 diamond formation in the total and high-intensity distance and lower values for sprinting distance compared to other formations ($0.16 \leq ES \leq 1.36$). Furthermore, wide midfielder in a 3-4-3 formation experienced a smaller physical load than wide midfielder in other formations. More specifically, wide midfielders showed lower values in 3-4-3 formation for total distance, high-intensity distance, sprinting distance, and accelerations compared to other formations ($0.13 \leq ES \leq 1.36$). By contrast, other investigations were not able to reveal a smaller load for wide midfielders in a 3-4-3 formation (Tierney et al., 2016). However, Tierney et al. used data from two youth teams, and therefore the results are not comparable to those of the present study.

Additionally, wide midfielders showed more ball possessions, short, middle, and long passes as well as fewer dribblings in the 4-4-2 diamond formation compared to other formations ($0.06 \leq ES \leq 1.25$). The technical as well as the physical performance of wide midfielders in 4-4-2 diamond are similar to the general match-performance profile of central midfielders (see Paper IV. Supplementary Table 3). Therefore, it is reasonable to conclude that wide midfielders act similar to central midfielders due to their central positioning in the diamond formation. Similarly, higher values for ball possessions, short and middle passes were evident in the formations 4-2-3-1 and 4-3-3. As mentioned previously, this finding could be related to different contextual factors (ball possession, team ranking).

Regarding forwards, there were only little differences between the formations in terms of physical performance. Contrasting the results of several other investigations (Baptista et al., 2019; Borghi et al., 2020; Modric et al., 2020; Tierney et al., 2016) that found the highest total distance for forwards in 3-5-2, the present results revealed the lowest total distance for forwards in 3-5-2. Furthermore, forwards in the 4-4-2 diamond formation showed higher values regarding sprint distance and maximum speed compared to other formations ($0.40 \leq ES \leq 1.09$). These two parameters (sprinting distance, maximum speed) could probably be associated with each other. Larger sprinting distances of a player are associated with either longer distances per sprint or a higher number of sprints. In both cases, the chance of a higher maximum speed potentially increases.

Regarding the technical performance, there is no clear tendency identifiable. It is worth noting that forward is the only position where no higher values were found for middle passes and ball-possessions in 4-2-3-1 und 4-3-3. The position of forwards is higher up on the pitch compared to the other positions. Thus, they do not benefit from higher ball-possession percentages of their team, which commonly not manifest in the attacking third.

There are some limitations that need to be acknowledged, with the first relating to the sample of players. In detail, only players were included that participated in the whole specific match. Since offensive players are substituted more frequently, this results in a smaller sample size for these positions (Bradley et al., 2014). Furthermore, only starters are included and the results are not transferable to substitutes. Moreover, the Bundesliga increased the possible amount of substitutions from three up to five in relation to the COVID-19 pandemic. Therefore, one could assume that the impact of substitutions has increased because of the rule change. This topic needs to be addressed in future studies. In addition, the tactical formations and the playing positions were recorded at the beginning (first 15 minutes) of each game. Therefore, possible position and formation changes could not be considered. The positions and playing formations indeed were reviewed by a game analyst of a German Bundesliga team but still can only represent a reduced picture of reality. Another limitation regarding the statistical analysis with ANOVAs is present. In the present study, game observations of some players could potentially be included in different groups and hence the groups cannot be considered completely independent. Therefore, the analysis with ANOVAs might not be optimal. However, other approaches such as mixed models do not provide analysis of group differences considering the current research question. Therefore, despite the inherent limitations, ANOVAs were applied as they provide robust and conservative analysis of group differences. To help this problem, we provided effect sizes to help interpret the restricted results of the ANOVAs. Nevertheless, it is fundamental to further explore the combined effects of tactical formation and position on physical and technical match performance in soccer.

Regarding future studies, investigating other leagues seems crucial given that match performance is dependent on the competitive level and the country (Dellal et al., 2011; Rampinini et al., 2007). To allow for comparison between studies, standardized coding of positions and formations seems fruitful. In addition, most studies only looked at physical performance and therefore, technical aspects should get more attention in upcoming studies.

7.6 Conclusion

This study revealed that tactical formation affects physical and technical match performance of professional soccer players. Moreover, the changes in match performance differ according to the specific playing position.

Physical and technical performance of center backs, full backs and wide midfielders differed markedly between the tactical formations. For example, center backs and full backs showed higher physical performance when playing in a formation with three defenders in the back row (3-4-3 & 3-5-2). Due to the central positioning in the 4-4-2 diamond formation, in this formation, wide midfielders showed physical and technical performance similar to the general profile of central midfielders. Conversely, central midfielders and forwards demonstrated less pronounced differences between different formations regarding the physical and technical match performance.

From a practical point of view, results can help coaches in scheduling their practice. For example, if a coach wants to change the playing formation he can anticipate the changes in physical and technical load for each playing position and can adapt training and recovery processes accordingly.

8 Does Technical Match Performance in Professional Soccer Depend on the Positional Role or the Individuality of the Player? (Paper V)

Published version of the original research article

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8.1 Abstract

The aim of the study was to examine the impact of the positional role and the individuality on the technical match performance in professional soccer players.

From official match data of the Bundesliga season 2018/19, technical performance (short[<10 m]/medium[10-30 m]/long[>30 m] passes, dribblings, ball possessions) of all players who played during the season were analyzed (normative data). Five playing positions (center back, full back, central midfielder, wide midfielder, forward) were distinguished. As the contextual factor tactical formation is known to influence match performance, this parameter was controlled for. Further, those players who played at minimum four games in at least two different playing positions were included in the study sample (n = 13).

The technical match performance of the players was analyzed in relation to the normative data regarding the extent to which the players either adapted or maintained their performance when changing the playing position.

When switching playing positions, positional role could explain 3-6% of the variance in short passes and ball possessions and 27-44% of the variance in dribblings, medium passes, and long passes. Moreover, we observed large interindividual differences in the extent to which a player changed, adapted, or maintained his performance. In detail, five players clearly adapted their technical performance when changing playing positions, while five players maintained their performance.

Coaches can use these findings to better understand the technical match performance of single players and, further, to estimate the impact of a change in the positional role on the technical performance of the respective player.

Keywords: team sports, football, tactics, passing, dribbling, technical performance

8.2 Introduction

Soccer match performance is determined by a complex interaction of numerous factors including tactical, physical, and technical aspects (Sarmento et al., 2014). In this context, tactical factors like the playing position and the tactical formation have been shown to affect the physical as well as the technical match performance of professional soccer players (Bradley et al., 2011; Dolci et al., 2020).

In terms of physical performance, wide playing positions (e.g. full backs, wide midfielders) generally cover greater distances at high-intensity and sprinting speed than central positions (e.g. center backs) (Aquino, Carling, Palucci Vieira, et al., 2020; Dellal et al., 2010; Rivilla-Garcia et al., 2018). Further, the technical performance of both wide and central midfielders is characterized by a higher number of ball possessions compared to other positions (Dellal et al., 2010). Relating to the tactical formation players in a 3-5-2 formation cover more total distance (Aquino et al., 2019; Bradley et al., 2011; Palucci Vieira et al., 2018) and players in a 4-2-3-1 formation accelerate more often (Arjol-Serrano et al., 2021; Tierney et al., 2016) than in other tactical formations. Moreover, players in a 4-4-2 formation play more passes than players in other formations (Arjol-Serrano et al., 2021; Bradley et al., 2011).

In addition to investigating the isolated effect of playing position and tactical formation, combining both tactical factors provides deeper insights into how tactical aspects influence physical and technical match performance. This combination of tactical factors playing position (e.g. center back) and tactical formation (e.g. 4-4-2) will be defined as *positional role*. Specifically, a player's positional role consists of 1. the playing position and 2. the tactical formation leading to a combined phrase like '*center back in 4-4-2'.* Using the combination of both tactical factors results in more detailed outcomes. Further, the results throughout the studies become more consistent. For example, previous studies revealed that the physical match performance of central defenders, wide defenders, and attackers is higher in a 3-5-2 formation than in a 4-4-2 formation (Arjol-Serrano et al., 2021; Baptista et al., 2019; Borghi et al., 2020; Modric et al., 2020; Tierney et al., 2016). An example that illustrates this connection once again is that center backs cover the greatest sprinting distance in a 3-5-2 formation (Baptista et al., 2019; Modric et al., 2020) and the least sprinting distance in a 4-4-2 formation (Arjol-Serrano et al., 2021; Modric et al., 2020).

Nevertheless, the match performance of soccer players is not only dependent on a positional role (i.e. combination of playing position and tactical formation) but also depends on various contextual factors. Examples for those factors include the league and country being played in, the opponent strength, or whether the match is at home or away (Aquino, Carling, Palucci Vieira, et al., 2020; Dellal et al., 2011; Rampinini et al., 2007; Trewin et al., 2017). Another factor that influences the match performance is the individuality of the respective player. An interesting observation of practitioners is that certain players always show similar match performances even if they play in different positional roles. A logical conclusion of this practical observation could be that soccer match performance is less dependent of the positional role and more strongly associated with the individual player. Each player has his unique set of skills and abilities. These individual factors influence match performance and therefore, can help to explain interindividual differences in single players match performances.

Two studies already examined the extent to which the match performance of soccer players is not only position-specific, but also player-specific (Altmann et al., 2021; Schuth et al., 2016). Altmann et al. (Altmann et al., 2021) investigated the behavior of players that switched between playing positions (e.g. center back to full back). Their results showed that 44-58% of the intraindividual changes in physical match performance due to the change in position can be explained by the factor playing position. Another interesting finding was that for players that switched from center back to full back, a higher physical performance was observed when these players acted as a full back (vs. playing as a center back). Further, this result follows normative data which also indicate a higher physical performance for full backs in comparison to center backs. This finding is also observed in the investigation of Schuth et al. (Schuth et al., 2016). Further, both studies observed high interindividual differences in the way players either adapted or maintained their physical match performance when changing their playing position.

As already mentioned, different players possess different technical and physical skills and might also interpret their playing position differently. This can lead to different technical or physical match performances of individual players, even though they play the same position. Nevertheless, these two studies focused only on the tactical aspect of playing position and did not consider the tactical formation as an additional factor affecting physical or technical match performance. Further, Altmann et al. only focused on physical aspects of match performance. Hence, it is worth investigating the technical soccer match performance on this topic, considering the tactical formation as well. In the present paper, the tactical formation (e.g. 4-4-2) will be controlled as a combined factor with the playing position (e.g. center back), resulting in different positional roles (e.g. *'center back in 4-4-2'*).

Therefore, the aim of this study was to examine to what extent the technical match performance of professional soccer players is dependent on the positional role or on the individuality of the respective player. To address this question, we evaluated data of players switching positional roles and normative positional data in relation to each other. The normative data consists of all players that participated in the study period. We used an idiographic study design to analyze the behavior of individual players. In contrast to a nomothetic approach, an idiographic approach investigates individual cases to describe and interpret them in the respective context. Based on the results of Altmann et al. (Altmann et al., 2021) we hypothesize that some players will maintain their performance while some players will adjust their performance towards the positional role.

8.3 Materials and Methods

8.3.1 Study Design

In this study, official match data from the 2018/2019 season of the German Bundesliga were used, since this was the last season that has not been affected by the COVID-19 pandemic (Thron et al., 2021). A total of 267 games were analyzed, as every match with at least one sent-off (39 games) was excluded. Only players that were involved in the whole respective game (i.e. full 90 min) were included, leading to a maximum of 20 outfield players per match. The 474 players that participated in this season lead to 3,810 single players match performances that were analyzed in this study (normative data).

First, the tactical formation of each team and the playing position of each player who took part in at least one of the included 267 matches of this season were recorded. Five different playing positions (center back, full back, central midfielder, wide midfielder, forward) and eight tactical formations were distinguished (4-4-2, 4-4-2 diamond, 4-2-2-2, 4-3-3, 4-5-1, 4-2-3-1, 3-4-3, 3-5-2).

To determine whether technical performance is not only specific to the positional role but also to the individual athlete, players that played in at least two different positional roles (i.e. playing position = e.g. center back] & [tactical formation = e.g. 4-4-2]: positional role = '*center back in 4-4-2'*) were identified. Therefore, the technical performance for the players' first and second positional role was examined independently. Further, the possible differences in technical performance that occurred when players switched their playing position was analyzed. For all players that were included, the technical performance was analyzed (dribblings, short passes [<10 m], medium passes [10-30 m], long passes [>30 m], ball possessions). Data was collected as part of the players' professional employment so that ethical approval was not required for this study (Winter & Maughan, 2009).

8.3.2 Subjects

To be included in the study sample, players must have completed at least four entire matches (i.e. 90 mins) in at least two different positional roles (i.e. one playing position in a respective tactical formation: e.g. 4 games: '*center back in 4-4-2'*, 4 games: '*full back in 4-3-3'*). Consistent with Altmann et al. (Altmann et al., 2021), only players that changed their playing position were included in the study sample. Therefore, players that combined two positional roles

(e.g., *‘center back in 4-4-2’* & *‘center back in 4-3-3’*) representing only one playing position (e.g. center back) were excluded. On the other hand, if a player played on two positional roles (e.g., *‘center back in 4-4-2’* & *‘full back in 4-4.2’*) while the formation (e.g., 4-4-2) did not change, he was included in the sample. A minimum of four games per positional role was used to account for the variability of technical performance between matches and to minimize the influence of contextual factors (Aquino et al., 2019; Arjol-Serrano et al., 2021; Bradley et al., 2011). As a result, 13 players were included in the study sample.
Normative data for every positional role were collected simultaneously. The normative data consisted of 3,810 single-player match performances (i.e., each single-player match performance of all players that played at least one entire match of the 267 games that were analyzed). These normative data provide information about the typical technical match performance of players representing the specific positional role in the German Bundesliga season 2018/19.

8.3.3 Procedures

Every player (study sample & normative data) was assigned to a positional role representing the playing position in a corresponding tactical formation (see Paper V. Supplementary Table 1). The tactical formations are constructed out of the starting eleven and reviewed by observation after 15 minutes of each match. To analyze the accuracy of the provided tactical formation data, we validated the formations provided for the first match day of the 18/19 season (9 games, 18 formations) by the observation of an experienced game and video analyst of the German Bundesliga team TSG 1899 Hoffenheim. Given the high agreement between the results of the provided formations and the observations of the video analyst (Cohen‘s Kappa: 0.93, $p<0.05$), the data provided by Deltatre (Deltatre, Turin, Italy) were used in this study (Landis & Koch, 1977). For each player in the study sample, the first and the second positional role was determined. If a player combined two positional roles (e.g. *‘center back in 4-4-2’* & *‘center back in 4-3-3’*) representing only one playing position (e.g. center back), the subject was excluded. If a player reached the minimum number of four matches for three different positional roles, the positional role with the least games was excluded (e.g. Player 1: 4 games: ‘*center back in 4-4-2’*, 5 games: ‘*center back in 4-3-3’*, 8 games: ‘*full back in 3-4-3’*; -> only ‘*center back in 4-3-3’* and ‘*full back in 3-4-3’* were analyzed). Therefore, the players in the study sample combined two positional roles, with both positional roles representing two different playing positions. This ensures comparability of the results with previous studies (Altmann et al., 2021; Schuth et al., 2016). We used an idiographic study design. Therefore, the variability of performance changes that cannot be attributed to the positional role could potentially be associated with the individuality of the respective player.

The technical performance was analyzed using the number of dribblings, passes, and ball possessions. Throughout previous studies that investigated technical match performance, ball possessions, passes and dribblings were the most frequently analyzed parameters (Aquino et al., 2019; Arjol-Serrano et al., 2021; Bradley et al., 2011). Based on the covered distance of the ball, passes were divided into three categories (short [<10 m], medium [10≥30 m], long [>30 m]). One dribbling was counted if one player attempted to dribble past an opponent while safely in control of the ball. One ball-possession phase for one player was counted when he had a ball action in a ball-possession phase of his team. All definitions are based on the catalog of the German soccer league (DFL) (Deutsche Fußball Liga (DFL), 2019).

The technical performance was conducted using the DFL Observed Tracking-Data processed by Deltatre. The data are based on a Multi-Camera-Tracking System (TRACAB, Chyron Hego, Melville, NY, USA), that was previously validated (Linke et al., 2020).

8.3.4 Statistical Analysis

All statistical analyses were executed using IBM SPSS Statistics 25.0.0.0 (IBM Co., New York, USA). The significance level for all tests was set to 0.05. Mean values and standard deviations (SD) were calculated for each player of the study sample and for the normative data for each playing position in the different tactical formations.

To determine possible performance changes when changing the positional role, the study sample data and the normative data were analyzed in relation to each other. The differences between the technical performance between the first and the second positional role of player of the study sample were tested by independent t-tests and represented by Cohen’s d effect sizes (ES). Small ($0.2 \leq ES < 0.5$), medium ($0.5 \leq ES < 0.8$) and large ($ES \geq 0.8$) ES were distinguished (Cohen, 1988). Further, Pearson’s product-moment correlations with 95 % confidence intervals (95 % CI) were calculated between the positional difference of the players in the study sample and the associated positional difference in the normative data. This correlation helps to quantify the contribution of the positional role in the variability between the first and second positional role of the players in the sample. The correlation coefficients were classified into small ($0.1 \le r \le 0.3$), moderate ($0.3 \le r \le 0.5$), large ($0.5 \le r \le 0.7$), very large ($0.7 \le r < 0.9$), and nearly perfect ($r \ge 0.9$) (Hopkins, 2002).

8.4 Results

Regarding the study sample, six players [players 6, 7, 8, 9, 10 & 11] combined the playing positions of wide midfielder and central midfielder, while their positional roles were different (i.e. different tactical formations). Moreover, two players combined the playing positions center back and central midfielder [players 1 & 2], and wide midfielder & forward [players 12 & 13], representing different positional roles, respectively. The other playing position combinations (center back / full back [player 3]; wide midfielder / full back [player 4]; central midfielder / forward [player 5]) were represented by one player, each.

For the technical parameters short passes and ball possessions, the correlation between the positional performance difference of the players in the study sample and the respective normative data was small (r-range = 0.18-0.24; r^2-range = 3-6%) (See Table 8.1). For the parameters dribblings, medium passes, and long passes this correlation was large (r-range = 0.52-0.66; r^2-range = 27-44%).

Figures 8.1-8.5 show the technical performance of the players of the study sample in relation to the respective normative data of the positional role. Descriptive values (means ± SD), t-test results, and ES regarding the study sample are presented in Paper V. Supplementary Table 2.

Five players [players 1, 6, 8, 10 & 12] rather maintained their technical performance when changing the positional role, as indicated by a maximum of two large ES in the five reported parameters. However, five players [players 3, 5, 7, 11 & 13] apparently changed their technical performance when changing the positional role, as indicated by at least four large ES in the reported performance parameters. The other 3 players [players 2, 4 & 9] showed large ES in three of the five parameters and therefore revealed inconsistent differences when changing the positional role. Further, we observed large interindividual differences in the way players adapted or maintained their performance when changing the playing position. Players showed different magnitudes in performance changes and these differences individually occurred in different performance parameters.

Additional descriptive information about the players of the study sample can be found in Paper V. Supplementary Table 7. Eight players were born in Germany, while player 3 (Senegal), player 6 (Austria), player 7 (Ivory Coast), player 9 (Netherlands), and player 12 (France) were born in other countries. Except for players 1, 2, and 7 all players belong to teams that finished the season in the top half of the table. Furthermore, four players (players 3, 6, 10 & 11) were active in international competition during the study period. Moreover, the players of the study sample played in 85% of all league matches during the study period.

Moreover, the normative data reveals further information. Regarding playing positions (see Paper V. Supplementary Table 4) the most obvious results were that center backs and full backs reveal more ball possessions compared to the other playing positions. Furthermore, center backs play the most short and medium passes of all playing positions. Moreover, combining the playing position and formation reveals deeper insights (see Paper V. Supplementary Table 3). While center backs, full backs, and wide midfielders reveal larger differences between formations, the technical performance of central midfielders and forwards differed only slightly between the formations.

Table 8.1. Pearson's r (r^2), 95 % CI and p-values for correlations between the positional difference of the players in the study sample and the associated positional difference in the normative data for dribblings, short passes, medium passes, long passes, and ball possessions.

	Dribblings	**Short Passes**	**Medium Passes**	**Long Passes**	**Ball Possessions**
Person's r (r^2)	0.66 (44 %)	0.18 (3 %)	0.54 (29 %)	0.52 (27 %)	0.24 (6 %)
95 % CI	0.18-0.89	-0.42-0.66	-0.02-0.84	-0.05-0.83	-0.36-0.70
p-value	0.01	0.57	0.06	0.07	0.44

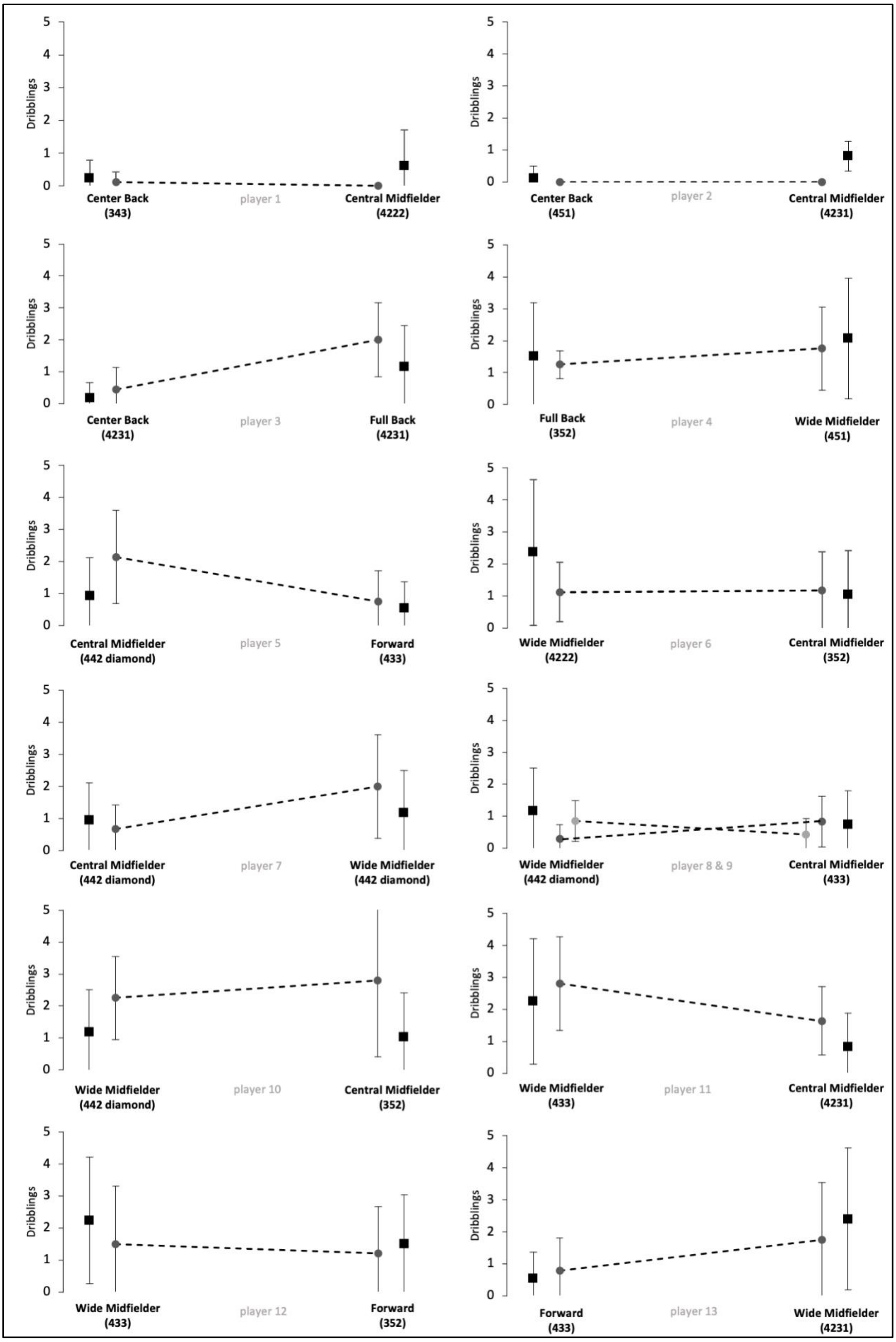

Figure 8.1. Number of dribblings of players from the study sample (grey circles) in relation to normative positional data (black squares). Data are presented as means ± SD for the respective games played on the respective positional role. Solid lines indicate significant differences in performance between the two positions for the respective player.

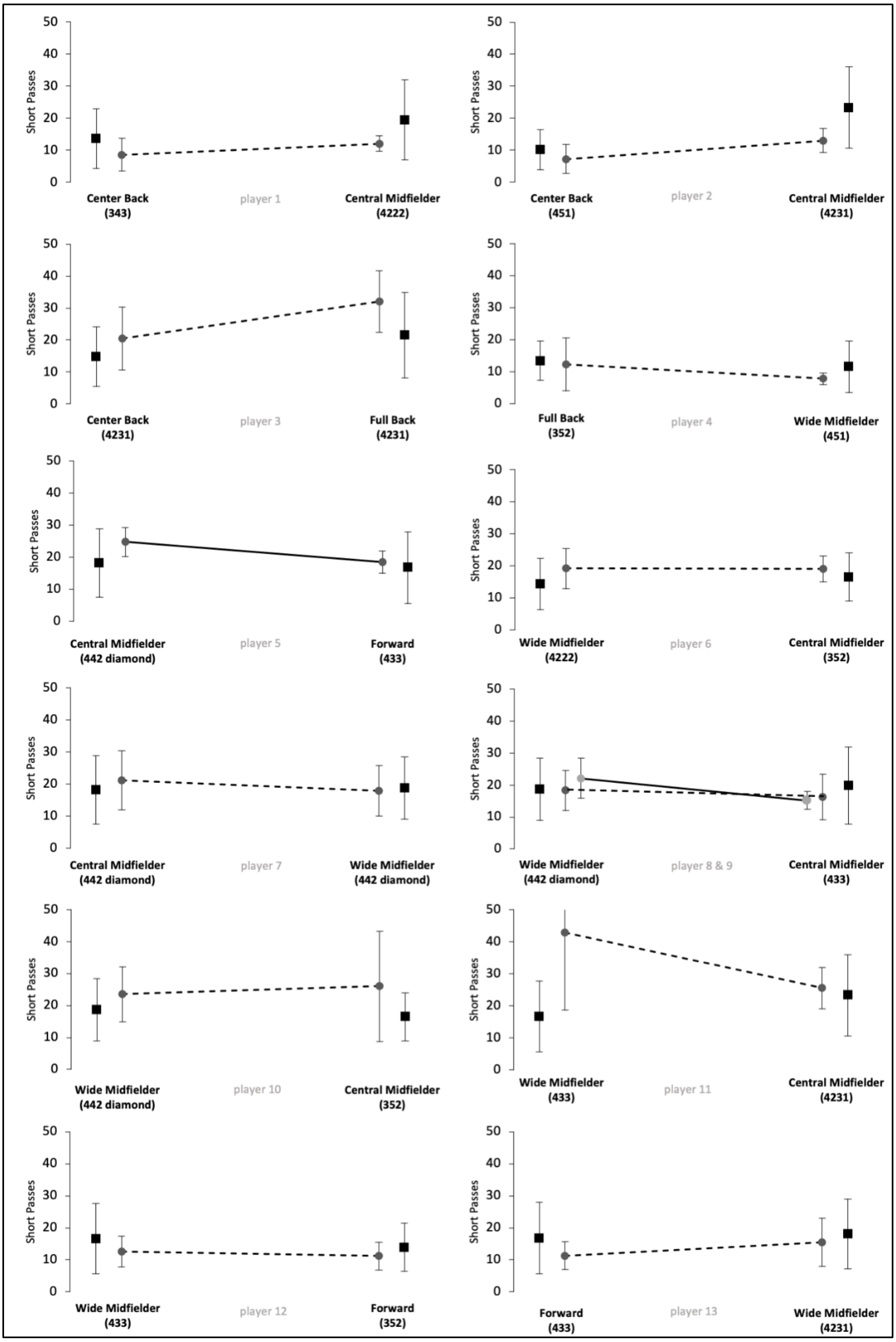

Figure 8.2. Number of short passes of players from the study sample (grey circles) in relation to normative positional data (black squares). Data are presented as means ± SD for the respective games played on the respective positional role. Solid lines indicate significant differences in performance between the two positions for the respective player.

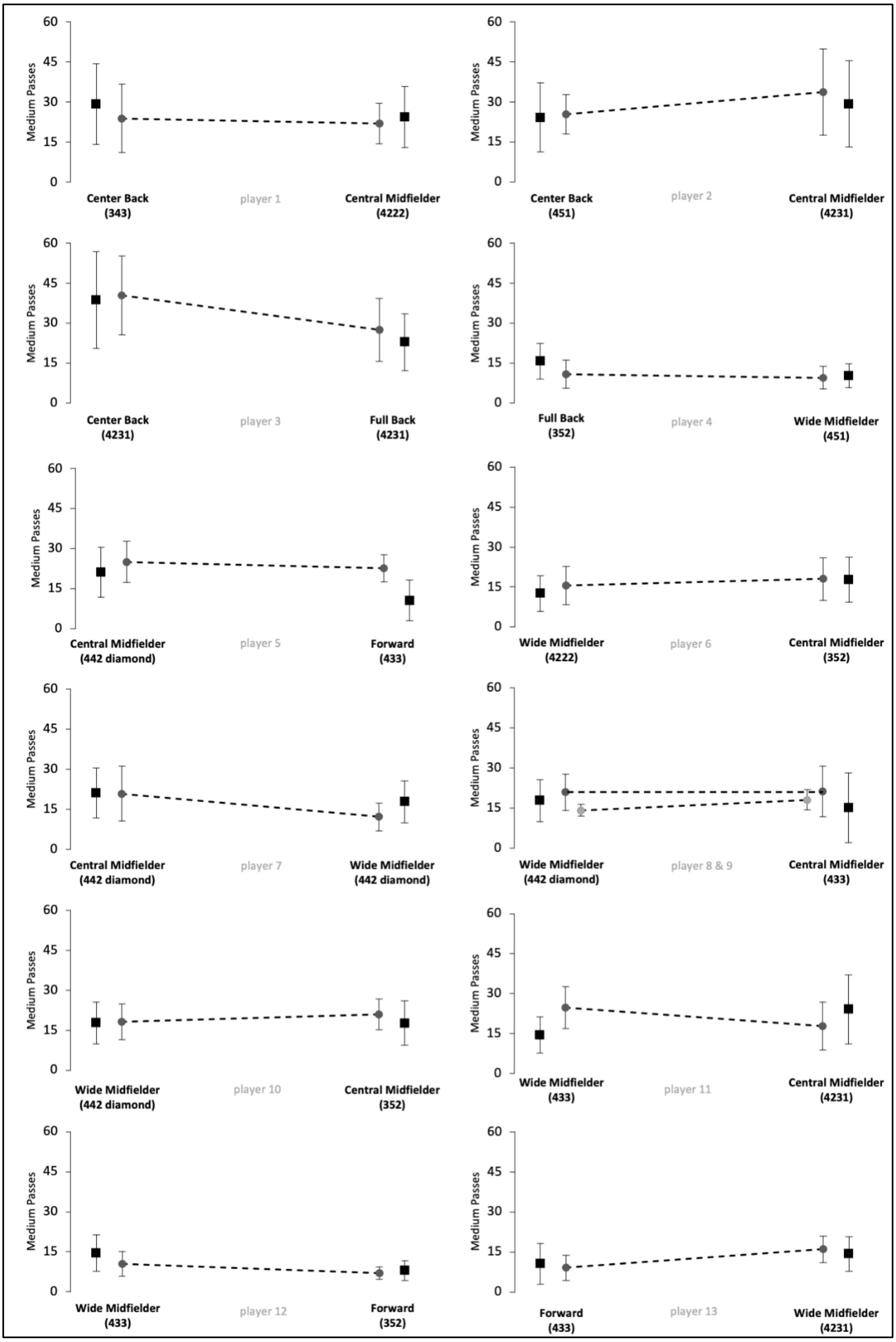

Figure 8.3. Number of medium passes of players from the study sample (grey circles) in relation to normative positional data (black squares). Data are presented as means ± SD for the respective games played on the respective positional role. Solid lines indicate significant differences in performance between the two positions for the respective player.

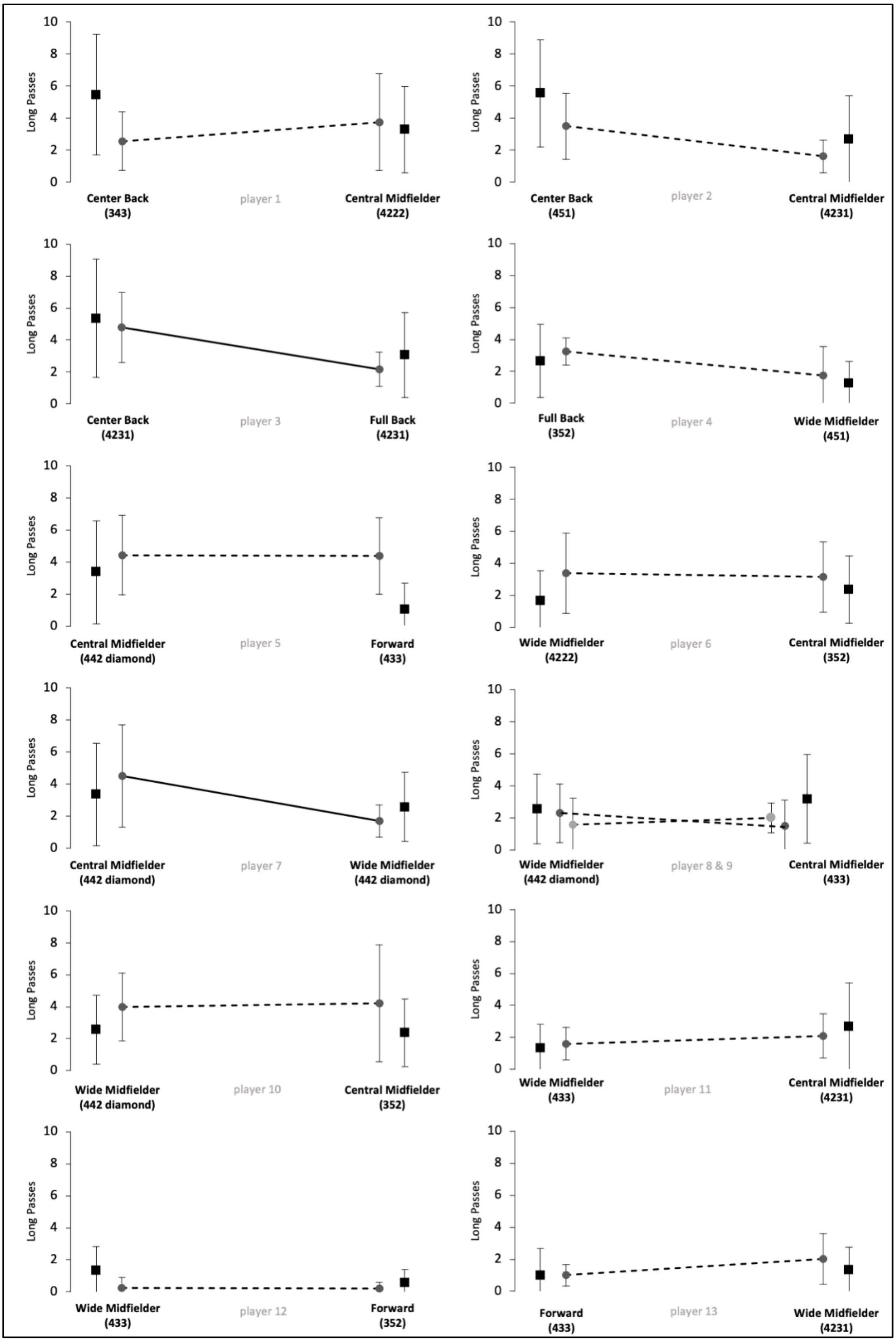

Figure 8.4. Number of long passes of players from the study sample (grey circles) in relation to normative positional data (black squares). Data are presented as means ± SD for the respective games played on the respective positional role. Solid lines indicate significant differences in performance between the two positions for the respective player.

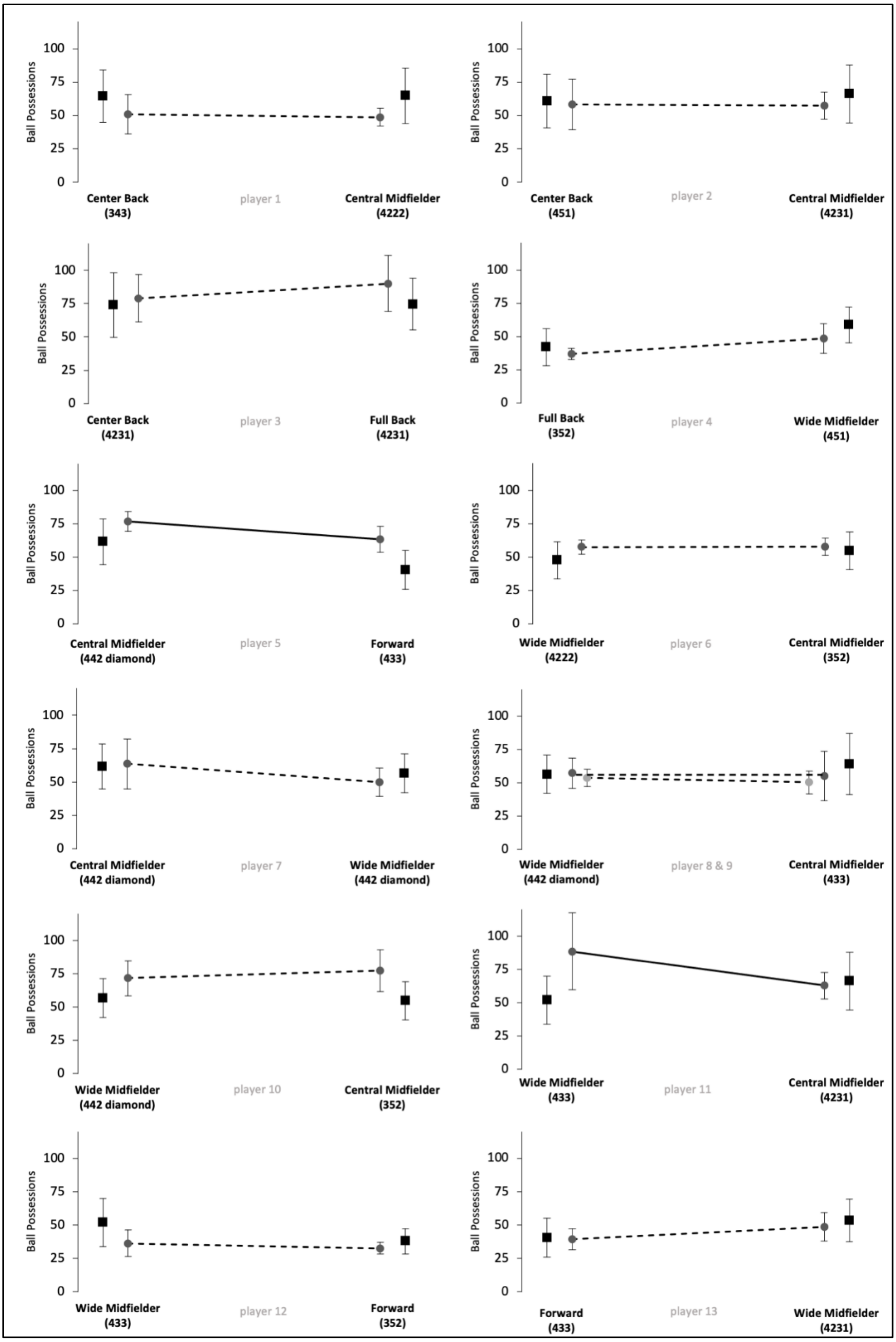

Figure 8.5. Number of ball possessions of players from the study sample (grey circles) in relation to normative positional data (black squares). Data are presented as means ± SD for the respective games played on the respective positional role. Solid lines indicate significant differences in performance between the two positions for the respective player.

8.5 Discussion

The aim of the current study was to examine to what extent the technical match performance of professional soccer players is dependent on the positional role (i.e. a combination of playing position and tactical formation) or on the individuality of the respective player. Positional role could explain 3-6% of the variability in short passing and ball possessions and 27-44% of the variability in dribbling, medium passing, and long passing. The remaining variability in the respective parameters can be attributed to different influencing factors including the individuality of each player. The results showed large differences in the way the players adapted or maintained their technical match performance when changing positional roles.

The results of the normative data on technical match performance revealed conflicting outcomes to previous investigations. Center backs and full backs seemed to display the most ball possessions compared to other playing positions. Previous investigations found that central and wide midfielders had the most ball possessions (Dellal et al., 2010). While in the past midfielders were the playmakers, in recent years defensive positions (e.g. center back) have been given more and more responsibility in shaping the game. For example, Bush et al. found that the number of passes from center backs has increased in the last decade. Importantly this increase was larger for center backs than for the remaining playing positions (Bush, Barnes, et al., 2015). Therefore, the conflicting results could potentially be associated with the data by Dellal et al. (Dellal et al., 2010) being collected over a decade ago. Further, the center backs played the most medium and long passes, while together with forwards playing the fewest short passes. Central midfielders played the most short passes and wide midfielders displayed the most dribblings of all positional groups. Moreover, the results indicated that the tactical formation has an effect on technical match performance (see Paper V. Supplementary Table 5). Further, the influence of tactical formation on technical performance is position-dependent (see Paper V. Supplementary Table 3). While the technical performance of center backs, full backs, and wide midfielders differed markedly between tactical formations, central midfielders and forwards showed smaller differences between the tactical formations. These results indicate that the tactical formation needs to be considered when looking at the match performance of soccer players.

To figure out how players adapt or maintain their technical match performance when changing the positional role, we analyzed the results of the study sample in relation to the normative data for each positional role. The correlation between the positional performance difference of the players in the study sample and the respective differences in the normative data revealed differences depending on the parameter. For the parameters short passes and ball possessions, the respective positional roles could explain only 3-6 % of the variability. Regarding the parameters dribblings, medium passes, and long passes the positional roles explained 27-44 % of the variability. Therefore, short passes and ball possessions underlie less influence of the positional role, while the influence of the positional role on medium passes, long passes, and dribblings is markedly larger. This finding could be associated with the heterogenous normative positional data. Larger variability in the normative data promoted higher correlations. While the normative positional data show large differences between the playing positions regarding the parameters medium passes, long passes, and dribblings, the differences regarding short passes and ball possessions are much smaller. For example, wide midfielders show 980% more dribblings than center backs and center backs reveal 777% more long passes than forwards. Therefore, the results of the correlation regarding these parameters can strongly be linked with the normative data regarding the playing positions. The results of Altmann et al. (Altmann et al., 2021), who used a similar strategy in study design and methods, showed that physical performance was influenced by position to a greater extent than technical performance. These results can indicate that the influence of the playing position on technical performance is smaller than on physical performance. Therefore, we could potentially conclude that the individual playing style of the respective player has a larger impact on technical performance than on physical performance.

The results of Figures 8.1-8.5 and Paper V. Supplementary Table 2 indicate large interindividual differences in adaption or maintenance of the technical match performance when changing the positional role. Regarding their reaction to switching positional roles, the players in the study sample could be categorized into three different groups.

The first group consists of five players that markedly changed their technical performance when changing the positional role, indicated by at least four large ES in the five analyzed parameters [players 3, 5, 7, 11 & 13]. Two players represented the position combination wide midfielder and central midfielder, while the other position combinations (center back/full back; central midfielder/forward; wide midfielder/forward) were only represented by one player.

The second group is represented by five players who tended to maintain their technical performance when changing the positional role, as indicated by a minimum of two large ES in the five technical parameters [players 1, 6, 8, 10 & 12]. Three of those players changed between the positions of wide midfielder and central midfielder. The position combinations center back & central midfielder, as well as wide midfielder & forward, were represented only once.

The remaining three players indicated three large ES in the examined parameters and therefore revealed inconsistent changes when changing the positional role [players 2, 4 & 9]. Each position combination was represented by one player (center back/central midfielder; full back/wide midfielder; wide midfielder/central midfielder).

The way single players changed or maintained their technical performance when changing the positional role highlights large interindividual differences. For instance, players 12 and 13 represented the same position combination (wide midfielder/forward) but behaved markedly different when changing from wide midfielder to forward. In detail, player 12 rather maintained his technical performance for the parameters dribblings, short passes, long passes, and ball possessions and only adapted his performance towards the normative positional data regarding medium passes (decrease from wide midfielder to forward). In contrast, player 13 adapted his performance towards the normative positional data in all five technical performance parameters. In detail, player 13 revealed a decreasing number of passes (short, medium & long), ball possessions, and dribblings when switching from wide midfielder to forward. Both players played in 100% games of their teams in the investigated Bundesliga season and finished the season in a top table position respectively (i.e. table position 4 and 5, see Paper V. Supplementary Table 7). However, the team of player 13 was active in the Europa League throughout the study period. The additional number of games could mean that the match performance of player 13 was affected by the enormous number of games (Folgado et al., 2015; Palucci Vieira et al., 2018). Overall, the differences that occur when players change positional roles are multivariate. Accordingly, the change in the playing position as well as the change in the tactical formation can affect performance. In contrast to the results of Altmann et al., who used a similar study design (e.g. Bundesliga) and had different explanation approaches for the performance changes of individual players in the study sample, the results of the current study were more heterogeneous (Altmann et al., 2021). Logical explanations as why single players in the current study sample adapted or maintained their technical performance in the respective parameters could not be derived.

In the study of Schuth et al., the technical performance of players who changed playing positions from center back to full back changed according to the normative data for each position (Schuth et al., 2016). The only player representing this positional interchange combination in the present study (player 3) revealed a similar reaction in adapting his technical performance. Moreover, Schuth et al. revealed that players changing from central midfielder to wide midfielder showed fewer passes and ball possessions in their second position, which also followed the normative positional data. In our study, six players represent the mentioned position combination (i.e. center back/full back). Two players (players 7 & 11) adapted their technical performance towards the normative positional data. The other three players (players 6, 8 & 10) tended to maintain their performance and, therefore, were somehow unaffected by the change of positional roles. One player (player 9) showed an alternating behavior when switching from central to wide midfielder and, therefore, could not be assigned to either group. One possible explanation for the conflicting results could be that Schuth et al. examined data of seven consecutive seasons. Single players develop during this long period of time and might also adapt to the evolving game, which became more technically demanding during this time span (Bush, Barnes, et al., 2015). Further, Schuth et al. did not consider tactical formations, which might limit the generalizability of their results.

The players of the sample were regulars who played in 85% of all league matches (see Paper V. Supplementary Table 7). With the exception of players 3 (Senegal), 6 (Austria), 7 (Ivory Coast), 9 (Netherlands), and 12 (France), all players were born in Germany. Most of the players in the sample played for clubs that finished the season in the top half of the table. Only players 1, 2, and 7 were not as successful with their respective teams. However, all players managed to prevent their teams from relegation. Only four players (players 3, 6, 10 & 11) were active with their teams in the Champions League or the Europa League.

Moreover, the results can be discussed from an ecological dynamics perspective. Previous studies revealed that a players‘ main playing position (e.g. defender, midfielder, or forward) has a significant influence on the technical-tactical elements in soccer (Laakso et al., 2019, 2021). Therefore, from an ecological dynamics perspective, when considering the results, it must be taken into account that the main player position has an influence on the perception-action systems of soccer players (Araújo et al., 2006). Since the players mostly play in their main playing position during their development in soccer, they learn to perceive, process and implement the position-specific technical-tactical elements of the soccer game. From these points of view, the players from the current study sample need to be considered specifically.

To be more precise, the players in this sample are regulars at different main positional roles and, therefore, cannot be assigned to a single specific main playing position. From an ecological dynamics perspective, it would be profitable to test the findings of Laakso et al. (Laakso et al., 2019, 2021) using such special player samples. The results from such studies might indicate in what way these theories also apply to this particular type of player.

The technical performance of soccer players varies from match to match (Bush, Archer, et al., 2015). Therefore, we tried to minimize the effect of single match performances by extending the criterion for inclusion in the study sample to a minimum of four games per positional role. Because we considered the tactical formation and playing position for each player, this simultaneously led to a small sample size (n = 13), which can be considered a limitation of this study. However, these strict inclusion criteria lead to more meaningful outcomes compared to a larger sample size that would result from a smaller number of games as an inclusion criterion. In the study sample, 12 out of 13 players played as midfielders (central or wide) in at least one of the two positional roles considered per player. Therefore, midfielders represented a majority of the study sample. This finding could be associated with the assumption that midfielders are more flexible in terms of positional roles than players in other playing positions. More specifically, midfielders are strongly integrated into both the attack and defense, while the task focus of forwards and defenders is either attack or defense. Hence, midfielders could possibly better fill a second defensive (center back or full back) or offensive position (forward) in addition to their main midfield position (central or wide). Moreover, we only analyzed five different technical performance parameters. To provide a full picture of the technical performance of a professional soccer player more different technical performance parameter would be desirable in future studies. Another limitation of this study is that contextual factors are only provided for the tactical formations (see Paper V. Supplementary Table 6) but were not implemented in the study design referring to the players of the study sample. In addition, only players that played the whole specific match were included. Since offensive players are substituted more frequently, this results in a smaller sample size for offensive positions (see Paper V. Supplementary Table 4) (Bradley et al., 2014). Because only starters are included, the results of the current study are not transferable to substitutes. Furthermore, the goal of this study was to describe the technical performance and to assess the typical technical requirements of players in the German Bundesliga. Analyzing the ratio of successful actions would add another level of evaluating and interpreting the results by assessing the quality of the respective technical actions. Future studies could focus on the success rate of actions and thus evaluate the quality of technical match performance. Moreover, the positions and tactical formations were observed at the beginning (first 15 minutes) of the respective match. Therefore, possible position and formation changes were not considered. However, the playing positions and formations indeed were reviewed by an experienced match analyst of a German Bundesliga team. In the future, these changes in tactical formations should be considered to obtain more precise and accurate results. To the best of the authors' knowledge, no study has been published to date that investigated the frequency of formation changes of single teams during games. Further, to expand the gain of knowledge, studies should also consider substitutes. This could also potentially help to increase the sample size and, therefore, improve the robustness of the gained insights. In addition, dividing players that switched the playing position while tactical formation stayed constant and players that changed playing position and tactical formation could be profitable. Furthermore, the goalkeeper is becoming more and more important in modern build-up play. Future studies could also investigate the effect of tactical formation on the match performance of a goalkeeper.

8.6 Conclusion

This study revealed that not only the playing position in a specific tactical formation, but also the individuality of the respective player influences the technical match performance of professional soccer players. Depending on the technical performance parameter, the positional role (i.e. playing position in a respective tactical formation) explains 3-44 % of the variability due to the switch in playing position. The interindividual differences how players adapted or maintained their technical performance were large. Therefore, the manner (i.e. magnitude and direction of performance changes) in which the positional role influences the technical match performance depends on the individual player.

The findings of this study can help coaches interpret the technical match performance of single players after switching positional roles. Hence, it is worthwhile to adapt training programs not only to the positional role but also to the respective player. The results suggest that the size of the impact of tactical factors (i.e. positional role) is profoundly dependent on the individual player. When coaches have their players play in different positional roles, they need to consider not only the tactical position but also the individuality of each athlete. Further, scouts need to be aware of the extent of the influence of each the positional role and the individuality of the player when interpreting technical match performances of possible transfer candidates.

9 Is ball-possession style more physically demanding than counter-attacking? – The influence of playing style on match performance in professional soccer (Paper VI)

Version of the original research article currently under review

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9.1 Abstract

In Soccer, the offensive style of play describes characteristic behavioral features of the players at team level during the offensive phase of matches. This study aimed to investigate the effect of offensive playing style (i.e. while in ball possession) on physical and technical match performance during offensive play as well as success-related factors.

The sample consisted of official tracking and event data of 153 matches of the 2020/21 German Bundesliga season. In every match, for both teams, an offensive playing style coefficient [PSC] was calculated to locate teams on a continuum between ball possession and counter-attacking style. In addition, dependent physical (e.g. sprinting distance), technical (e.g. passes), and success-related (e.g. goals) variables were examined. A separate linear mixed model was calculated for each dependent variable.

While teams with lower PSC values (= counter-attacking style) covered more high-intensity and sprinting distances per second in possession, teams with higher PSC values (= ball possession style) were physically more demanded over a whole match (e.g. more accelerations, decelerations, high-intensity, sprint distance) ($p \leq 0.03$; $R2=0.08-0.69$). Furthermore, teams with higher PSC values played more horizontal passes and revealed better passing success rates ($p<0.01$; $R2=0.17-0.73$). In contrast, teams with lower PSC values played more long passes ($p<0.01$; $R2=0.58$). The influence of the PSC on success-related variables was smaller ($p \leq 0.36$; $R2=0.10-0.13$).

Concluding, offensive playing style affects physical and technical match performance, but has limited influence on success. Hence, coaches can use the findings to optimize training contents before and recovery processes after matches.

9.2 Introduction

Match performance in soccer primarily consists of physical, technical, and tactical components. With the increasing availability of big data in professional soccer, this match performance can now be well quantified within its components. For instance, from a physical perspective, professional players run between 10 and 13 km per match while only sprinting 2-3% of this distance (Sarmento et al., 2014; Stølen et al., 2005). Furthermore, from a technical point of view, players are in ball possession 57 times and play 38 passes on average (Forcher, Forcher, Jekauc, Woll, et al., 2022). Lastly, in a tactical context, studies revealed that passes with a higher potential of disrupting the opposing team lead to more successful attacks (Forcher et al., 2021; Kempe & Goes, 2019).

This physical, technical, and tactical match performance is influenced by a variety of contextual factors. On the one hand, external parameters like match venue (home/ away), congested fixtures, or the respective league can affect match performance components (Dellal et al., 2011; Dolci et al., 2020; Rampinini et al., 2007). On the other hand, individual characteristics like anthropometry or physical capacities influence the physical, technical, and tactical output of players on the pitch (Aquino, Carling, Maia, et al., 2020). Moreover, the influence of tactical factors on match performance has increasingly moved into the focus of scientific soccer research (Forcher, Forcher, Wäsche, et al., 2022).

Tactical factors can be defined as variables affecting the convenient behavior of players to achieve the goals of the match (e.g. scoring goals). Typical tactical factors influencing match performance are the playing position of a player or the tactical formation (i.e. distribution of the eleven field players on the pitch) of a team. Regarding the influence of tactical factors, for example, wide players (i.e. wide defenders & wide midfielders) have been shown to exhibit more accelerations and greater sprinting distances than other playing positions (e.g. forwards) (Altmann et al., 2021; Bush, Barnes, et al., 2015; Vigh-Larsen et al., 2017). Furthermore, teams with a 3-5-2 formation are more compact and, therefore, can put more pressure on the opposing team than in other formations (Memmert et al., 2019).

Besides playing position and tactical formation, another well-studied tactical factor in soccer is the playing style of a team. The playing style describes the behavior of the players at a team level. In detail, which characteristic behavioral features a team reveals that are repeated in their occurrence over a longer period (Fernandez-Navarro et al., 2016). A distinction is made between offensive (i.e. own ball possession) and defensive (i.e. opposing ball possession) playing styles, as the goals and thus the actions of the players in the respective phase of the match differ considerably.

On the one hand, in the defensive phase, the team tries to prevent the opposition from scoring and regaining ball control. These objectives can be used to define two substantially different defensive playing styles. Firstly, there are teams, particularly emphasizing the objective of preventing a goal from being scored by the opponent. To achieve this objective, teams withdraw far into their half and try to condense the space in front of their own goal (Wright et al., 2011). This defensive playing style with a focus on preventing goals also includes the famous "catenaccio" (Orejan, 2011). Secondly, other teams place more emphasis on the objective of winning back the ball by putting the opponent under pressure in their half and thus creating early ball regains to eventually create own goal-scoring opportunities (Bangsbo & Peitersen, 2000). The strategy of early pressing to regain the ball can be observed at Liverpool FC under Jürgen Klopp (Toetz, 2022). Both playing styles accentuate the objectives of the defensive match phases differently and, therefore, from a tactical perspective the behavior of the players as a team needs to be different.

On the other hand, in offensive match phases teams try to control the ball through possession and eventually score goals. Again, emphasizing either one or the other of the two objectives leads to fundamentally different offensive playing styles also known as ball possession and counter-attacking style. Firstly, some teams attempt to control the match with their ball possession and consequently try to disrupt the well-organized defending team with a series of passes (= ball possession style) (Forcher et al., 2021). Control through passing was perfected by Pep Guardiola at FC Barcelona and has since become known as "tiki-taka". Secondly, other teams try to score goals by benefiting from the disrupted defense directly after the ball regain (= counter-attacking style) (Kempe et al., 2014). A well-known advocate of the counter-attacking opportunity is Ralf Rangnik (Fritsch, 2016). After successes as a manager with TSG Hoffenheim and RB Leipzig, he had meanwhile also arrived at Manchester United. These two offensive playing styles are the most reported in the current literature (Bate, 1988; Garganta et al., 1997; Redwood-Brown, 2008; Ruiz-Ruiz et al., 2013; Tenga, Holme, et al., 2010a, 2010b; Tenga, Ronglan, et al., 2010; Tenga & Larsen, 2003; Travassos et al., 2013). Both playing styles can be described as extremes on an offensive playing style continuum, which categorizes the offensive possession phases. Since previous research has focused mainly on offensive playing styles, this study will also examine offensive playing styles.

Already existing studies have mainly focused on the distinction and definition of offensive playing styles by analyzing performance data (Kempe et al., 2014; Tenga & Larsen, 2003). A study by Yi et al. has already investigated the influence of offensive playing style on physical and technical match performance (Yi et al., 2019). However, only a small sample of 59 games was examined in this study. Furthermore, the investigation of Yi et al. did not consider that a team's playing style can also change between several matches. Therefore, this study aimed to investigate the effect of offensive playing style (i.e. while in ball possession) on physical and technical match performance during offensive play as well as success-related factors. Since other tactical factors like the playing position or the tactical formation have been shown to influence physical and technical match performance (Forcher, Forcher, Wäsche, et al., 2022), we hypothesized that the offensive playing style affects physical and technical match performance in professional soccer.

9.3 Materials and Methods

9.3.1 Sample

In the present study, all 153 matches of the second half of the 2020/21 German Bundesliga season were analyzed. The data basis was official tracking and event data. The tracking data consisted of X and Y data of all 22 players on the pitch and the ball and were recorded by a semi-automated optical tracking system (TRACAB, ChyronHego, Melville, NY, USA). This system was recently considered valid (Linke et al., 2020). The event data were raised manually by Sportec Solutions (Sportec Solutions AG, Ismaning, Germany) and the definitions of the events were based on an official checklist (Deutsche Fußball Liga (DFL), 2019). Tracking and event data were synchronized by matching the respective time-point of the tracking data for every event using the algorithm of Forcher et al. (Forcher, Forcher, Altmann, et al., 2022). All data processing and analysis were executed using Python 3.9 with the NumPy, Pandas, and Matplotlib libraries.

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the local ethics committee (Human and Business Sciences Institute, Saarland University, Germany, identification number: 22-02, 10 January 2022).

9.3.2 Procedures

To quantify the offensive playing style (i.e. ball possession or counter-attacking style) of each team in every match, we used and further developed a playing-style formula of Kempe et al. (Kempe et al., 2014). Therefore, we conducted a principle component analysis to weigh the physical and technical parameters within this already existing formula. This procedure allows a weighting of the parameters according to their importance concerning the classification into an offensive style of play. This new weighted formula is subsequently referred to as the playing style coefficient [PSC]. The PSC elevates the offensive style of play on an offensive playing style continuum between *ball possession* and *counter-attacking* style. While high PSC values are associated with a focus on ball possession, low PSC values are associated with a focus on counter-attacking.

PSC *(playing style coefficient)* = (**PA** * 0.35) + (**FP** * -0.03) + (**TP** * 0.23) + (**PS** * 0.32) + (**FPS** * 0.32) + (**BP** * 0.32) + (**DPA** * 0.34) + (**RAT** * -0.32) + (**MAT** * 0.35) + (**RD** * -0.24) + (**MPA** * 0.35)

PA *≙ Number of passes of one offensive action*
FP *≙ Number of passes forward in relation to the overall number of passes subtracted from 1*
TP *≙ Number of passes to a target player in relation to number of overall and non-target player passes*
PS *≙ Number of successful passes in relation to the overall number of passes*
FPS *≙ Number of successful passes forward in relation to the overall number of passes forward*
BP *≙ Sum of all periods of possession of one team in relation to the sum of the periods of possession of both teams*
DPA *≙ Distance covered during all attacks in relation to the total number of attacks*
RAT *≙ Mean time of the attack of the opponent subtracted by the own mean time of the attack*
MAT *≙ Relation of the total time of all attacks to the number of attacks*
RD *≙ Relation of the distance covered within one attack to the time with ball possession*
MPA *≙ Relation of the total number of passes to the total number of attacks*

The study by Yi et al., which already investigated the influence of offensive playing style on match performance, surveyed match performance throughout the whole match (Yi et al., 2019). However, Yi et al. revealed that the offensive playing style significantly influences the ball possession rate of a team. Since the ball possession rate influences match performance (e.g. high-intensity running profile, number of passes), the present study examines all dependent variables solely during the ball possession of the respective team (Bradley et al., 2013; Mota et al., 2015). Therefore, similar to Goes et al. and Forcher et al. (Forcher, Forcher, Altmann, et al., 2022; Goes et al., 2018), ball possessions were defined as a phase where one team is controlling the ball. A possession ended with either the opponent gaining ball control or a stoppage of play (i.e. foul, offside, goal, final whistle, ball out of bounds). The dependent variables were examined at a team level and were categorized into three performance parts (physical, technical, & success).

Firstly, the physical variables acceleration, deceleration, high-intensity distance, and sprint distance per attack were collected. Similar to Rhodes et al. predetermined thresholds for accelerations (> 3 m/s^2) and decelerations (< -3 m/s^2) were used (Rhodes et al., 2021). The high-intensity distance was defined as the distance where running speeds between 19.8-25.0 km/h are reached and the sprint distance with speeds above 25.0 km/h (Aquino et al., 2019; Arjol-Serrano et al., 2021; Borghi et al., 2020; Bradley et al., 2011; Tierney et al., 2016). Moreover, since it can be assumed that ball possession-oriented teams have longer ball possessions per attack, all physical variables were not only used as absolute values but also normalized based on attacking time and subsequently included as additional parameters.

Secondly, the technical variables passes and dribblings were raised. Additionally, for each technical parameter, the success rate was determined. Dribbling was recorded if a player in safe ball control tried to dribble past an opponent. Dribblings were considered successful if the respective player managed to dribble past the opponent. Furthermore, based on their distance, passes were categorized into short (<10m), medium (10-30m), and long (>30m) (Forcher, Forcher, Jekauc, Woll, et al., 2022). In addition, passes were classified backward or horizontal according to their playing angle (see Paper VI. Supplementary Figure 1). Since the results of Yi et al. suggest that ball possession oriented teams play more passes per attack, all passes were analyzed in relation to the total number of passes (Yi et al., 2019). Moreover, the average velocity of a pass was quantified. Passes were rated as successful when the ball reached a teammate.

Thirdly, as success-related variables points per match (0=loss, 1= draw, 3= win), goals scored, and expected goals [xGoals] were recorded. xGoals were estimated after the definition of the German football league (Deutsche Fußball Liga (DFL), 2019).

Furthermore, the offensive tactical formation was captured by deploying the formation description algorithm by Forcher et al. (Forcher, Forcher, Altmann, et al., 2022). It clusters the average positions of all players into three formation lines (e.g. 4-4-2). The offensive formation represents the tactical distribution of all players on the pitch and is only measured for the team in possession (Forcher, Forcher, Jekauc, Wäsche, et al., 2022).

Evaluation of the Playing Style Coefficient

Since the PSC is a new formula, it was examined a priori for its validity. To evaluate the PSC, the results of the *PSC for every match performance*, the results of the *formula of Kempe et al.* (Kempe et al., 2014), and the results of a *formula based on an expert rating* were compared. The *formula based on an expert rating* was developed by weighting the individual parameters based on the rating of three licensed and experienced coaches of a professional club. All three raters independently rated the parameters according to their importance for the quantification of the offensive playing style with the help of a questionnaire (i.e. each variable could be classified as important, neutral, or unimportant). To compare the results of the three calculations, all eighteen included teams were sorted in a table (i.e. from ball possession to counter-attacking focused) based on their average values (i.e. average score over all 17 matches). Before executing the three alternating calculations, the values were transformed into z-scores. To compare the table results of the three calculations, a Spearman rank correlation was calculated between the tables based on the results of all three formulas (see Paper VI. Supplementary Table 1). As the results between the *PSC*, the previously evaluated *formula by Kempe et al.*, and the *formula based on the expert rating* showed a high degree of agreement (ρ=0.93-0.97; 95% CI=0.77-0.99; $p<0.01$), the *PSC* was assessed as valid.

9.3.3 Statistical Analysis

For each dependent physical (e.g. sprinting distance), technical (e.g. dribblings), and success (e.g. xGoals) variable a single repeated measures linear mixed model was conducted using the statsmodels library in Python 3.9. The value of the PSC served as the fixed effect for each model. Hence, the PSC is the independent variable used to predict the respective dependent variable (i.e. physical, technical, or success variable). Each physical variable was examined in absolute form and in relation to the attacking time.

A hierarchical modeling strategy was implemented, following the example of Fernandez-Navarro et al. (Fernandez-Navarro et al., 2018). Therefore, random effects (i.e. team, offensive formation) were added step by step for each model independently. Hence, depending on the model, a different number of random effects were the consequence. The data structure was hierarchical, as, for example, all teams are ranked higher than one single team (Heck et al., 2014).

To evaluate the model performance, the Akaike criterion [AIC] was used (i.e. lower AIC values = better model). Furthermore, restricted maximum likelihood (REML) estimation was implemented for model fitting. The statistical significance level was set a priori at $p < 0.05$.

9.4 Results

Table 9.1. Linear mixed models. Results of the linear mixed models with the physical, technical, and success parameters as dependent variable. The coefficients of the effects (β), the standard error (SE), the 95% confidence interval and the z- and according p-values are presented. The fixed effect playing style coefficient [PSC] and the random effects team and offensive formation are distinguished. If a random effect was excluded the row was labelled with 'not included'.

linear mixed models (LMM)	β	SE	95 % CI		z	p
accelerations						
fixed effect						
Intercept	257.73	7.03	243.96	271.50	36.69	<0.01
Playing style coefficient [PSC]	38.75	1.75	35.33	42.18	22.17	<0.01
Random effects						
teams	1032.09	9.42				
offensive formation	6.47	0.17				
R^2	0.69					
accelerations in relation to time						
fixed effect						
Intercept	17.21	0.58	16.07	18.35	29.54	<0.01
Playing style coefficient [PSC]	0.33	1.16	0.10	0.56	2.86	<0.01
Random effects						
teams	6.52	0.79				
offensive formation	0.04	0.01				
R^2	0.23					
decelerations						
fixed effect						
Intercept	284.26	7.77	269.03	299.50	36.58	<0.01
Playing style coefficient [PSC]	45.45	1.95	41.63	49.27	23.33	<0.01
Random effects						
teams	1434.12	11.10				
offensive formation	13.216	0.23				
R^2	0.69					
decelerations in relation to time						
fixed effect						
Intercept	18.86	0.57	17.74	19.99	32.89	<0.01
Playing style coefficient [PSC]	0.51	0.13	0.26	0.76	4.00	<0.01
Random effects						
teams	-0.36	0.73				
offensive formation	0.11	0.03				
R^2	0.22					
sprinting distance						
fixed effect						
Intercept	313.50	12.44	289.12	337.89	25.20	<0.01
Playing style coefficient [PSC]	7.87	3.72	0.58	15.17	2.11	0.03
Random effects						
teams	1615.47	7.67				
offensive formation	not included					
R^2	0.08					
sprinting distance in relation to time						
fixed effect						
Intercept	22.60	1.06	20.53	24.67	21.36	<0.01
Playing style coefficient [PSC]	-1.72	0.28	-2.27	-1.18	-6.17	<0.01
Random effects						

teams	13.77	0.75				
offensive formation	not included					
R^2	0.14					
high-intensity distance						
fixed effect						
Intercept	835.57	19.40	797.54	873.60	43.07	<0.01
Playing style coefficient [PSC]	60.92	5.75	49.65	72.18	10.60	<0.01
Random effects						
teams	3619.64	10.78				
offensive formation	not included					
R^2	0.36					
high-intensity distance in relation to time						
fixed effect						
Intercept	58.89	2.00	54.96	62.81	29.39	<0.01
Playing style coefficient [PSC]	-2.19	0.45	-3.08	-1.30	-4.82	<0.01
Random effects						
teams	54.51	1.54				
offensive formation	not included					
R^2	0.13					

percentage short passes						
fixed effect						
Intercept	0.37	32.72	0.35	0.40	32.72	<0.01
Playing style coefficient [PSC]	0.00	0.00	0.46	0.00	0.74	0.46
Random effects						
teams	0.00	0.01				
offensive formation	not included					
R^2	0.17					
success rate passes short						
fixed effect						
Intercept	0.89	0.00	0.88	0.89	223.42	<0.01
Playing style coefficient [PSC]	0.01	0.00	0.01	0.01	12.03	<0.01
Random effects						
teams	0.00	0.00				
offensive formation	not included					
R^2	0.46					
percentage medium passes						
fixed effect						
Intercept	0.53	0.01	0.52	0.55	60.00	<0.01
Playing style coefficient [PSC]	0.01	0.00	0.00	0.01	3.70	<0.01
Random effects						
teams	0.00	0.01				
offensive formation	0.01	0.01				
R^2	0.20					
success rate passes medium						
fixed effect						
Intercept	0.83	0.00	0.82	0.84	225.88	<0.01
Playing style coefficient [PSC]	0.02	0.00	0.01	0.02	15.71	<0.01
Random effects						
teams	0.00	0.00				
offensive formation	0.00	0.00				
R^2	0.62					
percentage long passes						
fixed effect						
Intercept	0.10	0.00	0.10	0.11	24.78	<0.01
Playing style coefficient [PSC]	-0.01	0.00	-0.01	-0.01	-12.74	<0.01
Random effects						
teams	0.00	0.00				
offensive formation	0.00	0.00				
R^2	0.58					
success rate passes long						

fixed effect						
Intercept	0.45	0.01	0.43	0.48	37.32	<0.01
Playing style coefficient [PSC]	0.01	0.00	0.01	0.02	5.67	<0.01
Random effects						
teams	0.00	0.01				
offensive formation	not included					
R^2	0.29					
percentage horizontal passes						
fixed effect						
Intercept	0.46	0.00	0.45	0.47	123.60	<0.01
Playing style coefficient [PSC]	0.02	0.00	0.02	0.02	20.77	<0.01
Random effects						
teams	0.00	0.00				
offensive formation	0.00	0.01				
R^2	0.73					
success rate passes horizontally						
fixed effect						
Intercept	0.94	0.00	0.93	0.95	258.19	<0.01
Playing style coefficient [PSC]	0.01	0.00	0.00	0.01	5.30	<0.01
Random effects						
teams	0.00	0.00				
offensive formation	0.00	0.01				
R^2	0.17					
percentage backward passes						
fixed effect						
Intercept	0.13	0.00	0.13	0.14	61.57	<0.01
Playing style coefficient [PSC]	0.00	0.00	0.00	0.00	2.65	<0.01
Random effects						
teams	0.00	0.00				
offensive formation	not included					
R^2	0.15					
success rate passes backward						
fixed effect						
Intercept	0.88	0.00	0.88	0.89	328.75	<0.01
Playing style coefficient [PSC]	0.01	0.00	0.01	0.01	15.79	<0.01
Random effects						
teams	0.00	0.00				
offensive formation	not included					
R^2	0.51					
passing velocity						
fixed effect						
Intercept	50.29	0.35	49.61	50.98	144.03	<0.01
Playing style coefficient [PSC]	0.21	0.04	0.13	0.30	4.81	<0.01
Random effects						
teams	2.02	0.46				
offensive formation	not included					
R^2	0.37					
dribblings						
fixed effect						
Intercept	9.55	0.57	8.43	10.67	16.75	<0.01
Playing style coefficient [PSC]	0.19	0.13	-0.05	0.44	1.55	0.12
Random effects						
teams	4.42	0.43				
offensive formation	not included					
R^2	0.13					
success rate dribblings						
fixed effect						
Intercept	0.66	0.02	0.61	0.70	29.25	<0.01
Playing style coefficient [PSC]	0.00	0.01	-0.01	0.01	-0.06	0.95
Random effects						
teams	0.00					

offensive formation	0.04					
R^2	0.07					

x Goals						
fixed effect						
Intercept	1.28	0.07	1.15	1.41	19.57	<0.01
Playing style coefficient [PSC]	0.06	0.02	0.02	0.09	3.19	<0.01
Random effects						
teams	0.05	0.04				
offensive formation	not included					
R^2	0.13					
goals						
fixed effect						
Intercept	1.35	0.15	1.06	1.64	9.14	<0.01
Playing style coefficient [PSC]	-0.05	0.03	-0.10	0.01	-1.49	0.14
Random effects						
teams	0.32	0.13				
offensive formation						
R^2	0.13					
points						
fixed effect						
Intercept	1.37	0.14	1.10	1.64	9.86	<0.01
Playing style coefficient [PSC]	-0.03	0.04	-0.10	0.04	-0.92	0.36
Random effects						
teams	0.11	0.10				
offensive formation	1.54	0.68				
R^2	0.10					

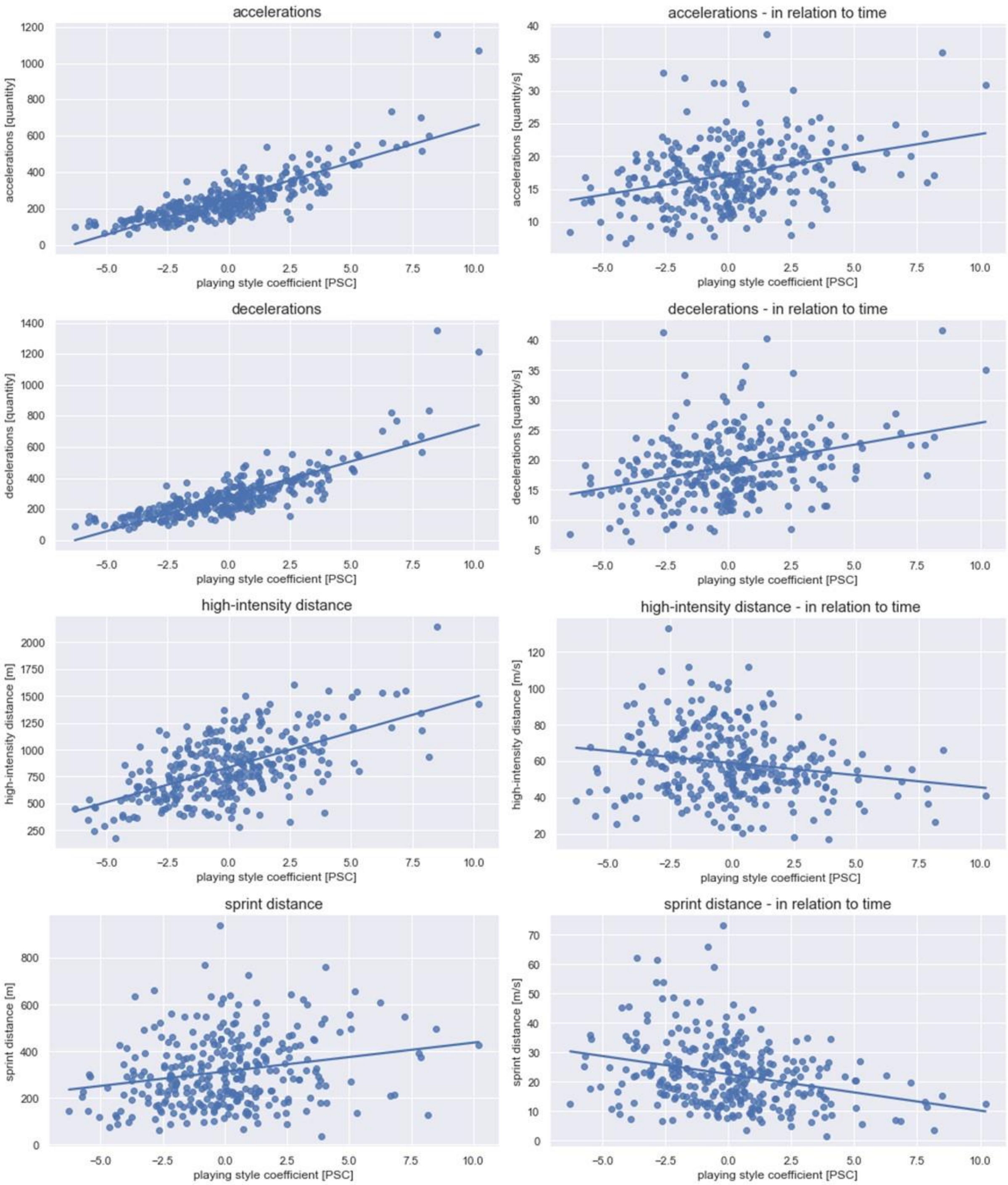

Figure 9.1. Physical Match Performance. Data for the physical parameters are presented. One data point depicts one team in one match. The line represents the linear regression between the playing style coefficient [PSC] and the dependent physical variable. While high PSC values indicate a ball possession focus, low PSC values indicate a counter-attack focus.

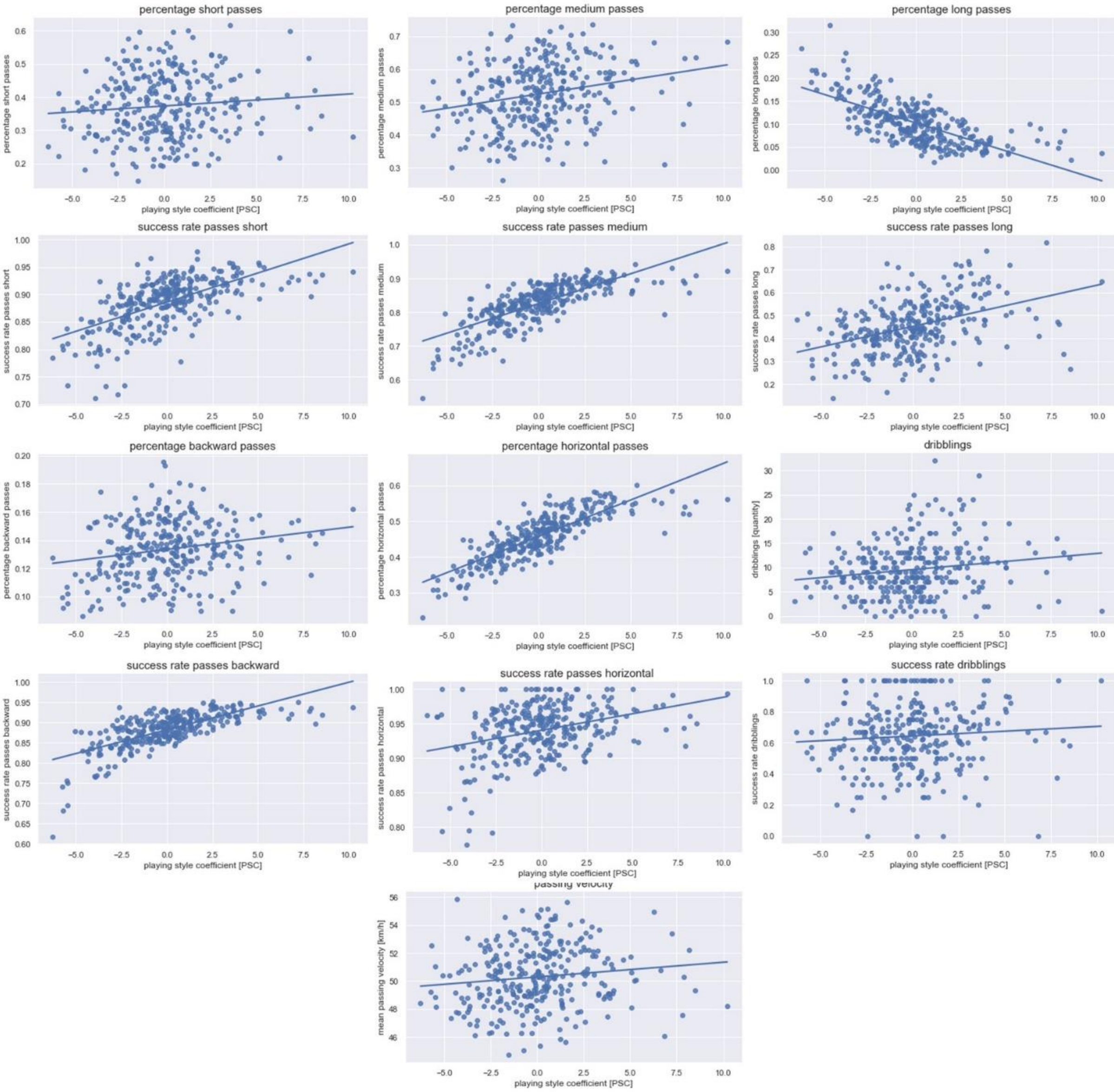

Figure 9.2. Technical Match Performance. Data for the technical parameters are presented. One data point depicts one team in one match. The line represents the linear regression between the playing style coefficient [PSC] and the dependent technical variable. While high PSC values indicate a ball possession focus, low PSC values indicate a counter-attack focus.

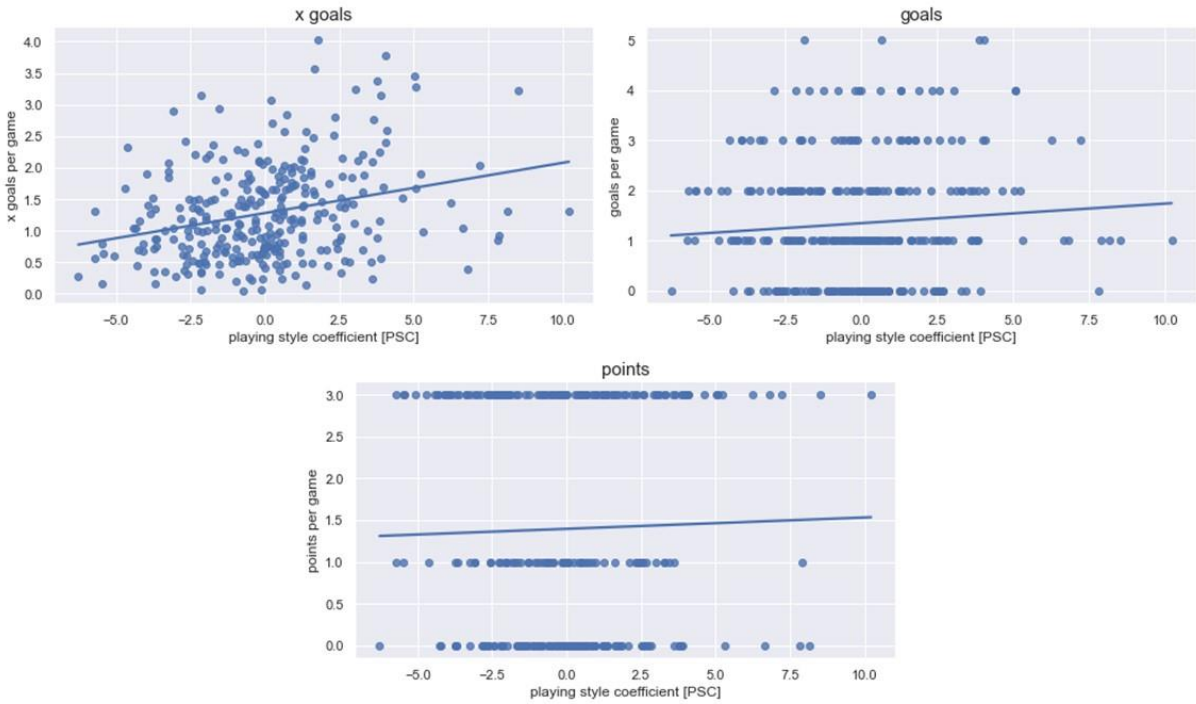

Figure 9.3. Success. Data for the success factors are presented. One data point depicts one team in one match. The line represents the linear regression between the playing style coefficient [PSC] and the dependent success variable. While high PSC values indicate a ball possession focus, low PSC values indicate a counter-attack focus.

A total of 9,546 attacks were evaluated (Ø = 31.2 attacks per team per match, standard deviation [SD] = 8.4), of which one attack lasted on average 14.65 seconds (SD = 4.62). The average PSC value was 0.00 with values ranging from a minimum of -6.27 to a maximum of 10.21 for one team in a single match. Figures 9.1-9.3 illustrate the results concerning the influence of the PSC on the respective dependent variable graphically. Table 9.1 provides detailed information on each linear mixed model including the weights of effects. The random effect *team membership* improved each model. The random effect *offensive formation* improved the model only for selected parameters and was therefore excluded for all other parameters. Additional information on the means and SD for the variables used in the PSC formula and the dependent variables can be found in Paper VI. Supplementary Tables 2-4.

For all physical variables, the influence of the PSC was significant ($p<0.03$). High R^2 values were found for accelerations ($R^2 = 0.69$; $\beta = 38.75$; $p<0.01$) and decelerations ($R^2 = 0.69$; $\beta = 45.45$; $p<0.01$). Lower R^2 was found for sprinting distance ($R^2 = 0.08$; $\beta = 7.87$; $p = 0.03$), high-intensity distance ($R^2 = 0.36$; $\beta = 60.92$; $p<0.01$), accelerations in relation to time ($R^2 = 0.23$; $\beta = 0.33$; $p<0.01$), decelerations in relation to time ($R^2 = 0.22$; $\beta = 0.51$; $p<0.01$), sprinting distance in relation to time ($R^2 = 0.14$; $\beta = -1.72$; $p<0.01$), and high-intensity distance in relation to time ($R^2 = 0.13$; $\beta = -2.19$; $p<0.01$).

The influence of the PSC was significant for all technical variables ($p<0.01$), except for the percentage short passes, dribblings, and success rate of dribblings ($p=0.12$-0.95). High values for R^2 can be found for the parameters percentage long passes ($R^2 = 0.58$; $\beta = -0.01$; $p<0.01$), percentage horizontal passes ($R^2 = 0.73$; $\beta = 0.02$; $p<0.01$) as well as the success rate of short ($R^2 = 0.46$; $\beta = 0.01$; $p<0.01$), medium ($R^2 = 0.62$; $\beta = 0.02$; $p<0.01$), and backward ($R^2 = 0.51$; $\beta = 0.01$; $p<0.01$) passes. Lower R^2 values were revealed for the parameters percentage short passes ($R^2 = 0.17$; $\beta = 0.00$; $p = 0.46$), percentage medium passes ($R^2 = 0.20$; $\beta = 0.01$; $p<0.01$), percentage backward passes ($R^2 = 0.15$; $\beta = 0.00$; $p<0.01$), passing velocity ($R^2 = 0.37$; $\beta = 0.21$; $p<0.01$), and dribblings ($R^2 = 0.13$; $\beta = 0.19$; $p = 0.12$), as well as the success rate of dribblings ($R^2 = 0.07$; $\beta = 0.00$; $p = 0.95$), long ($R^2 = 0.29$; $\beta = 0.01$; $p<0.01$), and horizontal ($R^2 = 0.17$; $\beta = 0.01$; $p<0.01$) passes.

Concerning the success parameters, the influence of the PSC was solely significant for xGoals ($R^2 = 0.13$; $\beta = 0.06$; $p<0.01$). It was not significant for goals ($R^2 = 0.13$; $\beta = -0.05$; $p = 0.14$) and points ($R^2 = 0.10$; $\beta = -0.03$; $p = 0.36$).

9.5 Discussion

The present study revealed an effect of the offensive playing style (i.e. while in ball possession) on physical and technical match performance during offensive play in professional soccer. However, the influence of the offensive playing style on success-related variables was marginal. In detail, teams with a ball possession style were more physically demanded over a whole match (e.g. more accelerations/decelerations, high-intensity, sprinting distance). In contrast, teams with a counter-attacking style covered more high-intensity and sprinting distance normalized at the attacking time. Furthermore, on the one hand, teams with a ball possession style played more horizontal passes and had better passing success rates. On the other hand, counter-attacking style teams played more long passes.

To gain a better understanding of the influence of the offensive playing style on match performance, the results and discussion of the physical match performance, technical match performance, and success-related variables will be considered separately.

9.5.1 Physical Match Performance

All physical match performance parameters examined in this study were significantly influenced by the offensive style of play. In detail, with increasing PSC values (i.e. emphasis on ball possession) the number of accelerations and decelerations, as well as the distance in high-intensity and sprinting speeds per match increased. Moreover, Yi et al. found similar results, indicating higher high-intensity and sprinting distances for ball-possession style teams (Yi et al., 2019). However, it should be noted that Yi et al. investigated the physical match performance of a whole match (i.e. also during opposing ball possession). Accordingly, the offensive playing style of ball possession is associated with an additional physical effort for the players. It is important to highlight, that since physical match performance increases with effective playing time (Altmann et al., 2023), it can be assumed that the increased attacking time regarding the ball possession style (see Paper VI. Supplementary Table 3, e.g. team 17) is the reason for the higher physical match performance of ball possession-oriented teams.

Furthermore, high-intensity and sprint distances decreased with increasing PSC value (i.e. emphasis on ball possession style), when analyzing the distances normalized at the attacking time. One could conclude that after gaining the ball, teams with an emphasis on counter-attacking style have to cover a large distance at high speeds in transition to get in front of the opponent's goal. This has to happen as quickly as possible to use the short time when the opposing defense is disorganized. In contrast, teams with a focus on ball possession have more time since they face an orderly opponent and try to disorganize him with several successive passes. Therefore, the distance to the opponent's goal can be covered with lower speeds. However, the number of accelerations and decelerations normalized by attacking time remains the same comparing both ends of the playing style continuum. This relationship reveals that irrespective of the offensive playing style, short high-intensity actions (e.g. accelerations & decelerations) are necessary to get in goal-threatening situations.

9.5.2 Technical Match Performance

In terms of the technical match performance, the offensive playing style influenced the technical parameters to varying degrees. On the one hand, the percentage of short passes, the percentage of medium passes, the average passing velocity, the number of dribblings, and the success rate of dribblings are influenced by the offensive playing style to only a small extent. Accordingly, it can be stated that teams of both extreme ends on the playing style continuum play a similarly high percentage of short and medium passes. One possible explanation for this finding is that short and medium passes are used very frequently regardless of the style of play (see Paper VI. Supplementary Table 4). Both styles of play also go along with a similar amount of dribblings. There seems to be no difference in the amount of dribbling, as both playing styles use dribblings only to a small extent (see Paper VI. Supplementary Table 4).

On the other hand, the percentage of long passes is strongly influenced by the offensive playing style. With a growing focus on counter-attacking (=PSC values decreased), the proportion of long passes increased. As explained above, counter-attacking teams try to quickly bridge the space to the opponent's goal in transition play. To optimally achieve this objective, counter-attacking teams play more long passes. In contrast, ball possession teams try to control the ball throughout longer periods (see Paper VI. Supplementary Table 3, e.g. team 1). Since long passes increase the risk of losing the ball (see passing success rates), ball possession-style teams play fewer long passes to reduce the risk of losing ball control.

The abovementioned conclusion is also supported by the results for the passing success rates. For almost all passes (e.g. medium, backward), teams with a focus on ball possession revealed better success rates than counter-attacking style teams. This finding is supported by the results of Yi et al., who similarly found better passing success for ball-possession style teams (Yi et al., 2019). As already explained, a poorer passing rate leads to more ball losses and consequently less control of the match. Consequently, ball possession-oriented teams need to have high-quality passing success rates to control the match by possession and thus allow little possession time for the opponent.

Moreover, with a rising focus on a ball possession style (= higher PSC values), the percentage of horizontal passes increased. As counter-attacking style teams try to exploit the disorganized opponent directly after gaining ball control, they have to cover the long distance to the opponent's goal with not only long but also vertical passes (see Paper VI. Supplementary Table 3, e.g. team 15). Teams with a focus on ball possession pursue the approach of destabilizing a defensively organized opponent through targeted passing (Forcher et al., 2021). Therefore, a larger percentage of the passes needs to be played horizontally, for example, to enable lateral shifts to destabilize the opponent and hence receive scoring opportunities.

9.5.3 Success

In contrast to physical and technical match performance, the influence of offensive playing style on success-related parameters remained small. Concluding, values that are strongly influenced by chance, such as goals and points (Brechot & Flepp, 2020) (i.e. points awarded for the match outcome e.g. three, two, or zero), are not influenced by the style of play. In contrast, findings by Yi et al. suggested that a focus on a ball-possession style is associated with an increased probability of success (Yi et al., 2019). In the context of the present study, the only success-related parameter significantly interacting with the PSC was xGoals. In detail, there was a slight tendency for teams with a greater focus on ball possession to achieve more xGoals than teams with an accent on counter-attacking. A possible explanation for this result could be related to the two different playing styles and their objectives. A common observation in professional soccer suggests a higher focus on defensive play for teams playing against a stronger opponent. Therefore, these weaker teams (i.e. in relation to the opponent) strongly focus on the objective of not conceding a goal. Consequently, their offensive play is limited to a few counter-attacking opportunities, which decreases the chance of realizing a large number of scoring opportunities (i.e. potentially low xGoals value). The opposite scenario can be observed with teams playing against a weaker opponent (i.e. focus on offensive play potentially leads to more scoring opportunities). Thus, these stronger teams (i.e. in relation to the opponent) could be associated with ball-possession and weaker teams with a counter-attacking style which possibly leads to the observed difference in xGoals (Kempe et al., 2014).

9.5.4 Limitations and Future Research

To obtain a complete picture of the present study, the limitations should be considered in the following. Since the used data is from the Bundesliga and the dependence of match performance on country and league is confirmed, the transfer of results and conclusions is limited (Dellal et al., 2011; Rampinini et al., 2007). In addition, only a continuum of two offensive playing styles was considered in the survey of different styles of play (Fernandez-Navarro et al., 2016). This may represent a simplification of reality. Furthermore, to strengthen the significance of the findings in this study an already validated formula was used to determine the style of play. However, in this calculation, various technical and physical parameters were included and, therefore, it cannot be precluded that those variables are independent of the dependent physical, technical, and success variables used in this study. Moreover, the opponent was not considered in the present study. Since performance in soccer arises from the interaction between the two teams, the opponent should be considered in future studies. This leads directly to the topics for future research.

Fruitful avenues for future studies could be to examine the parameters collected on an individual level and, for example, consider other contextual factors influencing soccer match performance (e.g. playing position, quality of the teams) (Forcher, Forcher, Jekauc, Woll, et al., 2022). Furthermore, an investigation of the influence of defensive playing style on match performance during defensive play could complete the picture of the current study (Forcher, Altmann, et al., 2022).

9.6 Conclusion

This is one of the first studies examining the influence of offensive playing style on soccer match performance and, therefore, enhances our understanding regarding performance characteristics of different offensive playing styles. The offensive playing style influences the technical and physical match performance considerably, with success-related variables only being affected to a small extent.

While counter-attacking style teams covered more high-intensity and sprint distances normalized at the attacking time, teams with a focus on ball possession were physically more demanded in consideration of a whole match (e.g. accelerations, decelerations, high-intensity, sprint distances). Furthermore, ball possession-oriented teams played more horizontal passes and revealed better passing success rates. In contrast, counter-attacking teams played more long passes.

The findings are particularly relevant for coaches and practitioners working in professional soccer clubs, who can use the findings to better interpret physical and technical match performance data. Furthermore, training before and recovery processes after matches can be optimized accordingly. However, since the effect of the offensive playing style on success-related factors is minor, coaches can still freely decide which offensive playing style does fit their philosophy and players without affecting the chance of success per se.

10 General Discussion

Soccer is one of the most popular sports in the world, which is reflected not only in media attention but also in scientific interest. In the course of the growing scientific interest in soccer in recent years, the quality and quantity of available data in the professional soccer context are increasing. As a result, the performance of soccer players is becoming increasingly quantifiable. Nevertheless, there is a need for research on the influence of external factors, such as tactical factors, on match performance (see *2.5 Environment [External Factors]*). Therefore, the aim of this thesis is the tactical contextualization of the match performance in professional soccer, using the German Bundesliga as an example.

This objective is addressed with the help of one systematic review (*Paper I*) and five original research articles (*Paper II-VI*). Based on the results of the systematic review, three research gaps are identified, which are examined by the original research papers. In this chapter, the results of the review and the three identified research gaps are summarized and critically discussed based on the current state of the literature. Subsequently, the main findings of the research will be linked to the *model of the individual complex match performance in professional male soccer* presented in *2 Theoretical Background*. Furthermore, the limitations and future research objectives will be outlined. Finally, the practical applications of the findings of this thesis are addressed.

10.1 Main Findings

10.1.1 Review [Paper I]

The number of studies investigating the effect of tactical factors, such as playing position and tactical formation, on match performance in soccer has increased over the past years. Following the results of the previous research, it is widely known, that match performance differs according to different playing positions (Dolci et al., 2020). Even though the number of studies investigating the effect of tactical formation on match performance in soccer increased, the current state of research lacks an overview summarizing available findings regarding this topic. Therefore, the aim of *Paper I* was to synthesize the available literature on the effects of tactical formation on the physical and technical match performance in soccer.

The main findings of *Paper I* regarding the influence of tactical formations on match performance can be stated as follows:

- The tactical factor of tactical formation influenced match performance.
- At a team level:
  The physical match performance (e.g. high-intensity distance) was lower in formations with a back four (e.g. 4-4-2) in comparison to formations with a back three (e.g. 3-5-2). The differences in physical and technical match performance were smaller between formations when comparing formations that are similar (i.e. in the number of players in each playing position (e.g. 4-5-1 & 4-2-3-1)).
- At an individual level:
  All playing positions were affected by the tactical formation similarly. However, the distance covered in sprinting speed zones remained rather constant between different formations for wide defenders and central midfielders, while more pronounced differences between formations were revealed for all other playing positions.

While those findings are discussed in detail in *Paper I*, the systematic review also highlighted further issues related to methodological aspects of the existing literature in the research field of tactical formation.

The first issue resulting from *Paper I* concerned the way investigations recorded the tactical formations. A majority of studies included in the review did not provide any information about the recording of the tactical formations (Borghi et al., 2020; Modric et al., 2020; Palucci Vieira et al., 2018; Riboli et al., 2021; Tierney et al., 2016; Vilamitjana et al., 2021). Following, the question arose whether the studies controlled for changes in tactical formations within matches [in-game formation changes]. In detail, most of the studies did not explain the process of how in-game formation changes were handled (Aquino et al., 2019; Borghi et al., 2020; Modric et al., 2020; Palucci Vieira et al., 2018; Riboli et al., 2021; Vilamitjana et al., 2021). Neglecting in-game formation changes may lead to inaccurate results. In detail, for example, by not considering in-game formation changes, an entire match of one team could be recorded with a 4-4-2 formation, even though the team changed to a 3-5-2 formation at half-time (i.e. second half leads to inaccurate results). The other studies included in the review respected this problem but did not provide information on the frequency of in-game formation changes. In detail, one study did not find any in-game formation changes (Baptista et al., 2019). At least, the remaining four studies included in the systematic review excluded matches with in-game formation changes (Aquino, Palucci Vieira, et al., 2017; Arjol-Serrano et al., 2021; Bradley et al., 2011; Tierney et al., 2016). In conclusion, no statements were made about the frequency of in-game formation changes. Therefore, it remained unclear whether future studies have a need to control for in-game formation changes. Furthermore, to date, no study could be identified that investigated the effect of in-game formation changes on match performance. On these grounds the research of *Identified Research Gap I* was reasoned. In detail, this part of the dissertation focused on in-game formation changes and their influence on match performance.

The second concern, following the results of the systematic review, was related to the characteristics of the samples and the methodological approaches of the studies included in *Paper I*. In detail, all of the studies included in the systematic review analyzed small samples, which ranged from 16 to 61 matches. The majority (i.e. seven of eleven studies) of studies solely investigated fewer than 37 matches (Arjol-Serrano et al., 2021; Baptista et al., 2019; Borghi et al., 2020; Bradley et al., 2011; Modric et al., 2020; Riboli et al., 2021; Vilamitjana et al., 2021). Furthermore, a majority of investigations only analyzed a maximum of three different tactical formations (Aquino, Palucci Vieira, et al., 2017; Arjol-Serrano et al., 2021; Baptista et al., 2019; Borghi et al., 2020; Bradley et al., 2011; Modric et al., 2020; Palucci Vieira et al., 2018; Vilamitjana et al., 2021). Since there exist a large number of different tactical formations, this small number of different formations can only guarantee an approximation to the real practical situation to a limited extent (Bauer et al., 2023). Concluding, there was a need for investigations using larger samples and a greater variety of different tactical formations to enable increased accuracy and robustness of findings when analyzing the influence of formations on match performance. Based on the reasoning outlined in this paragraph, the second identified research gap processed the need for a larger sample size and a greater variety of tactical formations. Furthermore, the review raised the question of the magnitude of the influence of tactical factors (e.g. tactical formation) on match performance and the proportion of match performance that depends on the individuality of the player. This issue was also dealt with in the original research included in *Identified Research Gap II*.

The third issue resulting from *Paper I* was related to the conclusion of the systematic review. In detail, the main conclusion of *Paper I* was that tactical factors have a significant influence on match performance. Hence, there existed a possibly useful opportunity for further research on tactical factors and their influence on match performance. Therefore, *Identified Research Gap III* dealt with another tactical factor, namely playing style, whose influence on match performance has not yet been sufficiently investigated. As already defined, the playing style describes the characteristic behavioral features (e.g. high pressing) a team is repeatedly displaying over a long period (Fernandez-Navarro et al., 2016).

As mentioned above, a major conclusion from *Paper I* was that tactical factors markedly influence match performance in soccer. On the one hand, the playing position is already acknowledged to influence performance (Dolci et al., 2020). On the other hand, based on the results of the systematic review, it could also be assumed that tactical formation affects match performance to a pronounced extent. Concluding, tactical factors and their influence on match performance were identified as important subjects future research in soccer should consider continuatively. Therefore, the study of *Identified Research Gap III* was dedicated to extending the tactical contextualization of the match performance to new tactical parameters (e.g. playing style).

10.1.2 Identified Research Gap I – In-game Formation Changes [Paper II & III]

The findings of *Paper I* highlighted the importance to investigate in-game formation changes in professional soccer. Therefore, *Paper II* and *Paper III* investigated in-game formation changes in the German Bundesliga, and their main findings can be summarized as follows:

- In-game formation changes were found in 30-43 % of investigated cases.
- Scenarios that led to in-game formation changes were dependent on the respective coach (e.g. current score). However, most in-game formation changes were recorded in the second half (85-95 %).
- In-game formation changes improved offensive (e.g. more goals) and defensive (e.g. less opposing chances) performance.

To discuss the findings of *Paper II* and *Paper III* in more detail, first, the frequency of in-game formation changes will be discussed, followed by the contextual factors associated with a change of formation within a match. Finally, the effect of in-game formation changes on match performance will be considered.

First, the frequency of in-game formation will be outlined in the following. Frequencies of in-game formation changes ranged between 43 % [*Paper II*] and 30 % [*Paper III*] of investigated cases. However, *Paper III* solely investigated one single team while *Paper II* analyzed a variety of different teams. Because *Paper II* revealed that the frequency of in-game formation changes is team dependant, the transfer from one team to another is only possible to a limited extent. Therefore, the results of *Paper III* regarding the frequency of in-game formation changes are limited in their transferability to other teams. Further information from *Paper II* will delineate this topic. While 44 % of the teams in *Paper II* changed formation within a match in at least one-third of the matches studied, 56 % of the teams revealed an in-game formation change in less than one-third of the matches studied. One can conclude that there exist teams changing their formation within a game frequently and teams do so rarely. Therefore, it can be deduced that there are differences in how flexible teams are during the match from a tactical perspective. Hence, the transferability from one team to another is restricted.

Second, contextual factors going along with in-game formation changes will be discussed in further detail. Besides the dependence on the team, further results indicate that the frequency of in-game formation changes is also influenced by the respective coach. In detail, the results of *Paper III* indicated that the frequency of in-game formation changes within one single team varies between different seasons (season 1 = 27 %, season 2 = 37 %, season 3 = 82 %). Since a different coach was responsible in each of the three seasons investigated, the results suggested that the frequency of in-game formation changes is dependent on the respective coach. To date, *Paper II* and *Paper III* are unique studies in professional soccer, since there are no comparative studies in this sport. However, in handball, a study also suggested that the frequency of in-game formation changes is dependent on the coach, which supports the abovementioned reasoning (Debanne & Laffaye, 2015). To conclude, in-game formation changes are a common phenomenon in the German Bundesliga, although the frequency of in-game formation changes differs between coaches.

Moreover, results regarding the timing of in-game formation changes were insightful. The majority of formation changes took place in the second half (85-95 %). Exemplary reasoning from a practical point of view could give a possible explanation for this phenomenon. At the start of a match, each team initially follows a prepared match plan. Only after some time, it becomes visible which of the two opposing match plans will prevail. The team whose approach works well will usually not change its tactics. The coaching staff of the team falling behind with their initial plan in the course of the match will then try to adjust its own tactics to potentially improve performance in the next phase of the match. This tactical adjustment can happen, for example, using an in-game formation change. Moreover, towards the end of the game, coaches may want to change the tactical orientation of their team, for example, to still get a point when trailing or to save a lead over time. This change in the tactical orientation could also be implemented through an in-game formation change. These examples indicate that most in-game formation changes are likely to occur after some time has already passed in the respective match. Furthermore, results also suggested that the most common time for formation changes was the half-time break. In this special match interruption, the formation change can be communicated to the players. In detail, due to the calmer atmosphere and the resting situation in the dressing room, all players can be equally informed about the tactical adjustments. In addition, at this point in the match, there is still enough playing time left so that the tactical formation change could still have a positive influence on the performance of the players, which could bring success.

Furthermore, the scoreline at the time of the change was identified as an important contextual factor related to the characteristics of in-game formation changes. The results revealed that the majority of in-game formation changes occurred when the respective team was trailing (*Paper II* = 69 %, *Paper III* = 44 %). A study by Tamura et al. displayed a similar phenomenon when investigating the influence of match outcomes on formation changes (Tamura & Masuda, 2015). This phenomenon is called the Win-Stay-Lose-Shift strategy [WSLS]. Accordingly, a defeat increased the probability of a formation change in the next match. The results of *Paper II* and *Paper III* suggested that the WSLS strategy also exists within a match. In conclusion, the results of *Papers II* and *III* revealed that in-game formation changes occur mainly in the second half and when trailing.

Third, the influence of in-game formation changes on match performance shall be considered. First of all, *Paper III* revealed that match performance before in-game formation changes was below average (e.g. fewer goals or chances created than average). Results from *Paper II* and *Paper III* suggested that especially goals conceded led to in-game formation changes (see further details in *Paper II* and *Paper III*). Furthermore, the team studied in *Paper III* revealed an improved match performance after in-game formation changes. In particular, the chances created by the investigated team increased after an in-game formation change. This finding can be related to the fact that the change of formation during the match leads to a new tactical

orientation of the own team. Since this adjustment matches the opponent's approach in the optimal case (see explanation on the development of different phases in the match), one's offensive and defensive match performance can benefit from a tactical modification within a match. Concluding, in-game formation changes can improve a below-average performance into a better performance after the change.
As in-game formation changes are a novel field of research, no literature has produced comparable and thus discussable results to put the findings of *Papers II* and *III* in a broader context. Therefore, the results of this section should be considered with caution, especially when transferring them to other teams and leagues.

10.1.3 Identified Research Gap II – Influence of Formation/Individual [Paper IV & V]

Besides the importance of in-game formation changes which have been processed in *Identified Research Gap I*, the findings of *Paper I* revealed further limitations regarding the methodology of the analyzed investigations. The systematic review included studies that generally used small sample sizes and mostly compared solely two or three different tactical formations. Therefore, *Paper IV* focused on closing this research gap, while *Paper V* analyzed a question that arose in the future research directions of *Paper IV*. Namely, *Paper V* analyzed to which extent the match performance is dependent on tactical factors or the individuality of a player. The main findings of *Paper IV* and *Paper V* are summarized below:

- Pronounced differences between tactical formations regarding the match performance were found for central defenders, wide defenders, and wide midfielders.
- Central midfielders and forwards revealed smaller differences between tactical formations.
- Large interindividual differences were found regarding the influence of tactical factors on the match performance of the individual players.

First, the findings of *Paper IV* on the effects of the combination of playing position and tactical formation on match performance will be discussed in detail. Since the results differed between the playing positions, each playing position will be treated separately in the following. Furthermore, physical and technical match performance will be discussed apart from each other. This structuring helps to explain the results and the conclusions in more detail and depth.

For central defenders, the most interesting finding was that players acting in this playing position revealed a higher physical match performance in formations with three central defenders (e.g. 3-4-3 or 3-5-2, see Paper IV. Supplementary File 1). Similar to previous studies, *Paper IV* found higher total and sprinting distances for central defenders playing in a 3-5-2 formation (Baptista et al., 2019; Borghi et al., 2020; Modric et al., 2020; Tierney et al., 2016). In a 3-4-3 and 3-5-2 formation, three central defenders have to cover the central pitch zones of the field, while in other formations (e.g. 4-2-3-1) there are four players to cover those areas. This could be a possible explanation for differing physical match performance for central defenders in 3-4-3 and 3-5-2 formations. Concluding, the physical performance of central defenders was markedly affected by tactical formation, with special regard to higher physical demands in formations with three central defenders (e.g. 3-4-3 or 3-5-2).

Similarly, *Paper IV* revealed a higher physical match performance in a 3-4-3 or a 3-5-2 formation for wide defenders. For wide defenders, the greatest distance in total, high-intensity, and sprinting speed zones was found in 3-4-3 and 3-5-2 formations. These findings are supported by previous research (Baptista et al., 2019; Modric et al., 2020; Tierney et al., 2016). One possible explanation for this finding could be, that in formations with three central defenders, wide defenders receive more defensive support than in other formations (i.e. support by three instead of two central defenders [e.g. 3-5-2 vs. 4-4-2]). Therefore, wide defenders in 3-5-2 or 3-4-3 formations can be more offensive than in other formations, which resulted in higher physical efforts to accomplish these additional offensive duties.

For wide midfielders, the results regarding physical match performance were less consistent compared to central and wide defenders. Furthermore, there were contradictions in comparing the results of *Paper IV* to the current state of research. For example, *Paper IV* found the lowest total, high-intensity, and sprinting distance and smallest number of accelerations for wide midfielders in a 3-4-3 formation. The study by Tierney et al. found the highest high-intensity distance for wide midfielders in a 3-4-3 formation, but solely examined youth teams (2016). Furthermore, *Paper IV* revealed an average high-intensity distance for wide midfielders in a 4-4-2 formation. Other studies found either an increased high-intensity distance (Borghi et al., 2020; Tierney et al., 2016) or a decreased high-intensity distance (Arjol-Serrano et al., 2021) for wide midfielders playing in a 4-4-2 formation compared to other formations. These examples highlight the disagreement regarding differences in physical match performance of distinct playing positions (i.e. mainly regarding central and wide midfielders) in varying tactical formations in the current literature. The disagreement could be possibly attributed to the variety of methodologic approaches used (e.g. differing quality of players, differing age groups, differing sample sizes, differing amounts of included teams, etc., see *Paper I*). To sum up, the physical match performance of wide midfielders differed between formations while a final conclusion regarding (e.g. which formation leads to a high or low physical load) has yet to be reached.

For central midfielders and forwards, *Paper IV* revealed small differences in physical match performance between formations. However, other studies found larger differences between formations regarding central midfielders and forwards. For example, while *Paper IV* indicated the smallest total distance for forwards in a 3-5-2 formation, other studies revealed the highest total distance for forwards in a 3-5-2 formation (Baptista et al., 2019; Borghi et al., 2020; Modric et al., 2020; Tierney et al., 2016). This again underlines the disagreement of the state of research on differences in match performance across different tactical formations.

In conclusion, the physical match performance of different playing positions varied across formations markedly. In detail, for example, the physical match performance of central defenders and wide defenders was higher in formations with three central defenders (e.g. 3-4-3 or 3-5-2). Furthermore, comparing the state of research with the findings of *Paper IV*, large differences were revealed. As mentioned above these contradictions can be possibly referred to the variety of methodological approaches used by studies dealing with tactical formations in soccer.

Focusing on the technical match performance, more consistent results throughout the five playing positions regarding the differences between tactical formations were displayed in *Paper IV*. For all playing positions, except forwards, *Paper IV* revealed higher values for ball possessions, short passes and medium passes in a 4-3-3 and a 4-2-3-1 formation compared to other tactical formations. Since higher ball possession rates for teams in 4-3-3 and 4-2-3-1 formations were found (see Table 7.1), players playing in these formations had more time to increase the number of individual ball possessions and passes while their team controlled the ball. Furthermore, teams playing in a 4-3-3 and a 4-2-3-1 displayed a higher team ranking, compared to other formations (see Table 7.1). Moreover, previous research revealed that better-ranked teams more often played a ball-possession style (Kempe et al., 2014). Since a ball-possession style is related to higher ball-possession rates and number of passes at a player level, the contextual factors of ball-possession rate and team quality possibly influence the number of ball possessions and passes of players in different playing positions. Contrary to the discussed finding of the higher number of ball possessions and passes in a 4-3-3 and a 4-2-3-1 formation, another study revealed a decreased number of passes for all playing positions in a 4-2-3-1 formation (Arjol-Serrano et al., 2021). However, in contrast to *Paper IV*, the mentioned study only investigated 31 matches of one single team and did not report any information about contextual factors (e.g. ball possession rate or team quality). Therefore, it remains unclear whether the finding of Arjol-Serrano et al. could also be explained by contextual factors related to the investigated matches (e.g. higher ball possession rate in specific formations). As mentioned above, forwards were the only playing position not representing the observed pattern of higher numbers of ball possessions and passes (i.e. short and medium) in a 4-3-3 and a 4-2-3-1 formation in *Paper IV*. An explanatory approach for this finding could be, that forwards do not benefit from higher-ball possession rates of their team, because the smallest part of ball possession is gathered in the attacking half (e.g. due to higher pressure by defending opponent) (Forcher, Forcher, Altmann, et al., 2022). Consequently, since forwards are mainly active in the attacking third, they do not benefit from the higher ball possession rate of their team.

In conclusion, the technical match performance of all playing positions in different tactical formations is highly affected by contextual factors, such as ball possession percentage or team quality. However, the technical match performance of forwards did not benefit from the higher ball possession rates of their team.

The discussion of the main findings of *Paper IV* suggested that the tactical factors of playing position and tactical formation influence physical and technical match performance in professional soccer to a pronounced extent. However, it remained unclear, to which extent the tactical factors influence the match performance of an individual player and if there exist interindividual differences in this regard. To answer this question, the main findings of *Paper V* will be discussed in the following.

To which extent tactical factors (e.g. tactical formation and playing position) influence the technical match performance, as well as interindividual differences in this context, were assessed in *Paper V*. In detail, *Paper V* revealed that 3-44 % of the variance in technical performance when players change their playing positions can be explained by the tactical factors of playing position and tactical formation. However, large differences were found between the different technical variables investigated (e.g. short passes: 3 % of the variance explained; dribblings: 44 % of the variance explained). Altmann et al. used a research methodology similar to *Paper V* (e.g. criteria to select players for the study sample, etc.) and revealed that 44-58 % of the variance in physical match performance could be explained by tactical factors. However, this study only examined the tactical factor of playing position and, therefore, neglected the influence of the tactical formation. Nevertheless, it can be concluded that technical match performance is influenced by tactical factors (i.e. as playing position and tactical formation) to a smaller extent compared to physical match performance.

Moreover, large interindividual differences regarding the way players reacted to the changing tactical context (i.e. changing playing position in a different tactical formation [e.g. central defender in 4-5-1 vs. central midfielder in 4-2-3-1]) were found in *Paper V*. Building on the results of *Paper V* and the conclusions drawn in the study of Altmann et al. players could be classified into three different groups (Altmann et al., 2021). First, a group of players clearly adapted their technical performance to the changing tactical context (i.e. change of formation and position). Second, another group of players maintained their technical match performance despite changing tactical context and, therefore, did not adjust their performance to the normative data of the playing position and tactical formation. Thirdly, the last group of players did not fit into either of the other two classifications due to inconsistent performance patterns. Concluding, the way players react to the changing tactical context (e.g. changing playing position in a specific tactical formation) is highly individual. Therefore, when assessing the match performance in professional soccer, it is essential to consider the tactical context (e.g. tactical formation and playing position) as well as the individual player. This information is especially important for coaches and scouts who are entrusted with interpreting and evaluating match performances in their daily work. Since match performance is subject to constant fluctuation and a variety of external factors (see *3.5 Environment [External Factors]*), it remains highly complex to explain the changes in match performance at the individual level to the fullest extent (Bush, Barnes, et al., 2015). Therefore, the results and conclusions of *Paper V* should be treated with caution.

10.1.4 Identified Research Gap III – Influence of Playing Style [Paper VI]

The discussed findings of *Paper I* up to *Paper V* suggested that tactical factors have a significant influence on match performance in professional soccer. Alongside the playing position and the tactical formation, another tactical factor that has already been researched is the playing style of a team. The playing style describes characteristic behavioral features a team is repeatedly displaying (Fernandez-Navarro et al., 2016). For example, teams coached by Jürgen Klopp are known for aiming to win the ball in the opponent's half (i.e. high pressing) and get in goalscoring opportunities directly after winning the ball through a counterattack (i.e. counter-attacking style) (Immler et al., 2021). In contrast, teams managed by Pep Guardiola, are known for their attempt to outplay the opponent through a long series of passes and thus score goals (i.e. ball-possession style) (Immler et al., 2021). However, the influence of a team's playing style on match performance in soccer has only been investigated once. However, this study featured some limitations (e.g. small sample size) which were addressed by *Paper VI*. Therefore, *Paper VI* aimed to investigate the effect of offensive playing style on match performance. It is important to note that the match performance discussed in the following referred exclusively to phases in own possession. Physical match performance out of possession (i.e. in defensive match phases) was not considered, as it was assumed to be independent of the offensive style of play. All parameters analyzed to assess the technical match performance were on-ball actions and, therefore, only occurred when the respective team was in ball control. The main findings of *Paper VI* can be summarised as follows:

- The offensive playing style influenced the technical and physical match performance at a team level considerably.
- Success-related variables (e.g. goals) were only affected to a small extent by the offensive playing style.

To discuss the main results of *Paper VI*, firstly physical match performance, secondly technical match performance, and thirdly success-related variables will be considered.

First, it can be stated that physical match performance at a team level was strongly influenced by the offensive style of play. In detail, teams emphasizing a counter-attacking style covered more high-intensity and sprinting distances per second in possession. Possible reasoning comes with the strategy behind the offensive playing styles. On the one hand, counter-attacking style teams try to build a quick transition after a ball gain to create scoring opportunities. Therefore, players have to cover a large distance at high speeds to threaten the opposing goal as fast as possible. On the other hand, ball-possession style teams attempt to disrupt the opposing team’s defensive organization with a series of passes. In this scenario, players have more time to cover the length of the field to get into goal-threatening areas and, therefore, are not as physically demanded per second in possession.

Furthermore, teams with a focus on a ball-possession style were physically more demanded when cumulating the possessions of a whole match (e.g. more accelerations, decelerations, high-intensity distance, and sprinting distance). Similarly, Yi et al. revealed that teams with a ball-possession style covered more high-intensity and sprinting distances compared to teams with a counter-attacking style (2019). However, it should be noted, that Yi et al. examined physical match performance throughout the whole match, while *Paper VI* examined physical performance exclusively during ball possession of the respective team. A possible reason for the higher physical match performance of ball-possession-oriented teams could be related to the effective playing time in soccer (Altmann et al., 2023). In detail, previous research indicated that physical match performance increases with effective playing time (Altmann et al., 2023). Additionally, *Paper VI* revealed that teams with a focus on a ball-possession style reveal larger attacking times (see Paper VI. Supplementary Table 3). Therefore, it seems reasonable that ball-possession style teams are physically more demanded when analyzing all possessions of a whole match in a cumulated manner.

Second, similarly to physical match performance, also technical match performance differed between offensive playing styles. While some technical variables were not affected by offensive playing style (e.g. average passing velocity and number of dribblings), other technical variables (e.g. proportion of long passes, proportion of short passes, and passing success rate) differed markedly between teams emphasizing a ball-possession or a counter-attacking style.

One major finding regarding technical match performance was that teams emphasizing a counter-attacking style played a larger proportion of long passes. One could conclude, counter-attacking style teams use long passes to get in front of the opposing goal as fast as possible after gaining the ball. However, since long passes increase the risk of losing the ball (see Figure 9.2), ball-possession style teams try to avoid long passes to decrease the risk of losing ball possession.

Moreover, teams playing a ball-possession style revealed a higher percentage of horizontal passes and a better passing success rate. As explained above, a better passing success rate is fundamental for ball control over a longer period (i.e. especially important for ball-possession style). Therefore, ball-possession style teams are dependent to have a good passing success rate to accomplish their goal of disrupting the opponent with a series of passes. In contrast, counter-attacking style teams can be more adventurous in their passing and, hence, indicated a poorer passing success rate in *Paper VI*. Furthermore, ball-possession style teams need to play more horizontal passes to enable lateral shifts to destabilize the opponents' defensive organization (Forcher et al., 2021). Contrary, counter-attacking style teams need to cover the pitch in a shorter amount of time, why they may resort to horizontal passes to a lesser extent. Third, in contrast to physical and technical match performance, the influence of offensive playing style on success-related variables was smaller. Since the investigated success-related variables (e.g. goals, points per game) are largely affected by chance, these results should be treated with caution (Brechot & Flepp, 2020). In contrast to this finding, the results of Yi et al. suggested that teams with a ball-possession style are more successful (2019). However, it should be noted that this study only investigated a small sample and analyzed national teams. Furthermore, Yi et al. assigned a playing style to each team and, thus, neglected that the offensive playing style of a team can change from match to match. In contrast, as outlined above, *Paper VI* implemented a continuum (i.e. from ball-possession to counter-attacking style) in which each game by each team was located separately. The mentioned methodological aspects should be respected when interpreting the results of Yi et al. in comparison to the findings of *Paper VI*.

To put it in a nutshell, offensive playing style influenced match performance in soccer. However, to date, only one other study investigated the influence of offensive playing styles on match performance. Therefore, discussions according to the current state of research were only possible to a limited extent.

10.1.5 Scientific Progress

As described in chapter *2.1 Theoretical Embedding*, the scientific position of this dissertation is critical rationalism, which assumes there is nothing absolutely certain (Haag & Mess, 2010). To achieve scientific progress, critical rationalism relies on the principle of falsification. In falsificationism, the development of new and ‘better’ (i.e. more specific, more falsifiable) models is a partial contribution to scientific progress (Chalmers, 2006). In this dissertation, the *model of the individual complex match performance in professional male soccer* was developed. Based on this model, highly falsifiable research questions and hypotheses were

derived, which were investigated and subjected to falsification examinations in *Identified Research Gaps I* to *III*. These falsification examinations will be briefly outlined in the following.
In *Identified Research Gap I*, the influence of changing tactical factors (i.e. in this context tactical formation) during matches on match performance was investigated. In the model of the individual complex match performance in professional male soccer, tactical factors are estimated as external factors (i.e. environment). The hypothesis that changes in tactical factors during a match (e.g. changing tactical formation) influence match performance could be derived from the model (see Figure 3.2). Furthermore, this derived hypothesis could not be falsified by the results of the investigations in *Identified Research Gap I*. Therefore, findings from *Identified Research Gap I* could not falsify the *model of the individual complex match performance in professional male soccer*.
Moreover, in *Identified Research Gap II*, it was tested whether tactical factors (i.e. environment - external factors) and individual factors (i.e. organism - internal factors) influence match performance. For example, the aim of *Paper IV* was to investigate whether tactical formation affects the physical and technical match performance of professional soccer players in the German Bundesliga. Deducting from the model, it was hypothesized that internal and external factors influence match performance (see Figure 3.3). Similarly, this hypothesis withstood the test of falsification. Therefore, findings from *Identified Research Gap II* could not falsify the *model of the individual complex match performance in professional male soccer*.
Finally, the original study in *Identified Research Gap III* examined whether the tactical factor of playing style influences match performance. Similarly, the hypothesis generated from the model (i.e. hypothesis = playing style influences match performance, see Figure 3.4) could not be falsified. Therefore, findings from *Identified Research Gap III* could not falsify the *model of the individual complex match performance in professional male soccer*.
Concluding, a logical deduction based on the observations in the individual investigations in *Identified Research Gaps I, II,* and *III* has not revealed that the *model of the individual complex match performance in professional male soccer* is incorrect. Therefore, the model can still be assessed as valid.
Moreover, sports science starts from everyday problems (Schröder & Dose, 2010). In this dissertation, the research questions being examined in *Papers I* to *VI* are to be regarded as everyday problems. Based on the *model of the individual complex match performance in*

professional male soccer, hypotheses for those research questions were derived, which in turn were subjected to falsification tests as outlined above. These attempts at the falsification of the derived hypotheses were implemented through empirical procedures in the methodology of the individual studies. Thereby, scientific progress could occur through the interplay of assumption and refutation. Since all hypotheses derived from the model have withstood the test of falsification, the *model of the individual complex match performance in professional male soccer* can remain valid at present. From the reasoning outlined in the sections above, it could be revealed how this dissertation has contributed to scientific progress.

Proceeding, this chapter summarized and discussed the main findings of the studies included in this dissertation. However, the investigations also feature some limitations that will be addressed in the upcoming section.

10.2 Limitations and Future Research

Given the present dissertation, the most important limitations of the individual papers are discussed by way of examples in the upcoming sections. Furthermore, each of the presented limitations will be examined in light of the entire dissertation.

The main limitation of the systematic review (*Paper I*) is related to the heterogeneity of approaches used by the included studies (e.g. different tactical formations, different match performance variables, etc.). As a result, there exist difficulties in summarizing and discussing the results of the different studies comprehensively. This limitation can also be applied to *Papers II* to *VI*, which similarly are very heterogeneous in their methodology, which is why comparisons and comprehensive discussions are also limited in this context. In detail, the included *Papers II* to *VI* contain approaches measuring match performance utilizing various physical, technical, and success-related variables at individual and team levels (e.g. high-intensity distance (i.e. physical match performance at an individual level) in *Paper IV*, goals (i.e. success-related variable at a team level) in *Paper III*). To sum up, this results in restrictions in drawing robust and comprehensive conclusions.

Furthermore, another limitation resulting from *Identified Research Gap I – In-game Formation Changes* (*Paper II* and *Paper III*) is that there is hardly any previous research allowing for a comprehensive discussion of results. This limitation is also one major weakness of this dissertation, as the included studies are located in research areas having not yet been frequently investigated by previous studies. Therefore, the discussion of results by comparing the findings with the current state of research is limited. This leads to limitations in the robustness and generality of the results of this dissertation. As a result of this issue, some of the conclusions drawn from the findings of the included studies lack robustness and, therefore, still need to be confirmed in the future.

Moreover, *Identified Research Gap II – Influence of Formation/Individual* (*Paper IV* and *Paper V*) reveals another issue concerning the fluctuation of the match performance in soccer. In detail, due to the high variability in match performance, it is only possible to attribute the change in match performance to the change in the independent variables (e.g. tactical formation) to a limited extent (Gregson et al., 2010). Although several studies included in this dissertation (e.g. *Paper IV* and *Paper V*) attempt to control for contextual factors (e.g. match location, current score, etc.; see 3.5 Environment [External Factors]), changes in match performance can always be subject to random variation and, therefore, cannot be explained conclusively. Due to the reasoning outlined, the results of all studies included in this dissertation should be interpreted by acknowledging the high variability in match performance in soccer (Gregson et al., 2010; Liu et al., 2015; Rampinini et al., 2007). To sum up, to reduce the impact of the high variability of the match performance, large samples were used in the original research studies included in this dissertation. However, it cannot be fully ruled out that outcomes of this dissertation are affected by random fluctuations in match performance.

Finally, *Identified Research Gap III – Influence of Playing Style* (*Paper VI*) opens up the limitation that solely matches and players from the German Bundesliga were studied. As performance differs between countries and performance levels, the findings can only be transferred to a different context to a restricted extent (Dellal et al., 2011; Rampinini et al., 2007). All other original studies (*Papers II-V*) included in this dissertation similarly investigate the German Bundesliga as an example of professional soccer. Therefore, as outlined above the transfer of findings to other countries and leagues is limited. This issue should always be considered when interpreting the findings of *Papers I-VI*.

As described above, *Papers II* to *VI* examined several research gaps (= *Identified Research Gaps I* to *III*) detected in *Paper I*. Besides the mentioned limitations, the studies included in this dissertation have also identified potential for future research, which will be addressed in the following.

First of all, since all studies included in this dissertation indicated an influence of tactical factors (e.g. playing position, tactical formation, and playing style) on match performance, future studies should control for the tactical context when analyzing match performance as a dependent variable. Therefore, studies could interpret the match performance outcome according to their initial aim (e.g. independent variable) with respecting the marked influence of the tactical context.

Furthermore, findings of the *Identified Research Gap I – In-game Formation Changes* suggested that upcoming studies investigating tactical formations in professional soccer should address in-game formation changes within their methodology. Therefore, possible changes in tactical formations during matches should be respected.

Moreover, the findings of the *Identified Research Gap III – Influence of Playing Style* could be extended by future research. While *Paper VI* only analyzed match performance at a team level, future studies could analyze match performance at an individual level with a focus on the different playing positions to provide further insights into the influence of the playing style. In addition, the effect of other tactical factors (e.g. defensive playing style) could complete the state of the literature on the effects of tactical factors on match performance in soccer.

Furthermore, *Identified Research Gaps I, II,* and *III* focused on match performance mainly analyzing technical and physical variables. Future studies could investigate similar research questions with a focus on the influence of tactical-cognitive and psychological aspects of the match performance. These aspects are also incremental parts of the match performance which is indicated by *the model of the individual complex match performance in professional male soccer* (see *2.3 Individual Complex Match Performance*).

Finally, as mentioned previously, it should be noted that only a few studies have been published in the research field on the effects of tactical factors on match performance in soccer. Therefore, it is difficult to draw robust conclusions from the findings of the studies included in this dissertation. Therefore, the greatest need for future research in this research field is to support or refute the findings of this dissertation with further studies. Such enrichment of the research base would significantly advance the interpretation of match performance at the individual and team levels. Therefore, future research could significantly improve not only research but also the practical application of findings, which will be addressed in the following chapter.

10.3 Practical Applications

Besides the need for future research, the papers contained in this dissertation have produced findings that can be transferred into practice. Because quantifying match performance in soccer is not only important in research but also in professional soccer clubs, it is crucial to present practical applications of the results. In this context, it is essential to understand the constraints of the match performance to eventually enhance the performance of players. Therefore, the following section will outline how the research included in this dissertation can help practitioners.

First of all, the findings of the studies can help to better interpret and thus evaluate the match performance of players and teams. Especially concerning the influence of the tactical context on the match performance, important clues can be derived. In detail, foremost tactical formations should be considered when interpreting the match performance of players in the future. At the player level, it is important to consider the combination of playing position and tactical formation, which has a significant influence on match performance. In addition, each player must be assessed individually, as it also depends on the individuality of a player whether and to what extent he adapts his match performance concerning the tactical context. Furthermore, the playing style of a team should also be considered when evaluating match performance at a team level. In conclusion, the findings are valuable for scouting, recruiting, and evaluating players. Therefore, findings can help staff in professional soccer clubs in various positions (e.g. scouts, sporting directors, match analysts, etc.) to put the assessed match performances into context (i.e. special focus on tactical factors, e.g. tactical formation, playing positions, and playing style).

Furthermore, in opponent preparation, match analysts are concerned with tactical formations that give a first tactical impression of an opposing team. Findings from the studies in this dissertation suggest that in-game formation changes should also be considered in this regard. In addition, the distinction between offensive and defensive formations is an important aspect of the survey of tactical formations. Concluding, the analytical work with a focus on tactical formations of upcoming opponents can be even more specific (e.g. analyzing in-game formation changes and respecting differences in offensive and defensive formations) by applying the findings of the studies included in this dissertation.

Moreover, also coaches can benefit from the findings of the studies. For example, they can plan training exercises considering the results of the studies, to train their players according to their respective tactical roles (e.g. playing position, tactical formation) and the playing style which a coach favors.

Furthermore, specific content regarding in-game formation changes could give coaches and analysts a decisive advantage during matches. On the one hand, an appropriate in-game formation change could help the own team to transform a below-average performance into a better performance after the change. On the other hand, important information about upcoming opponents can be identified (e.g. how often does the opposing coach change formation during a match? In which situations does he change the tactical formation?). In this way, it is possible to anticipate in-game formation changes and, thus, react to those changes more quickly during the match.

Concluding, the presented insights into practical applications of the findings could help practitioners in different roles (e.g. scouts, sporting directors, match analysts, coaches, etc.) to better interpret and assess the match performance of soccer players. In detail, a better interpretation of match performances could help to better evaluate players' match performances and identify possible transfer candidates (i.e. buying and selling players). Furthermore, findings could help to make a decisive contribution to the success of a soccer team by using in-game formation changes as a tactical weapon during matches, as they have been shown to possibly enhance match performance.

11 Conclusion

The aim of this dissertation was the tactical contextualization of the match performance in professional soccer, using the German Bundesliga as an example.

The findings of the studies included in this dissertation can help to better interpret and evaluate the performance of players and teams by contextualizing the match performance using a variety of tactical factors. All analyzed tactical factors (e.g. playing position, tactical formation, and offensive playing style) influence match performance in professional soccer markedly and, therefore, should be considered when evaluating the match performance of professional players. In addition, the findings provide information that can be used to improve the methodology of research on tactical formations in soccer. Accordingly, offensive and defensive formations should be differentiated and in-game formation changes should be considered, as these occur frequently and can influence match performance. In addition to the results on a scientific level, the practical application of the findings can offer further value. In detail, findings help to better interpret and assess the match performance of soccer players which is crucial for practitioners in different positions (e.g. scouts, sporting directors, match analysts, coaches, etc.). In their daily work, the evaluation of match performances is elementary, for example when trying to improve their own players or to identify transfer candidates.

In addition to the findings of *Papers I* to *VI*, modeling is also an important benefit of this dissertation. In detail, the model presented in *2.2.2 Model of the Individual Complex Match Performance in Professional Male Soccer* enables researchers to derive specific research questions and hypotheses. By working on and attempting to falsify these derived hypotheses, a valuable contribution to scientific progress in the specific field of performance analysis in soccer can be enabled.

To sum up, this dissertation revealed deep insights into tactical factors and their influence on match performance in professional soccer. Nevertheless, this dissertation forms a foundation while the research field of tactical factors in professional soccer is far from being explored sufficiently. On the one hand, further research should use the findings of this dissertation to produce more robust and comparable results (e.g. include in-game formation changes). On the other hand, upcoming studies could apply the research questions investigated in the studies of this dissertation to other leagues and countries, other sub-areas of match performance (e.g. tactical-cognitive aspects of match performance), or investigate further tactical factors on their influence on match performance (e.g. defensive playing style).

Finally, it should be noted that soccer match performance is very dynamic over time (Barnes et al., 2014). Therefore, the findings of this dissertation are always linked to the temporal context of the sample investigated. In addition, match performance in soccer is subject to many different influencing factors (see *3.4 Organism [Internal Factors]* and *3.5 Environment [External Factors]*). The variety of factors influencing match performance in soccer demonstrates that performance in this sport will hardly be explainable to the fullest extent. Therefore, it is important to utilize this dissertation as a starting point to examine the influence of various internal and external factors on match performance down the road. As this dissertation exemplifies, future research could help to explain match performance in soccer to an increasing extent and, therefore, help to unveil further secrets of the beautiful game.

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Appendices

Paper I. Supplementary Table 1. PICOS criteria.

PICOS	Detail
Population	Healthy male football players
Intervention	N/A
Comparison	1. Effects of team formation on match performance parameters
Outcome	Any physical or technical match performance parameter
Study Design	Any, but outcome measures need to be reported using a multi-camera, GPS or LPS based tracking system

Paper I. Supplementary Table 2. Database search strategy and results.

Search Terms	PubMed	Web of Science
1. Soccer *OR* Football	22,909	48,774
2. Formation *OR* System OR Tactical OR Tactics	10,253,485	28,587,062
3. Position OR Performance *OR* Physical OR Technical OR Load OR Running OR Acceleration OR Deceleration OR Total Distance OR High-Intensity OR Sprinting OR Passing OR Shooting OR Crossing OR Dribbling OR Duel	7,465,836	13,728,763
(1) *AND* (2) *AND* (3)	4,301	11,927
Total	16,228	

Paper I. Supplementary Table 3. Descriptive values (mean ± SD) for every included article.

Bradley et al. (2011)

	n	Total distance [m]	Walking (0.7-7.1 km/h) [m]	Jogging (7.1-14.3 km/h) [m]	High-intensity running (≥14.4 km/h) [m]	Very high-intensity running (≥19.8 km/h) [m]	Number high-intensive actions	Final third entries
4-4-2	58	10697 (±945)	3774 (±307)	4290 (±620)	2633 (±671)	956 (±302)	122 (±37)	5.9 (±4.0)
4-3-3	49	10786 (±1041)	3832 (±279)	4304 (±665)	2694 (±706)	924 (±316)	120 (±39)	6.3 (±4.1)
4-5-1	46	10613 (±1104)	3907 (±257)	4121 (±662)	2585 (±734)	901 (±305)	116 (±40)	5.5 (±3.5)
		passes	**Passes received**	**% succesfull passes**	**Touches per possession**	**dribbles**	**Possessions won**	**Possessions lost**
4-4-2	58	32.1 (±11.7)	34.3 (±12.2)	79.5 (±10.5)	2.5 (±0.4)	0.3 (±0.7)	22.8 (±11.9)	21.8 (±6.0)
4-3-3	49	28.8 (±16.7)	30.8 (±18)	73.4 (±13.2)	2.6 (±0.7)	0.5 (±1.2)	21.7 (±10.4)	22.5 (±6.7)
4-5-1	46	21.2 (±11)	24.9 (±11.1)	71.6 (±15.5)	2.4 (±0.5)	0.4 (±0.9)	18.3 (±9.9)	20.8 (±7.4)

		n	Total distance [m]	Very high-intensity running (≥19.8 km/h) [m]	High-intensity running (≥14.4 km/h) [m]	Number high-intensive actions	Recovery Time between high-intensive actions [sec.]
Defender	**4-4-2**	30	10452 (±755)	862 (±309)	2454 (±632)	111 (±37)	56 (±21)
	4-3-3	22	10073 (±852)	751 (±271)	2218 (±625)	98 (±36)	67 (±29)
	4-5-1	19	10123 (±875)	748 (±293)	2207 (±691)	93 (±33)	70 (±28)
Midfielder	**4-4-2**	18	11505 (±783)	1118 (±262)	3146 (±550)	146 (±31)	39 (±8)
	4-3-3	14	11586 (±494)	985 (±299)	3013 (±538)	134 (±28)	44 (±10)
	4-5-1	16	11606 (±722)	1103 (±259)	3207 (±555)	147 (±32)	41 (±11)
Attacker	**4-4-2**	10	9982 (±769)	950 (±236)	2250 (±454)	110 (±24)	53 (±11)
	4-3-3	13	11130 (±999)	1155 (±231)	2988 (±614)	142 (±34)	42 (±13)
	4-5-1	11	10012 (±946)	870 (±227)	2333 (±458)	108 (±25)	55 (±15)

Tierney et al. (2016)

	n	Total distance [m]	High-speed running (≥19.8 km/h) [m]	High metabolic load distance [m]	Accelerations	Decelerations
4-4-2	66	10131 (±583)	497 (±175)	1568 (±257)	33 (±10)	49 (±14)
4-3-3	50	10284 (±879)	514 (±204)	1828 (±518)	32 (±8)	50 (±12)
3-5-2	78	10528 (±565)	642 (±215)	2025 (±304)	34 (±7)	57 (±10)
3-4-3	39	10168 (±449)	551 (±171)	1855 (±301)	28 (±7)	51 (±10)
4-2-3-1	89	10044 (±538)	538 (±174)	1894 (±301)	38 (±8)	61 (±12)

		n	Total distance [m]	High-speed running (≥19.8 km/h) [m]	High metabolic load distance [m]
Center back	**4-4-2**	Not specified	9711 (±1236)	360 (±91)	1407 (±322)
	4-3-3	Not specified	9167 (±471)	348 (±58)	1432 (±144)
	3-5-2	Not specified	10034 (±676)	449 (±138)	1741 (±343)
	3-4-3	Not specified	9575 (±938)	406 (±138)	1511 (±324)
	4-2-3-1	Not specified	9677 (±827)	430 (±169)	1582 (±341)
Full back	**4-4-2**	Not specified	10075 (±1126)	675 (±172)	1788 (±399)
	4-3-3	Not specified	10229 (±972)	683 (±252)	1958 (±426)
	3-5-2	Not specified	10844 (±667)	818 (±269)	2256 (±280)
	3-4-3	Not specified	9936 (±475)	573 (±95)	1815 (±174)
	4-2-3-1	Not specified	10468 (±826)	729 (±162)	2049 (±344)
Central midfielder	**4-4-2**	Not specified	9886 (±1516)	308 (±162)	1377 (±605)
	4-3-3	Not specified	10643 (±1093)	357 (±183)	1686 (±628)
	3-5-2	Not specified	10659 (±974)	502 (±180)	1913 (±352)
	3-4-3	Not specified	10630 (±444)	434 (±106)	1935 (±232)
	4-2-3-1	Not specified	10329 (±2488)	487 (±182)	1990 (±350)
Wide midfielder	**4-4-2**	Not specified	10462 (±554)	599 (±157)	1843 (±262)
	4-3-3	Not specified	10985 (±730)	711 (±433)	1930 (±621)
	3-5-2	Not specified	10772 (±1153)	664 (±281)	1978 (±422)
	3-4-3	Not specified	10414 (±591)	718 (±97)	2153 (±269)
	4-2-3-1	Not specified	10268 (±538)	685 (±196)	2024 (±282)
Forward	**4-4-2**	Not specified	10365 (±1051)	539 (±256)	1816 (±439)
	4-3-3	Not specified	10648 (±452)	802 (±129)	2177 (±107)
	3-5-2	Not specified	10832 (±934)	894 (±188)	2337 (±374)
	3-4-3	Not specified	10660 (±1022)	675 (±222)	2045 (±425)
	4-2-3-1	Not specified	8644 (±984)	353 (±143)	1452 (±380)

Aquino et al. (2017)

	n	Total distance [m]	Maximal running speed [km/h]	Mean speed [km/h]	High-intensity activities
4-4-2	Not specified	8537.4 (±1251.6)	27.3 (±4.5)	4.6 (±0.6)	39.8 (±22.0)
4-3-3	Not specified	9518.0 (±1197.1)	29.2 (±3.7)	4.9 (±0.7)	55.6 (±32.0)

		n	Maximal running speed [km/h]	High-intensity activities
Center back	**4-4-2**	Not specified	26.3	30.5
	4-3-3	Not specified	27.7	47
Full back	**4-4-2**	Not specified	26.9	35.9
	4-3-3	Not specified	28.3	52.4
Central midfielder	**4-4-2**	Not specified	27.5	41.4
	4-3-3	Not specified	28.9	57.9
Wide midfielder	**4-4-2**	Not specified	28.1	46.8
	4-3-3	Not specified	29.5	63.3
Forward	**4-4-2**	Not specified	28.7	52.2
	4-3-3	Not specified	30.1	68.7

Palucci Vieira et al. (2018)

	n	Total distance [m]	Maximal running speed [km/h]	Mean speed [km/h]	High-intensity activities
4-4-2	56	8605 (±1333)	27.15 (±5.3)	5.39 (±0.82)	40.95 (±23.66)
4-3-3	173	9099 (±1228)	28.89 (±3.42)	5.72 (±0.75)	58.09 (±27.93)

Baptista et al. (2019)

	n	Total distance [m]	High-intensity runs (≥19.8 km/h)	High-intensity running distance (≥19.8 km/h) [m]	Sprints (≥25.2 km/h)	Sprinting distance (≥25.2 km/h) [m]
4-5-1	73	11049.5 (±140.2)	43.6 (±1.9)	779.9 (±50.9)	11.4 (±1.1)	156.9 (±19.1)
3-5-2	65	11091.2 (±149.5)	40.0 (±2.0)	762.8 (±52.7)	10.0 (±1.1)	158.6 (±19.8)
		Accelerations	**Acceleration distance [m]**	**Decelerations**	**Deceleration distance [m]**	**Turns**
4-5-1	73	75.8 (±3.2)	420.7 (±23.1)	77.8 (±3.5)	440.3 (±23.3)	36.9 (±1.9)
3-5-2	65	71.1 (±3.4)	401.1 (±23.8)	72.5 (±3.6)	413.7 (±24.2)	33.5 (±2.0)

		n	Total distance [m]	High-intensity runs (≥19.8 km/h)	High-intensity running distance (≥19.8 km/h) [m]	Sprints (≥25.2 km/h)	Sprinting distance (≥25.2 km/h) [m]
Center back	**4-5-1**	17	10865.0 (±227.6)	36.1 (±3.5)	512.0 (±81.5)	6.6 (±1.9)	64.4 (±29.6)
	3-5-2	21	10591.8 (±224.0)	28.2 (±3.5)	431.0 (±81.3)	5.4 (±1.9)	74.2 (±29.5)
Wide positions	**4-5-1**	28	10842.6 (±188.8)	45.9 (±2.7)	838.9 (±62.5)	14.1 (±1.4)	195.3 (±22.7)
	3-5-2	13	11143.0 (±233.0)	46.9 (±3.2)	977.2 (±73.7)	14.0 (±1.6)	236.9 (±26.8)
Cental midfielder	**4-5-1**	20	12009.0 (±218.5)	38.5 (±3.2)	643.2 (±73.1)	7.0 (±1.6)	101.4 (±26.6)
	3-5-2	15	11820.8 (±238.7)	35.7 (±3.4)	610.9 (±78.1)	7.0 (±1.7)	94.8 (±28.4)
Forward	**4-5-1**	9	10724.4 (±328.6)	48.6 (±4.7)	835.2 (±108.5)	11.7 (±1.4)	164.5 (±39.5)
	3-5-2	14	10732.8 (±328.6)	47.1 (±4.7)	930.5 (±108.5)	12.8 (±2.4)	208.5 (±39.5)
			Accelerations	**Acceleration distance [m]**	**Decelerations**	**Deceleration distance [m]**	**Turns**
Center back	**4-5-1**	17	63.2 (±6.1)	325.6 (±37.6)	60.3 (±6.9)	321.2 (±41.7)	32.2 (±3.5)
	3-5-2	21	59.7 (±6.1)	306.9 (±37.6)	53.6 (±6.9)	278.5 (±41.6)	25.8 (±3.4)
Wide positions	**4-5-1**	28	83.2 (±4.7)	462.2 (±28.5)	86.9 (±5.3)	501.2 (±31.5)	42.1 (±2.9)
	3-5-2	13	76.8 (±5.7)	447.1 (±33.2)	86.1 (±6.2)	505.4 (±36.9)	38.8 (±3.7)
Cental midfielder	**4-5-1**	20	62.3 (±5.5)	313.3 (±33.4)	69.4 (±6.2)	358.3 (±37.0)	34.7 (±3.4)
	3-5-2	15	55.9 (±5.9)	289.6 (±35.5)	64.2 (±6.6)	326.0 (±39.4)	40.3 (±3.7)
Forward	**4-5-1**	9	82.9 (±8.2)	483.4 (±49.4)	78.3 (±9.2)	461.4 (±54.8)	36.8 (±5.1)
	3-5-2	14	80.2 (±8.2)	477.7 (±49.4)	73.4 (±9.2)	470.8 (±54.8)	29.7 (±5.1)

Aquino et al. (2019)

	n	Total distance [m]	Sprints	Maximum running speed	Walking distance (0-7 km/h)	Jogging distance (7.1-15 km/h)
4-2-3-1	458	9409.7 (±2380.4)	27.8 (±14.7)	27.3 (±4.5)	3715.1 (±536.7)	3877.2 (±1433.4)
4-3-2-1	79	9101.6 (±2423.8)	27.2 (±15.6)	27.4 (±4.6)	4107.8 (±427.2)	3523.9 (±1436.3)
3-4-3	84	9241.2 (±2089.9)	27.4 (±14.9)	27.8 (±4.2)	3664.3 (±403.7)	3823.0 (±1268.1)
4-3-3	104	9233.1 (±2400.7)	28.4 (±13.8)	27.6 (±5.0)	3685.9 (±488.2)	3831.5 (±1359.5)
4-4-2	137	9103.5 (±1984.3)	25.5 (±12.7)	27.2 (±4.5)	3690.0 (±416.3)	3703.4 (±1278.6)
3-3-2-2	95	9531.9 (±2651.3)	27.5 (±15.3)	27.8 (±4.1)	3849.5 (±607.8)	3937.8 (±1475.5)
		High-intensity distance (15.1-20 km/h)	**Very high-intensity distance (20.1-25 km/h)**	**Sprinting distance (>25 km/h)**	**Ball possession (%)**	**Ball possession – defensive zone (%)**
4-2-3-1	458	1217.3 (±726.2)	471.9 (±237.8)	170.5 (±122.5)	52.0 (±10.5)	26.5 (±7.6)
4-3-2-1	79	1132.6 (±562.3)	466.0 (±248.1)	177.8 (±131.1)	46.1 (±12.3)	26.8 (±7.4)
3-4-3	84	1165.0 (±488.0)	457.6 (±236.6)	176.8 (±138.4)	49.5 (±7.9)	29.5 (±5.9)
4-3-3	104	1162.8 (±538.3)	471.2 (±219.2)	176.8 (±110.1)	50.1 (±7.0)	29.7 (±7.5)
4-4-2	137	1123.4 (±489.2)	429.1 (±210.0)	141.8 (±104.3)	44.9 (±10.9)	28.6 (±8.6)
3-3-2-2	95	1200.0 (±580.0)	458.2 (±244.8)	179.8 (±141.9)	53.9 (±7.5)	24.4 (±6.1)
		Ball possession – midfield zone (%)	**Ball possession – attack zone (%)**	**Completed passes**		
4-2-3-1	458	52.3 (±5.4)	21.6 (±6.4)	256.0 (±119.8)		
4-3-2-1	79	55.1 (±7.5)	19.0 (±4.8)	208.7 (±146.4)		
3-4-3	84	56.3 (±12.6)	16.9 (±4.0)	241.1 (±83.8)		
4-3-3	104	51.7 (±6.2)	19.0 (±4.1)	219.3 (±72.5)		
4-4-2	137	50.1 (±7.4)	20.8 (±4.5)	161.5 (±69.0)		
3-3-2-2	95	56.2 (±6.3)	19.3 (±4.4)	241.3 (±82.2)		

Modric et al. (2020)

		n	Total distance [m]	High-intensity running distance (>19.8 km/h) [m]	High-speed running distance (19.8-25.1 km/h) [m]	Sprinting distance (≥25.2 km/h) [m]	Accelerations
Center back	**3-5-2 / 3-4-1-2**	32	10327.4 (± 536.6)	529.0 (±180.4)	428.7 (± 130.9)	100.2 (± 57.7)	481.7 (± 51.7)
	4-4-2 / 4-1-3-2	16	10106.9 (± 472.0)	404.3 (±139.1)	332.9 (± 103.4)	71.3 (± 48.2)	467.1 (± 42.6)
Full back	**3-5-2 / 3-4-1-2**	14	11021.6 (± 361.8)	955.1 (±160.9)	729.3 (± 89.8)	226.0 (± 101.8)	485.9 (± 34.1)
	4-4-2 / 4-1-3-2	10	10143.7 (± 434.7)	708.2 (±151.8)	505.2 (± 86.7)	203.0 (± 92.7)	451.2 (± 42.6)
Midfielder	**3-5-2 / 3-4-1-2**	28	11731.0 (± 519.7)	725.9 (±205.5)	632.5 (± 164.6)	93.5 (± 53.8)	520.5 (± 28.6)
	4-4-2 / 4-1-3-2	19	11418.6 (± 549.6)	628.2 (±138.6)	525.2 (± 105.3)	103.1 (± 45.9)	473.4 (± 37.1)
Forward	**3-5-2 / 3-4-1-2**	9	10501.2 (± 647.0)	915.8 (±185.8)	696.1 (± 149.8)	229.9 (± 71.5)	414.7 (± 110.9)
	4-4-2 / 4-1-3-2	10	9827.6 (± 757.7)	795.6 (±213.6)	605.3 (± 145.0)	190.8 (± 82.9)	415.8 (± 38.0)

		N	Decelerations	High-intensity accelerations	High-intensity decelerations
Center back	**3-5-2 / 3-4-1-2**	32	479.2 (± 51.7)	22.3 (±10.4)	35.6 (±10.7)
	4-4-2 / 4-1-3-2	16	465.7 (± 39.0)	19.1 (±4.8)	27.8 (±8.7)
Full back	**3-5-2 / 3-4-1-2**	14	476.3 (± 33.7)	24.8 (±9.6)	43.1 (±11.1)
	4-4-2 / 4-1-3-2	10	448.1 (± 44.4)	28.0 (±5.2)	37.7 (±6.5)
Midfielder	**3-5-2 / 3-4-1-2**	28	514.9 (± 24.4)	19.5 (±9.0)	36.5 (±10.4)
	4-4-2 / 4-1-3-2	19	470.1 (± 40.2)	21.1 (±6.5)	30.7 (±5.1)
Forward	**3-5-2 / 3-4-1-2**	9	440.3 (± 42.2)	37.9 (±16.0)	52.7 (±11.6)
	4-4-2 / 4-1-3-2	10	415.8 (± 39.8)	40.9 (±10.1)	48.9 (±10.1)

Arjol-Serrano et al. (2021)

	n	Total distance [m]	Distance >14.4 km/h	Distance >19.8 km/h	Distance > 25.0 km/h	Accelerations (2-4 ms²)	Accelerations (>4 ms²)
4-2-3-1	Not specified	11114 (± 806)	2282 (± 511)	629 (± 214)	119 (± 79)	169 (± 37)	14 (± 9)
4-4-2	Not specified	11021 (± 809)	2218 (± 577)	662 (± 252)	143 (± 105)	160 (± 42)	17 (± 8)
	n	**Decelerations (2-4 ms²)**	**Decelerations (>4 ms²)**	**Game volume**	**Ratio interceptions-turnover**	**Defensive volume**	**Interceptions**
4-2-3-1	Not specified	158 (± 33)	28 (± 17)	48.3 (± 14.9)	-1.1 (± 5.4)	11.3 (± 5.3)	5.4 (± 3.3)
4-4-2	Not specified	146 (± 38)	30 (± 13)	57.7 (± 19.0)	-0.1 (± 4.5)	11.9 (± 5.5)	6.3 (± 3.5)
	n	**Opposing pitch interceptions**	**Clearences**	**Offensive volume**	**Total pass**	**Long pass**	**Short-medium pass**
4-2-3-1	Not specified	1.1 (± 1.1)	3.0 (± 2.8)	37.0 (± 11.8)	35.7 (± 11.6)	5.5 (± 3.7)	30.2 (± 9.9)
4-4-2	Not specified	1.1 (± 1.4)	3.3 (± 2.9)	45.3 (± 16.9)	43.4 (± 17.2)	5.6 (± 3.6)	37.7 (± 15.4)
	n	**Forward pass**	**Attack zone pass**	**Goal shot**	**Crosses**	**dribbles**	
4-2-3-1	Not specified	23.2 (± 9.5)	6.5 (± 5.6)	0.7 (± 1.0)	1.3 (± 1.8)	1.2 (± 1.4)	
4-4-2	Not specified	27.7 (± 13.2)	6.7 (± 5.6)	1.0 (± 1.4)	1.0 (± 1.8)	1.4 (± 1.5)	

		n	Total distance [m]	Distance >14.4 km/h	Distance >19.8 km/h	Distance > 25.0 km/h	Accelerations (2-4 ms²)	Accelerations (>4 ms²)
Center back	**4-2-3-1**	Not specified	10261 (± 552)	1667 (± 428)	405 (± 157)	77 (± 62)	165 (± 43)	13 (± 11)
	4-4-2	Not specified	10250 (± 494)	1555 (± 273)	397 (± 104)	68 (± 36)	160 (± 32)	14 (± 6)
Full back	**4-2-3-1**	Not specified	10713 (± 525)	2309 (± 341)	800 (± 250)	178 (± 89)	168 (± 45)	15 (± 9)
	4-4-2	Not specified	10864 (± 439)	2270 (± 335)	759 (± 181)	177 (± 93)	164 (± 38)	19 (± 8)
Central midfielder	**4-2-3-1**	Not specified	11517 (± 515)	2517 (± 430)	565 (± 123)	85 (± 59)	161 (± 32)	8 (± 6)
	4-4-2	Not specified	10935 (± 290)	2051 (± 381)	428 (± 168)	48 (± 39)	164 (± 37)	14 (± 6)
Wide midfielder	**4-2-3-1**	Not specified	11682 (± 696)	2458 (± 494)	694 (± 163)	128 (± 85)	162 (± 31)	13 (± 8)
	4-4-2	Not specified	11959 (± 614)	2871 (± 424)	820 (± 197)	152 (± 82)	173 (± 44)	15 (± 7)
Offensive midfielder	**4-2-3-1**	Not specified	12529 (± 335)	2811 (± 156)	714 (± 130)	101 (± 73)	223 (± 19)	22 (± 10)
	4-4-2	Not specified	12039 (± 645)	2778 (± 347)	704 (± 142)	127 (± 55)	170 (± 50)	17 (± 4)
Forward	**4-2-3-1**	Not specified	11039 (± 325)	24 (± 2)	732 (± 122)	167 (± 35)	178 (± 7)	23 (± 4)
	4-4-2	Not specified	11014 (± 610)	24 (± 4)	825 (± 223)	242 (± 133)	159 (± 22)	23 (± 5)

		n	Decelerations (2-4 ms^2)	Decelerations (>4 ms^2)	Game volume	Ratio interceptions-turnover	Defensive volume	Interceptions
Center back	**4-2-3-1**	Not specified	146 (± 34)	19 (± 13)	55.7 (± 12.6)	1.2 (± 3.8)	15.8 (± 1.8)	5.4 (± 2.6)
	4-4-2	Not specified	140 (± 25)	23 (± 10)	58.2 (± 16.1)	1.7 (± 2.8)	15.1 (± 5.3)	5.9 (± 2.8)
Full back	**4-2-3-1**	Not specified	152 (± 21)	33 (± 21)	55.6 (± 10.1)	-0.6 (± 3.8)	12.1 (± 4.1)	5.7 (± 2.7)
	4-4-2	Not specified	146 (± 30)	35 (± 11)	63.7 (± 13.1)	-0.3 (± 3.5)	11.5 (± 3.9)	5.8 (± 2.5)
Central midfielder	**4-2-3-1**	Not specified	170 (± 40)	22 (± 15)	54.6 (± 10.2)	2.1 (± 4.0)	13.6 (± 3.9)	8.3 (± 2.7)
	4-4-2	Not specified	167 (± 36)	25 (± 12)	80.7 (± 16.5)	4.0 (± 3.7)	15.0 (± 5.5)	10.3 (± 4.2)
Wide midfielder	**4-2-3-1**	Not specified	151 (± 39)	33 (± 17)	44.0 (± 10.1)	-5.2 (± 8.6)	8.4 (± 5.0)	5.6 (± 3.9)
	4-4-2	Not specified	170 (± 40)	34 (± 13)	60.9 (± 13.9)	0.7 (± 4.5)	12.8 (± 4.3)	7.8 (± 3.8)
Offensive midfielder	**4-2-3-1**	Not specified	191 (± 19)	45 (± 10)	31.8 (± 5.8)	-1.0 (± 2.2)	7.0 (± 4.2)	2.3 (± 1.0)
	4-4-2	Not specified	174 (± 26)	39 (± 12)	54.3 (± 11.2)	-2.1 (± 3.6)	8.4 (± 1.9)	6.8 (± 2.3)
Forward	**4-2-3-1**	Not specified	152 (± 12)	32 (± 7)	25.2 (± 9.5)	-8.0 (± 4.0)	3.4 (± 3.0)	1.2 (± 1.1)
	4-4-2	Not specified	128 (± 18)	31 (± 7)	32.0 (± 8.2)	5.7 (± 2.9)	5.7 (± 3.4)	3.0 (± 1.9)
		n	**Opposing pitch interceptions**	**Clearences**	**Offensive volume**	**Total pass**	**Long pass**	**Short-medium pass**
Center back	**4-2-3-1**	Not specified	0.7 (± 0.7)	6.2 (± 2.6)	39.9 (± 11.8)	39.2 (± 11.3)	8.7 (± 4.3)	30.6 (± 11.0)
	4-4-2	Not specified	0.6 (± 0.7)	6.4 (± 3.1)	42.6 (± 15.7)	42.2 (± 15.3)	7.0 (± 2.6)	35.3 (± 15.0)
Full back	**4-2-3-1**	Not specified	0.8 (± 1.3)	3.1 (± 2.0)	43.6 (± 9.5)	42.0 (± 9.1)	6.2 (± 2.8)	35.8 (± 8.8)
	4-4-2	Not specified	0.6 (± 0.9)	3.1 (± 1.7)	52.2 (± 12.1)	50.3 (± 11.9)	7.1 (± 3.2)	42.9 (± 11.8)
Central midfielder	**4-2-3-1**	Not specified	2.2 (± 1.1)	2.8 (± 3.0)	39.8 (± 12.5)	39.6 (± 10.1)	7.0 (± 1.8)	32.6 (± 8.9)
	4-4-2	Not specified	2.6 (± 2.0)	2.8 (± 1.8)	65.7 (± 15.2)	64.5 (± 15.4)	9.3 (± 3.3)	55.2 (± 14.4)
Wide midfielder	**4-2-3-1**	Not specified	0.8 (± 0.8)	1.8 (± 0.8)	35.6 (± 7.6)	32.4 (± 7.6)	2.4 (± 1.7)	30.0 (± 7.3)
	4-4-2	Not specified	1.6 (± 1.5)	2.3 (± 2.1)	46.0 (± 14.6)	45.2 (± 13.2)	4.6 (± 2.9)	40.6 (± 11.7)
Offensive midfielder	**4-2-3-1**	Not specified	1.3 (± 0.5)	0.0 (± 0.0)	29.0 (± 5.0)	27.0 (± 2.8)	2.5 (± 1.7)	24.8 (± 3.9)
	4-4-2	Not specified	2.1 (± 1.8)	0.0 (± 0.0)	45.9 (± 10.2)	41.4 (± 9.9)	2.8 (± 2.2)	38.6 (± 9.0)
Forward	**4-2-3-1**	Not specified	0.8 (± 0.5)	0.8 (± 0.8)	21.8 (± 8.7)	18.4 (± 7.0)	0.8 (± 0.8)	17.6 (± 7.0)
	4-4-2	Not specified	1.0 (± 1.1)	1.1 (± 1.4)	26.3 (± 6.0)	21.4 (± 6.3)	1.5 (± 1.0)	19.9 (± 6.5)
		n	**Forward pass**	**Attack zone pass**	**Goal shot**	**Crosses**	**dribbles**	
Center back	**4-2-3-1**	Not specified	30.1 (± 11.3)	0.8 (± 1.4)	0.4 (± 0.7)	55.7 (± 12.6)	1.2 (± 3.8)	
	4-4-2	Not specified	31.9 (± 11.1)	0.5 (± 0.7)	0.4 (± 0.6)	0.0 (± 0.2)	0.4 (± 0.8)	
Full back	**4-2-3-1**	Not specified	24.6 (± 4.1)	9.6 (± 5.7)	0.1 (± 0.3)	2.4 (± 2.5)	1.5 (± 0.9)	
	4-4-2	Not specified	30.2 (± 7.8)	10.7 (± 5.5)	0.2 (± 0.5)	2.1 (± 1.7)	1.7 (± 1.6)	
Central midfielder	**4-2-3-1**	Not specified	28.2 (± 7.5)	4.2 (± 3.7)	0.9 (± 0.9)	1.6 (± 2.1)	0.6 (± 1.0)	
	4-4-2	Not specified	45.9 (± 11.7)	6.9 (± 5.2)	0.5 (± 0.6)	2.9 (± 3.1)	0.7 (± 1.0)	
Wide midfielder	**4-2-3-1**	Not specified	18.8 (± 4.7)	11.8 (± 6.7)	0.8 (± 0.8)	1.8 (± 1.1)	2.4 (± 2.6)	
	4-4-2	Not specified	26.4 (± 9.0)	7.2 (± 4.7)	1.3 (± 0.9)	0.7 (± 1.0)	1.7 (± 1.5)	
Offensive midfielder	**4-2-3-1**	Not specified	15.3 (± 2.2)	10.5 (± 2.7)	1.8 (± 1.3)	2.0 (± 0.8)	2.2 (± 1.0)	
	4-4-2	Not specified	22.0 (± 5.4)	11.9 (± 6.2)	1.9 (± 1.3)	1.4 (± 2.6)	3.4 (± 2.5)	
Forward	**4-2-3-1**	Not specified	9.4 (± 4.4)	7.8 (± 3.3)	1.6 (± 1.1)	0.2 (± 0.5)	1.8 (± 1.1)	
	4-4-2	Not specified	9.7 (± 4.4)	8.5 (± 3.9)	2.8 (± 1.8)	0.3 (± 0.4)	1.9 (± 1.4)	

Borghi et al. (2020)

	n	Total distance [m]	High speed running distance (>19.8 km/h) [m]	Powerplays (>22 W/kg)	Power Score (W/kg)	Sprints (> 25 km/h)	Accelerations
4-4-2	45	10510 (± 880)	758.02 (± 253.63)	75.51 (± 20.06)	18.51 (± 1.80)	22.87 (± 7.99)	116.71 (± 23.21)
4-3-3	60	10080 (±1040)	756.66 (±235.77)	74.92 (±19.60)	17.70 (±1.88)	23.27 (±7.72)	120.55 (±21.64)
3-5-2	32	10390 (±1120)	762.62 (±235.48)	75.56 (±19.31)	17.36 (±0.94)	23.22 (±7.35)	127.44 (±30.18)

		n	Total distance [m]	High speed running distance (>19.8 km/h) [m]	Powerplays (>22 W/kg)	Power Score (W/kg)	Sprints (> 25 km/h)	Accelerations
Center back	**4-4-2**	15	9720 (±520)	485.46 (±150.81)	51.87 (±8.52)	16.82 (±0.97)	14.40 (±4.60)	115.33 (±21.90)
	4-3-3	16	9250 (±500)	535.7 (±128.78)	52.38 (±6.92)	16.10 (±0.88)	16.25 (±4.02)	119.00 (±18.28)
	3-5-2	11	9760 (±540)	512.45 (±113.12)	56.91 (±13.17)	16.59 (±1.06)	15.82 (±4.67)	124.82 (±18.44)
Full back	**4-4-2**	11	10870 (±580)	980.69 (±142.01)	89.27 (±12.08)	19.54 (±1.05)	30.00 (±4.20)	127.91 (±18.76)
	4-3-3	15	10390 (±430)	927.74 (±175.95)	85.60 (±9.85)	18.11 (±0.71)	28.33 (±6.48)	122.07 (±22.26)
	3-5-2	-	-	-	-	-	-	-
Central midfielder	**4-4-2**	6	11650 (±700)	719.26 (±142.54)	90.67 (±16.92)	20.48 (±1.28)	21.33 (±5.05)	112.67 (±16.82)
	4-3-3	12	11490 (±650)	652.40 (±176.94)	88.58 (±17.25)	19.96 (±1.33)	20.50 (±6.61)	127.83 (±19.91)
	3-5-2	7	11470 (±1230)	789.46 (±83.67)	92.57 (±12.65)	20.61 (±0.91)	23.43 (±3.69)	128.86 (±31.14)
Wide midfielder	**4-4-2**	4	11160 (±190)	822.48 (±91.60)	91.00 (±3.16)	20.29 (±1.10)	24.25 (±4.11)	128.75 (±26.40)
	4-3-3	-	-	-	-	-	-	-
	3-5-2	7	11130 (±510)	1018.81 (±169.05)	91.00 (±10.58)	20.61 (±0.91)	31.57 (±4.93)	147.00 (±42.24)
Forward	**4-4-2**	9	10340 (±700)	937.33 (±161.55)	81.11 (±9.20)	17.96 (±1.31)	28.67 (±5.00)	102.67 (±27.64)
	4-3-3	17	9590 (±880)	887.29 (±196.05)	77.06 (±17.95)	17.27 (±1.96)	27.35 (±6.40)	115.53 (±25.22)
	3-5-2	7	9570 (±849)	872.70 (±152.70)	72.43 (±10.05)	17.36 (±0.94)	26.29 (±3.50)	110.57 (±24.36)

Vilamitjana et al. (2021)

	n	High intensity load rate [m/min]	High speed running/sprints load rate [m/min]	High speed runs	sprints	Mean heart rate	Maximal heart rate
3-4-3	Not specified	19.9 (±4.4)	6.7 (±2.6)	15.7 (±3.1)	6.2 (±3.2)	170.3 (±7.5)	193.3 (±12.7)
4-2-3-1	Not specified	21.6 (±3.3)	7.8 (±2.6)	15.7 (±2.3)	7.2 (±3.3)	171.0 (±8.2)	193.7 (±6.6)

		n	High intensity load rate [m/min]	High speed running/sprints load rate [m/min]	High speed runs	sprints	Mean heart rate	Maximal heart rate
Center back	**3-4-3**	Not specified	15.5 (±1.3)	4.4 (±0.9)	19.8 (±4.3)	4.2 (±1.1)	167.4 (±9.4)	190.4 (±8.8)
	4-2-3-1	Not specified	18.0 (±1.3)	6.0 (±1.4)	19.0 (±1.8)	5.1 (±0.7)	169.8 (±6.3)	191.6 (±7.5)
Full back	**3-4-3**	Not specified	23.8 (±4.7)	8.1 (±2.0)	25.0 (±2.7)	7.2 (±1.7)	176.1 (±6.1)	196.7 (±3.4)
	4-2-3-1	Not specified	23.7 (±2.5)	8.7 (±1.1)	25.1 (±2.7)	7.7 (±1.2)	174.1 (±7.9)	195.4 (±3.7)
Central midfielder	**3-4-3**	Not specified	18.1 (±3.7)	5.0 (±1.3)	17.0 (±4.9)	3.7 (±2.4)	170.9 (±6.5)	193.7 (±5.4)
	4-2-3-1	Not specified	20.1 (±3.1)	5.2 (±1.2)	18.1 (±3.4)	3.9 (±1.3)	174.0 (±7.2)	195.6 (±3.9)
Wide midfielder	**3-4-3**	Not specified	23.5 (±2.0)	9.4 (±2.09)	20.2 (±0.8)	5.4 (±0.8)	160.1 (±12.7)	185.2 (±4.4)
	4-2-3-1	Not specified	23.9 (±1.7)	10.1 (±1.2)	25.7 (±1.8)	8.6 (±1.0)	160.6 (±14.1)	182.2 (±8.4)
Forward	**3-4-3**	Not specified	17.9 (±2.0)	6.4 (±1.0)	28.0 (±5.1)	9.1 (±3.7)	172.1 (±3.3)	194.9 (±4.0)
	4-2-3-1	Not specified	23.6 (±0.7)	10.7 (±1.9)	26.9 (±2.7)	11.1 (±2.5)	171.4 (±3.0)	197.2 (±3.9)

Riboli et al. (2021)

	n	1 min peak: total distance [m]	1 min peak: high speed running distance (14-20 km/h) [m]	1 min peak: very high speed running distance (20-24 km/h) [m]	1 min peak: sprinting distance (>24 km/h) [m]
3-4-1-2	396	188.8 (±28.3)	57.7 (±14.7)	36.8 (±11.2)	41.1 (±16.3)
3-4-2-1	161	189.6 (±25.2)	58 (±15.6)	36.3 (±11.7)	43 (±16.7)
3-5-2	154	188.4 (±28.4)	57.8 (±15.1)	37.7 (±13.3)	38.7 (±15.5)
4-3-3	97	189 (±27.3)	57.8 (±14.2)	37.7 (±12)	38.9 (±15.8)
4-4-2	48	190.2 (±17.4)	59.4 (±12.6)	39.6 (±13.3)	39.8 (±17.1)
	n	**1 min peak: Acceleration/Deceleration**	**1 min peak: average metabolic power**	**1 min peak: high metabolic load distance (>20 W/kg)**	
3-4-1-2	396	32.8 (±7.1)	20.1 (±3.8)	93.8 (±21.6)	
3-4-2-1	161	34.3 (±7.3)	20.7 (±7.2)	95 (±22.9)	
3-5-2	154	32.5 (±7.2)	20 (±3.3)	93 (±21.4)	
4-3-3	97	31.3 (±6.1)	19.7 (±3.2)	93.4 (±21.3)	
4-4-2	48	31 (±4.9)	19.5 (±2.1)	95 (±18.1)	

		n	1 min peak: total distance [m]	1 min peak: high speed running distance (14-20 km/h) [m]	1 min peak: very high speed running distance (20-24 km/h) [m]	1 min peak: sprinting distance (>24 km/h) [m]
Full back	**3-4-1-2**	3	158.3 (±62.4)	48.4 (±15.6)	28.7 (±19.5)	35.4 (±27.2)
	3-4-2-1	12	199.5 (±12.9)	63.8 (±7.9)	44.9 (±11.2)	48.4 (±15.9)
	3-5-2	26	186 (±20)	60.5 (±19.4)	37.6 (±12)	39.1 (±12.2)
	4-3-3	16	182.9 (±20.4)	54.4 (±14.8)	33.2 (±9.4)	40.7 (±15.3)
	4-4-2	6	197.5 (±7.1)	67.4 (±10.2)	42.3 (±12.9)	48.1 (±11.6)
Center back	**3-4-1-2**	108	183.7 (±30)	49 (±12.1)	33.8 (±11.2)	36 (±13.5)
	3-4-2-1	40	181.9 (±16.8)	47.6 (±6.6)	34.6 (±10)	40.2 (±13.1)
	3-5-2	32	174.7 (±34.5)	48.2 (±14.6)	36.1 (±14.8)	35.7 (±17.3)
	4-3-3	23	180.7 (±17.3)	47.7 (±9.4)	34.6 (±11.9)	33.6 (±12.1)
	4-4-2	11	184.3 (±17.8)	51 (±13.4)	36.5 (±0.6)	41.3 (±22.3)
Wide midfielder	**3-4-1-2**	83	193 (±32.4)	66.9 (±15.6)	39.7 (±12.7)	47.8 (±16.2)
	3-4-2-1	33	202.4 (±23.5)	73.4 (±22.4)	40.5 (±12.1)	47.8 (±20.4)
	3-5-2	12	198 (±14.5)	64.5 (±7.6)	41.7 (±14.2)	41.7 (±10.2)
	4-3-3	4	194 (±6.4)	61.6 (±5.5)	40.3 (±22.8)	50.4 (±27.2)
	4-4-2	7	192.2 (±10.9)	64.8 (±9)	41.7 (±12.6)	41.7 (±17.5)
Central midfielder	**3-4-1-2**	93	201.1 (±23)	69.4 (±11.9)	39.9 (±10.4)	42.5 (±17.1)
	3-4-2-1	41	190.1 (±34.1)	60.5 (±15.5)	36.9 (±12.7)	40.3 (±16.3)
	3-5-2	48	199.3 (±16)	64.4 (±8.3)	39.1 (±12.4)	39.7 (±13.8)
	4-3-3	25	199.4 (±14.3)	65.3 (±7)	40.2 (±10.4)	37.6 (±12.9)
	4-4-2	10	199.7 (±21.8)	68.6 (±18.2)	44.8 (±19.9)	35.1 (±19.7)
Wide forward	**3-4-1-2**	66	184.9 (±14.7)	53.2 (±5.9)	36.4 (±7)	42.5 (±13.1)
	3-4-2-1	18	186.2 (±18)	56.6 (±6.8)	32.4 (±8.7)	45.9 (±15.9)
	3-5-2	9	204.1 (±26.5)	55.2 (±3.9)	40.7 (±15)	43.7 (±13)
	4-3-3	14	195.6 (±23.2)	70.5 (±15.1)	42.3 (±10.1)	45.6 (±19.3)
	4-4-2	3	192.6 (±11.5)	56.7 (±16.5)	38.6 (±10.5)	34.6 (±13.9)
Forward	**3-4-1-2**	43	175 (±26.7)	44.6 (±16.6)	33 (±11)	36.3 (±19.3)
	3-4-2-1	17	178.8 (±21.3)	44.9 (±15.5)	29.3 (±9.7)	39.9 (±17.8)
	3-5-2	27	179.5 (±38)	46.9 (±14.8)	35 (±13.4)	37.3 (±20.5)
	4-3-3	15	183.7 (±52.4)	51.7 (±13.3)	37.8 (±14.4)	38 (±17.3)
	4-4-2	11	181.6 (±17.7)	52.5 (±11.1)	35.5 (±11)	38.3 (±12.6)

		n	1 min peak: Acceleration/Deceleration	1 min peak: average metabolic power	1 min peak: high metabolic load distance (>20 W/kg)
Full back	**3-4-1-2**	3	25.1 (±4.7)	18.1 (±5.4)	66.4 (±39.1)
	3-4-2-1	12	31.1 (±11.6)	21.7 (±2.6)	101.9 (±16)
	3-5-2	26	42 (±9.8)	19.8 (±1.8)	94.3 (±20.3)
	4-3-3	16	31.9 (±5.6)	20 (±3.8)	88.5 (±21)
	4-4-2	6	31.2 (±5.2)	19.8 (±1.6)	98.6 (±8.4)
Center back	**3-4-1-2**	108	25.1 (±3.8)	19.1 (±3.6)	86.9 (±20.1)
	3-4-2-1	40	32.7 (±6.6)	19.2 (±2.2)	87.7 (±16.7)
	3-5-2	32	33 (±6.4)	18.7 (±4)	85.8 (±22)
	4-3-3	23	30.7 (±6.3)	18.9 (±1.8)	85.2 (±17.1)
	4-4-2	11	31.6 (±7)	18.8 (±2.1)	89.2 (±22.5)
Wide midfielder	**3-4-1-2**	83	27 (±6.9)	20.6 (±3.4)	101.5 (±22.7)
	3-4-2-1	33	35.2 (±7.7)	24 (±4.3)	109.3 (±27.6)
	3-5-2	12	36.7 (±6.9)	21.6 (±1.6)	97.2 (±12.4)
	4-3-3	4	41.1 (±7.3)	20.7 (±2.2)	98.8 (±12.7)
	4-4-2	7	30.3 (±4.9)	19.6 (±2)	102.1 (±13.6)
Central midfielder	**3-4-1-2**	93	21.5 (±3.4)	21.3 (±4.9)	104.1 (±18)
	3-4-2-1	41	32.8 (±7.1)	20.1 (±4.2)	94.6 (±22.9)
	3-5-2	48	31.8 (±6.6)	20.7 (±1.8)	98.4 (±16.8)
	4-3-3	25	33.9 (±7.4)	20.2 (±1.5)	100.3 (±14.1)
	4-4-2	10	31.2 (±6.1)	20.1 (±2.7)	103.6 (±19.9)
Wide forward	**3-4-1-2**	66	26.1 (±4.6)	19.6 (±2.1)	89.1 (±13.1)
	3-4-2-1	18	33.2 (±6.5)	19.7 (±2)	94 (±16.3)
	3-5-2	9	36.1 (±8.3)	22.4 (±4)	108.4 (±28.1)
	4-3-3	14	34.1 (±7.6)	20.6 (±2.3)	105.1 (±19.9)
	4-4-2	3	31.2 (±4.4)	19.5 (±2.8)	92.3 (±15.3)
Forward	**3-4-1-2**	43	28.3 (±6.9)	19.4 (±2.8)	83.3 (±24.5)
	3-4-2-1	17	31.3 (±7)	19.6 (±3.5)	82.6 (±23)
	3-5-2	27	28.5 (±8.1)	19 (±4.7)	84.6 (±24.4)
	4-3-3	15	39.7 (±12.2)	19 (±6)	88.1 (±31.5)
	4-4-2	11	31.5 (±7.5)	19.5 (±2.1)	87.2 (±16)

Paper I. Supplementary Table 4. Quality criteria.

Criteria			
C1	The study purpose is clearly stated	No = 0	Yes = 1
C2	The number of observations per group (sample size) is clearly stated	No = 0	Yes = 1
C3	The duration of the data files is stated (it is indicated if substituted players were included)	No = 0	Yes = 1
C4	More than 2 different tactical formations were included	No = 0	Yes = 1
C5	The reliability/validity of the tracking technology is mentioned	No = 0	Yes = 1
C6	Contextual variables (e.g. quality of the opponent) are considered	No = 0	Yes = 1
C7	Results are clearly presented with statistical analysis	No = 0	Yes = 1

Adapted from (Castellano et al., 2014).

Paper I. Supplementary Table 5. Methodological quality assessment.

Source	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Total
Aquino et al. (2017)	1	0	1	0	1	1	1	**5**
Aquino et al. (2019)	1	0	1	0	1	1	1	**5**
Arjol-Serrano et al. (2021)	1	0	0	0	1	0	1	**3**
Baptista et al. (2019)	1	1	1	0	1	0	1	**5**
Borghi et al. (2020)	1	0	0	1	1	1	1	**5**
Bradley et al. (2011)	1	1	1	1	1	1	1	**7**
Modric et al. (2020)	1	0	1	0	1	0	1	**4**
Palucci Vierira et al. (2018)	1	1	1	0	1	1	1	**6**
Riboli et al. (2021)	1	0	1	1	1	1	1	**6**
Tierney et al. (2016)	1	0	1	1	1	1	1	**6**
Vilamitjana et al. (2021)	1	0	1	0	0	0	1	**3**
All studies	**11**	**3**	**9**	**4**	**10**	**7**	**11**	**5.0**

Paper I. Supplementary File 1. PRISMA 2020 check list.

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	✓
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	✓
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	✓
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	✓
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	✓
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	✓
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	✓
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	✓
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	✓
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	✓
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	✓
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	✓
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	✓
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	✓
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	✓
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	✓
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	✓
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	✓
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	✓
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	✓
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	✓

Paper II. Supplementary Table 1. Starting defensive and offensive formation for every recorded match.

Matchday	Team	Result (3=win; 1=draw; 0=defeat)	Table position (current matchday)	Offensive formation	Defensive formation	In-game formation change (0=no, 1=yes)
18	FCB	3	1	4-2-3-1	4-2-3-1	0
18	S04	0	18	4-2-3-1	4-2-3-1	0
18	DSC	0	15	4-4-2	4-4-2	1
18	SGE	3	8	3-4-3	3-4-3	1
18	FCA	3	12	3-4-3	3-4-3	0
18	FCU	0	6	3-4-3	3-4-3	0
18	TSG	3	11	3-5-2	3-5-2	0
18	KOE	0	16	3-4-3	3-4-3	0
18	BSC	0	14	4-4-2 diamond	4-3-3	0
18	SVW	3	13	3-5-2	3-5-2	0
18	SCF	3	9	3-4-3	3-4-3	0
18	VFB	0	10	3-4-3	3-4-3	1
18	BMG	3	7	3-5-2	3-5-2	1
18	BVB	0	4	4-2-3-1	4-2-3-1	1
18	M05	3	17	3-5-2	3-4-3	0
18	RBL	0	2	3-5-2	4-2-3-1	1
18	B04	0	3	4-3-3	4-3-3	1
18	WOB	3	5	4-2-3-1	4-4-2	0
20	M05	3	17	3-4-3	3-4-3	1
20	FCU	0	8	3-5-2	3-5-2	1
20	SCF	3	9	4-2-3-1	4-4-2	1
20	BVB	0	6	4-2-3-1	4-2-3-1	1
20	TSG	0	12	3-5-2	3-5-2	0
20	SGE	3	4	3-4-3	3-4-3	0
20	BMG	0	7	4-2-3-1	4-2-3-1	1

20	KOE	3	14	3-5-2	3-5-2	0
20	DSC	0	16	4-4-2 diamond	4-4-2 diamond	1
20	SVW	3	11	3-4-3	3-4-3	0
20	B04	3	5	4-3-3	4-2-3-1	0
20	VFB	0	10	3-4-3	3-4-3	0
20	S04	0	18	4-2-3-1	4-2-3-1	0
20	RBL	3	2	3-4-3	3-5-2	0
20	BSC	0	15	4-3-3	4-2-3-1	0
20	FCB	3	1	4-3-3	4-3-3	0
20	FCA	0	13	4-2-3-1	4-2-3-1	0
20	WOB	3	3	4-2-3-1	4-2-3-1	0
22	VFB	3	10	3-4-3	3-4-3	0
22	KOE	0	14	3-4-3	3-5-2	1
22	BSC	0	15	3-5-2	3-5-2	0
22	RBL	3	2	3-4-3	3-4-3	0
22	S04	0	18	4-3-3	4-3-3	0
22	BVB	3	6	4-2-3-1	4-2-3-1	1
22	TSG	3	12	3-5-2	3-5-2	0
22	SVW	0	11	3-5-2	3-5-2	1
22	FCA	1	13	4-2-3-1	4-2-3-1	0
22	B04	1	5	4-3-3	4-3-3	1
22	SGE	3	3	3-4-3	3-4-3	0
22	FCB	0	1	4-2-3-1	4-2-3-1	0
22	SCF	0	8	4-3-3	4-4-2	1
22	FCU	3	9	3-4-3	3-4-3	0
22	BMG	0	7	3-4-3	3-4-3	0
22	M05	3	17	3-5-2	3-5-2	0
22	DSC	0	16	4-3-3	4-4-2	1
22	WOB	3	4	4-2-3-1	4-2-3-1	0

24	SCF	0	8	4-4-2	4-4-2	1
24	RBL	3	2	3-4-3	3-5-2	0
24	DSC	1	16	4-4-2 diamond	4-4-2 diamond	1
24	FCU	1	7	4-2-3-1	4-4-2	0
24	S04	1	18	3-5-2	3-5-2	0
24	M05	1	17	3-5-2	3-5-2	0
24	BSC	3	15	3-5-2	3-5-2	0
24	FCA	0	13	4-2-3-1	4-2-3-1	0
24	SGE	1	4	3-5-2	3-5-2	0
24	VFB	1	10	3-4-3	3-5-2	0
24	FCB	3	1	4-2-3-1	4-2-3-1	0
24	BVB	0	5	3-4-3	3-4-3	0
24	TSG	3	12	3-5-2	3-5-2	0
24	WOB	0	3	4-2-3-1	4-2-3-1	0
24	BMG	0	9	4-2-3-1	4-4-2	0
24	B04	3	6	4-3-3	4-4-2	0
24	KOE	1	11	4-2-3-1	4-2-3-1	0
24	SVW	1	14	3-4-3	3-4-3	0
26	KOE	1	14	4-3-3	4-4-2	1
26	BVB	1	5	4-3-3	4-2-3-1	0
26	RBL	3	2	3-4-3	3-5-2	0
26	DSC	0	15	4-4-2 diamond	4-4-2 diamond	1
26	S04	0	18	3-5-2	3-5-2	0
26	BMG	3	10	4-2-3-1	4-4-2	0
26	BSC	3	16	3-4-3	3-4-3	1
26	B04	0	6	4-2-3-1	4-2-3-1	1
26	SVW	0	12	3-5-2	3-5-2	0
26	WOB	3	3	4-2-3-1	4-2-3-1	0
26	SGE	3	4	3-4-3	3-4-3	0

26	FCU	0	7	3-5-2	3-5-2	0
26	TSG	0	11	3-4-3	3-4-3	1
26	M05	3	17	3-5-2	3-5-2	0
26	SCF	3	9	4-2-3-1	4-4-2	0
26	FCA	0	13	4-2-3-1	4-4-2	0
26	VFB	0	8	3-4-3	3-4-3	0
26	FCB	3	1	4-2-3-1	4-2-3-1	1
28	VFB	0	8	3-4-3	3-4-3	1
28	BVB	3	5	4-3-3	4-3-3	0
28	SVW	0	13	3-4-3	3-4-3	1
28	RBL	3	2	4-3-3	4-2-3-1	1
28	BSC	1	14	3-5-2	3-4-3	1
28	BMG	1	9	3-5-2	3-4-3	1
28	TSG	1	12	4-3-3	3-5-2	0
28	B04	1	6	4-2-3-1	4-2-3-1	0
28	SGE	3	4	3-5-2	3-5-2	0
28	WOB	0	3	4-2-3-1	4-2-3-1	1
28	DSC	3	17	4-3-3	4-3-3	0
28	SCF	0	10	3-5-2	3-5-2	0
28	FCB	1	1	4-3-3	4-3-3	0
28	FCU	1	7	4-2-3-1	4-4-2	0
28	KOE	0	16	4-2-3-1	4-2-3-1	0
28	M05	3	15	3-5-2	3-5-2	0
28	S04	3	18	3-5-2	3-5-2	0
28	FCA	0	11	3-4-3	4-4-2	1
30	BSC	3	15	4-2-3-1	4-2-3-1	0
30	SCF	0	9	3-4-3	3-4-3	1
30	VFB	0	10	3-4-3	3-4-3	0
30	WOB	3	3	4-2-3-1	4-2-3-1	0

30	KOE	3	17	4-3-3	4-3-3	0
30	RBL	0	2	4-2-2-2	4-2-2-2	1
30	TSG	3	12	4-2-3-1	4-2-3-1	0
30	BMG	0	7	4-4-2	4-4-2	1
30	FCB	3	1	4-2-3-1	4-2-3-1	0
30	B04	0	6	3-4-3	3-4-3	0
30	BVB	3	5	4-2-3-1	4-2-3-1	0
30	FCU	0	8	4-2-3-1	4-4-2	0
30	DSC	3	16	4-3-3	4-3-3	0
30	S04	0	18	3-5-2	3-5-2	1
30	SVW	0	13	3-4-3	3-5-2	0
30	M05	3	14	3-5-2	3-5-2	0
30	SGE	3	4	3-4-3	3-5-2	0
30	FCA	0	11	3-5-2	3-5-2	0
32	FCB	3	1	4-2-3-1	4-2-3-1	1
32	BMG	0	7	4-4-2	4-4-2	1
32	VFB	3	10	3-4-3	3-4-3	0
32	FCA	0	14	4-2-3-1	4-2-3-1	0
32	BVB	3	5	4-2-3-1	4-2-3-1	0
32	RBL	0	2	3-4-3	3-5-2	0
32	SVW	1	15	4-3-3	4-3-3	1
32	B04	1	6	4-2-3-1	4-2-3-1	0
32	KOE	0	17	4-3-3	4-4-2	0
32	SCF	3	9	4-4-2	4-4-2	0
32	FCU	0	8	3-5-2	3-5-2	1
32	WOB	3	3	4-2-3-1	4-2-3-1	0
32	TSG	3	11	4-2-3-1	4-2-3-1	0
32	S04	0	18	3-5-2	3-5-2	0
32	SGE	1	4	3-4-3	3-5-2	0

32	M05	1	12	3-4-3	3-4-3	0
32	BSC	1	13	3-5-2	3-5-2	1
32	DSC	1	16	4-3-3	4-3-3	0
34	FCU	3	7	3-5-2	3-5-2	0
34	RBL	0	2	4-3-3	4-2-3-1	0
34	SVW	0	16	4-4-2 diamond	4-4-2 diamond	0
34	BMG	3	8	3-5-2	3-5-2	0
34	BVB	3	3	4-2-3-1	4-2-3-1	0
34	B04	0	6	4-4-2	4-4-2	0
34	SGE	3	5	3-5-2	3-5-2	0
34	SCF	0	10	4-2-3-1	4-4-2	0
34	TSG	3	11	4-2-3-1	4-4-2	0
34	BSC	0	14	4-2-3-1	4-4-2	0
34	KOE	3	17	4-2-3-1	4-2-3-1	0
34	S04	0	18	3-5-2	3-5-2	0
34	WOB	0	4	4-2-3-1	4-2-3-1	0
34	M05	3	13	3-5-2	3-5-2	0
34	FCB	3	1	4-2-3-1	4-2-3-1	0
34	FCA	0	12	4-2-3-1	4-4-2	1
34	VFB	0	9	3-4-3	3-4-3	0
34	DSC	3	15	4-3-3	4-2-3-1	1

Paper III. Supplementary Table 1. Results of inter-rater reliability for the key performance variables goals, chances, and scoring zone entries.

	Cohen‘s kappa	p-value
goals – own team	1.00	0.04
goals – opposing team	1.00	0.08
chances – own team	1.00	<0.01
chances – opposing team	0.62	0.03
last plane – own team	1.00	<0.01
last plane – opposing team	1.00	<0.01

Paper III. Supplementary Table 2. Kolmogorov-Smirnov-tests.

	p-value (all games)
season 1	
goals – own team	**>0.01**
goals – opposing team	0.07
chances – own team	0.20
chances – opposing team	0.20
last plane – own team	0.20
last plane – opposing team	0.19
season 2	
goals – own team	**0.02**
goals – opposing team	**>0.01**
chances – own team	0.20
chances – opposing team	0.17
last plane – own team	0.06
last plane – opposing team	0.20
season 3	
goals – own team	**>0.01**
goals – opposing team	**>0.01**
chances – own team	0.20
chances – opposing team	**0.03**
last plane – own team	0.20
last plane – opposing team	0.20
all seasons	
goals – own team	**>0.01**
goals – opposing team	0.07
chances – own team	0.20
chances – opposing team	0.20
last plane – own team	0.20
last plane – opposing team	0.19

Paper III. Supplementary Table 3. Comparison of games with and games without in-game formation change.

	Average 10 min. in games without formation change (mean ±SD)	95% Confidence intervall	Average 10 min. in games with formation change (mean ±SD)	95% Confidence intervall	U	Z	p-value	ES
season 1								
goals – own team	0.17 ±0.15	0.04-0.26	0.17 ±0.13	0.08-0.27	108	-0.18	0.85	0.01
goals – opposing team	0.17 ±0.14	0.12-0.30	0.19 ±0.11	0.10-0.27	101	-0.47	0.67	0.03
chances – own team	1.00 ±0.39	0.70-1.32	0.89 ±0.38	0.60-1.18	94	-0.73	0.47	0.17
chances – opposing team	0.83 ±0.37	0.80-1.35	0.69 ± 0.31	0.45-0.93	86	-1.04	0.32	0.24
last plane – own team	3.22 ±0.86	2.60-3.72	3.10 ±0.89	2.41-3.79	109	-0.16	0.88	0.13
last plane – opposing team	2.89 ±0.95	2.35-3.80	2.72 ±0.77	2.13-3.31	103	-0.39	0.70	0.28

season 2								
goals – own team	0.15 ±0.12	0.03-0.24	0.17 ±0.11	0.11-0.26	90	-0.46	0.68	0.05
goals – opposing team	0.13 ±0.11	0.03-0.24	0.30 ±0.21	0.12-0.39	49	-2.36	**0.02**	0.46
chances – own team	1.15 ±0.53	0.86-1.39	0.99 ±0.52	0.65-1.45	80	-0.91	0.37	0.22
chances – opposing team	1.16 ±0.43	0.64-1.48	0.96 ±0.43	0.61-1.12	79	-0.95	0.35	0.31
last plane – own team	2.94 ±0.87	2.38-3.20	3.21 ±1.26	2.54-4.30	83	-0.77	0.45	0.27
last plane – opposing team	3.86 ±1.04	2.86-4.28	3.48 ±1.27	2.39-4.13	82	-0.79	0.45	0.19
season 3								
goals – own team	0.21 ±0.12	0.11-0.28	0.24 ±0.16	0.11-0.36	122	-0.39	0.71	0.06
goals – opposing team	0.15 ±0.10	0.10-0.25	0.18 ±0.14	0.06-0.23	113	-0.72	0.51	0.10
chances – own team	1.28 ±0.55	0.85-1.62	1.15 ±0.46	0.85-1.57	116	-0.58	0.58	0.19
chances – opposing team	0.87 ±0.39	0.63-1.20	0.84 ±0.38	0.49-1.19	126	-0.24	0.82	0.04
last plane – own team	3.41 ±0.79	2.78-4.06	3.70 ±1.10	3.15-4.97	118	-0.51	0.63	0.29
last plane – opposing team	2.84 ±0.69	2.24-3.39	2.78 ±1.17	1.74-3.52	124	-0.29	0.79	0.06
all seasons								
goals – own team	0.17 ±0.13	0.14-0.21	0.21 ±0.14	0.16-0.25	1003	-1.29	0.20	0.09
goals – opposing team	0.15 ±0.12	0.12-0.20	0.21 ±0.16	0.16-0.26	909	-1.95	0.05	0.16
chances – own team	1.11 ±0.48	0.94-1.20	1.05 ±0.46	0.91-1.20	1045	-0.89	0.37	0.08
chances – opposing team	0.96 ±0.84	0.81-1.04	0.84 ±0.38	0.72-0.96	994	-1.27	0.21	0.19
last plane – own team	3.16 ±0.85	2.91-3.39	3.45 ±1.11	3.10-3.80	990	-1.29	0.20	0.29
last plane – opposing team	3.20 ±0.99	2.89-3.51	2.93 ±1.14	2.57-3.30	992	-1.28	0.20	0.26

Paper III. Supplementary Table 4. Comparison of 10-min-pre and 10-min-post in-game formation changes.

	Average 10 min. pre in game formation change (mean ±SD)	95% Confidence intervall	Average 10 min. post in game formation change (mean ±SD)	95% Confidence intervall	posit-ive spre-ad	neg-ative spre-ad	tie	p-value	ES
season 1									
goals – own team	0.00 ±0.00	0.00-0.00	0.33 ±0.50	-0.05-0.72	0	3	6	0.25	0.67
goals – opposing team	0.11 ±0.33	-0.15-0.37	0.11 ±0.33	-0.15-0.37	1	1	7	>0.99	0.00
chances – own team	0.56 ±0.73	0.00-1.11	1.56 ±1.51	0.40-2.72	1	5	3	0.22	0.95
chances – opposing team	1.33 ±0.87	0.67-2.00	1.00 ±1.12	0.14-1.86	4	1	4	0.38	0.33
last plane – own team	2.22 ±1.56	1.02-3.42	3.56 ±1.88	2.11-5.00	2	5	2	0.45	1.02
last plane – opposing team	4.22 ±2.05	2.65-5.80	2.44 ±1.74	1.11-3.78	7	0	2	**0.02**	1.29
season 2									
goals – own team	0.18 ±0.40	-0.15-0.37	0.36 ±0.50	-0.05-0.72	2	4	5	0.69	0.27
goals – opposing team	0.45 ±0.52	0.15-0.96	0.18 ±0.40	-0.15-0.37	4	1	6	0.38	0.40
chances – own team	1.18 ±1.08	0.47-2.19	1.91 ±1.81	0.53-3.24	2	4	5	0.69	0.60
chances – opposing team	0.64 ±0.92	-0.10-1.44	0.64 ±0.81	0.00-1.11	2	2	7	>0.99	0.00
last plane – own team	3.73 ±1.56	2.46-5.10	3.91 ±2.21	1.98-5.57	4	5	2	>0.99	0.13
last plane – opposing team	2.81 ±1.40	1.84-3.94	2.64 ±2.50	1.17-5.05	5	5	1	>0.99	0.13
season 3									
goals – own team	0.25 ±0.44	-0.15-0.37	0.29 ±0.53	-0.12-0.56	5	6	17	>0.99	0.05
goals – opposing team	0.21 ±0.42	-0.15-0.37	0.11 ±0.31	-0.15-0.37	6	3	19	0.51	0.18
chances – own team	0.96 ±1.14	-0.06-1.62	1.39 ±1.26	0.77-3.01	7	15	6	0.13	0.39
chances – opposing team	0.86 ±0.93	0.00-1.11	0.82 ±0.67	0.12-1.21	11	10	7	>0.99	0.04
last plane – own team	3.64 ±1.93	3.11-5.78	4.50 ±2.60	3.23-7.66	8	14	6	0.29	0.57
last plane – opposing team	2.43 ±1.75	0.85-3.15	2.57 ±1.83	1.53-5.14	9	13	6	0.52	0.11
all seasons									
goals – own team	0.19 ±0.39	0.03-0.26	0.31 ±0.51	0.15-0.48	7	13	28	0.26	0.18
goals – opposing team	0.25 ±0.44	0.11-0.38	0.13 ±0.33	0.02-0.23	11	5	32	0.21	0.19
chances – own team	0.94 ±1.06	0.68-1,37	1.54 ±1.43	1.21-2.15	10	24	14	**0.03**	0.54
chances – opposing team	0.90 ±0.93	0.57-1.09	0.82 ±0.79	0.52-1.04	17	13	18	0.58	0.09
last plane – own team	3.40 ±1.84	3.08-4.24	4.19 ±2.39	3.65-5.18	14	24	10	0.14	0.54
last plane – opposing team	2.85 ±1.83	2.23-3.33	2.56 ±1.95	1.86-3.17	21	18	9	0.75	0.19

Paper III. Supplementary Table 5. Descriptive information about the seasons 1-3. Single values (means± SD, where applicable).

	season 1	**season 2**	**season 3**
Information about the seasons			
Games incuded	34	30	34
games without formation change	25	20	12
games with formation change	9	10	22
ø points (games without formation change)	1.32 ±1.35	1.55 ±1.28	1.58 ±1.08
ø points (games with formation change)	1.11 ±1.17	1.20 ±1.55	1.45 ±1.37
formation changes in detail:			
formation changes total	9	11	28
ø minute of play of formation change	64.11 ±15.57	55.82 ±13.20	55.46 ±17.45
ø game day of formation change	20.00 ±10.56	10.73 ±6.37	20.59 ±10.64
ø points at moment of formation change	1.22 ±1.39	0.45 ±0.93	1.61 ±1.37
combined changes in offensive & defensive formation	7	5	16
changes only in defensive formation	1	2	8
changes only in offensive formation	1	4	4

Paper III. Supplementary Table 6. Descriptive information about the in-game formation changes.

matchday	defensive formation [before change]	defensive formation [after change]	offensive formation [before change]	offensive formation [after change]	minute	opposition quality [table position end of the season]	current score [own team:opposing team]	end result [own team:opposing team]	home/away match
season 1									
5	5-2-3	5-3-2	4-2-2-2	4-2-2-2	41	17	1:1	1:1	away
8	3-4-2-1	4-4-2 diamond	3-4-2-1	4-3-3	45	9	1:2	3:3	home
10	4-4-2 diamond	4-2-3-1	4-4-2 diamond	4-2-3-1	69	13	3:1	3:1	home
14	4-2-3-1	4-2-3-1	4-2-3-1	3-4-3 diamond	49	10	0:3	1:3	home
26	5-2-3	4-4-2 diamond	3-4-2-1	4-4-2 diamond	76	12	1:2	1:2	home
27	5-3-2	4-2-3-1	3-4-1-2	4-2-3-1	75	13	0:2	1:2	away
29	4-2-3-1	5-3-2	4-2-3-1	3-1-4-2	62	2	0:0	0:0	away
30	4-2-3-1/4-4-2	5-3-2	4-2-3-1	3-1-4-2	83	8	3:2	3:2	home
31	4-2-3-1/4-4-2	5-3-2	4-2-3-1	3-1-4-2	77	10	1:0	1:1	away
season 2									
2	5-4-1	5-4-1	3-4-3	3-1-5-1	46	16	0:1	3:2	home
4	3-4-3	4-3-3	3-4-1-2	4-3-3	46	8	0:2	0:3	home
4	4-3-3	3-5-2	4-3-3	3-5-2	70	8	0:3	0:3	home
7	4-1-4-1	5-4-1	3-4-2	3-4-2	82	1	2:1	2:1	away
8	3-4-3	3-5-2	4-1-3-2	3-5-2	45	12	0:0	2:0	home
11	3-5-2	3-4-3	3-4-2-1	3-4-2-1	46	14	0:1	2:1	away
12	3-4-3	3-4-3	3-4-2-1/3-1-5-1	3-2-3-2	55	13	0:2	1:5	home
15	4-2-3-1	4-2-3-1	4-2-2-2/3-1-5-1	3-5-2	61	15	1:3	2:4	home
15	4-2-3-1	4-2-3-1	3-5-2	4-1-4-1	71	15	1:3	2:4	home
18	4-3-3	3-5-2	4-3-3/3-1-5-1	3-5-2	46	9	0:1	1:2	home
22	3-5-2	4-2-3-1	3-1-5-1	4-2-3-1	46	7	1:1	2:3	home
season 3									
3	4-3-2-1	3-3-2-2	3-1-5-1	4-1-3-2	41	10	0:0	1:2	away
3	3-3-2-2	4-3-3	4-1-3-2	4-1-3-2	72	10	0:1	1:2	away
15	4-1-4-1	4-1-4-1	3-4-2-1	3-5-2	65	5	0:0	0:0	home
18	3-5-2	4-3-3	3-1-5-1	3-1-5-1	46	1	0:2	1:3	home
20	3-5-2	3-5-2	3-1-5-1	3-5-2	73	10	1:1	1:1	home
22	4-4-2 diamond	3-5-2	3-1-3-3	3-1-3-3	46	17	2:0	3:0	home
24	3-1-5-1	4-2-3-1	3-1-5-1	4-2-2-2	38	7	0:1	2:3	away
24	4-2-3-1	4-4-1	4-2-2-2	4-4-1	67	7	2:1	2:3	away
25	3-4-1-2	3-5-2	3-5-2	4-3-3	70	18	1:1	2:1	home
28	3-5-2	3-5-2	4-2-2-2	3-4-3	62	15	2:0	4:0	away
28	3-5-2	5-4-1	3-4-3	3-4-3	46	15	1:0	4:0	away
30	3-4-1-2	4-2-2-2	3-1-5-1	4-2-2-2	56	14	2:0	5:2	away

30	4-2-2-2	3-4-3	4-2-2-2	3-4-3	71	14	3:1	5:2	away
31	4-4-2 Raute	3-5-2	4-2-2-2	3-4-3	12	6	1:0	1:4	home
31	3-5-2	5-4-1	3-4-3	4-2-4	73	6	1:2	1:4	home
33	4-4-2 diamond	3-4-3	3-5-2	3-5-2	46	8	0:1	0:1	home
33	3-4-3	3-5-2	3-5-2	3-5-2	60	8	0:1	0:1	home
2	5-3-2	5-4-1	4-4-2	4-3-3	46	13	0:1	3:1	home
6	4-2-3-1	4-2-3-1	3-5-2	4-3-3	78	3	0:2	1:2	home
7	5-3-2	4-3-3	3-5-2	4-3-3	66	7	0:2	1:2	home
9	4-4-2 diamond	5-3-2	4-4-2 diamond	3-3-3-1	29	16	0:0	4:0	home
10	5-4-1	5-3-2	3-4-3	3-5-2	60	4	3:1	4:1	away
11	4-3-3	5-3-2	4-3-3	3-5-2	72	15	1:1	2:1	home
12	4-5-1	5-3-2	3-1-4-2	3-1-4-2	16	11	2:1	3:3	away
19	4-4-2 diamond	5-3-2	4-4-2 diamond	3-5-2	65	13	2:1	4:2	away
23	4-4-2 diamond	5-3-2	3-1-5-1	3-5-2	65	3	1:0	1:1	away
32	4-2-3-1	5-3-2	3-1-4-2	3-1-4-2	70	5	1:0	2:2	away
34	4-3-3	4-4-1	3-4-3	4-4-1	42	12	2:0	2:4	away

Paper IV. Supplementary Table 1. Descriptive values (mean ± SD) per position (center back, full back, central midfielder, wide midfielder, forward) depending on the tactical formation.

position	formation	sample	Mean	SD
total distance [km]				
CB	4-4-2	32	10.14	0.65
	4-4-2 dia.	121	10.14	0.58
	4-2-2-2	89	10.05	0.49
	4-3-3	209	10.48	0.59
	4-5-1	85	10.01	0.71
	4-2-3-1	195	10.20	0.59
	3-4-3	212	10.33	0.68
	3-5-2	184	10.21	0.67
FB	4-4-2	29	10.69	0.65
	4-4-2 dia.	110	10.87	0.64
	4-2-2-2	79	10.80	0.56
	4-3-3	183	10.98	0.68
	4-5-1	82	10.67	0.65
	4-2-3-1	181	10.81	0.65
	3-4-3	131	11.05	0.60
	3-5-2	118	11.03	0.67
CM	4-4-2	24	11.67	0.51
	4-4-2 dia.	83	11.32	0.67
	4-2-2-2	67	11.74	0.60
	4-3-3	221	11.78	0.67
	4-5-1	101	11.66	0.68
	4-2-3-1	210	11.64	0.71
	3-4-3	98	11.61	0.71
	3-5-2	123	11.81	0.66
WM	4-4-2	11	11.50	0.60
	4-4-2 dia.	77	11.78	0.65
	4-2-2-2	44	11.17	0.58
	4-3-3	88	11.16	0.66
	4-5-1	43	11.15	0.67
	4-2-3-1	112	11.28	0.85
	3-4-3	85	10.70	0.91
F	4-4-2	18	11.20	1.13
	4-4-2 dia.	57	11.00	0.65
	4-2-2-2	48	11.29	0.81
	4-3-3	74	10.92	0.64
	4-5-1	22	10.87	0.81
	4-2-3-1	54	10.97	0.94
	3-4-3	43	10.98	0.85
	3-5-2	67	10.62	0.77
high-intensity distance [km]				
CB	4-4-2	32	0.96	0.27
	4-4-2 dia.	121	1.00	0.17
	4-2-2-2	89	0.88	0.17
	4-3-3	209	1.01	0.24
	4-5-1	85	0.90	0.25
	4-2-3-1	195	0.96	0.18
	3-4-3	212	1.08	0.22
	3-5-2	184	1.05	0.24
FB	4-4-2	29	1.23	0.33
	4-4-2 dia.	110	1.41	0.22
	4-2-2-2	79	1.29	0.20
	4-3-3	183	1.43	0.26
	4-5-1	82	1.26	0.29
	4-2-3-1	181	1.38	0.24
	3-4-3	131	1.56	0.25
	3-5-2	118	1.49	0.25
CM	4-4-2	24	1.41	0.23
	4-4-2 dia.	83	1.48	0.30
	4-2-2-2	67	1.57	0.30
	4-3-3	221	1.58	0.34
	4-5-1	101	1.54	0.35
	4-2-3-1	210	1.58	0.30

position	formation	sample	Mean	SD
dribblings [quantity]				
CB	4-4-2	32	0.31	0.54
	4-4-2 dia.	121	0.23	0.57
	4-2-2-2	89	0.20	0.48
	4-3-3	209	0.19	0.45
	4-5-1	85	0.09	0.40
	4-2-3-1	195	0.19	0.46
	3-4-3	212	0.23	0.56
	3-5-2	184	0.22	0.54
FB	4-4-2	29	0.79	0.94
	4-4-2 dia.	110	1.09	1.24
	4-2-2-2	79	0.90	1.10
	4-3-3	183	0.77	1.11
	4-5-1	82	0.80	1.06
	4-2-3-1	181	1.17	1.28
	3-4-3	131	1.38	1.45
	3-5-2	118	1.51	1.68
CM	4-4-2	24	0.33	0.64
	4-4-2 dia.	83	0.94	1.18
	4-2-2-2	67	0.61	1.09
	4-3-3	221	0.75	1.05
	4-5-1	101	0.84	1.23
	4-2-3-1	210	0.80	1.07
	3-4-3	98	0.65	0.90
	3-5-2	123	1.04	1.38
WM	4-4-2	11	2.45	1.81
	4-4-2 dia.	77	1.18	1.32
	4-2-2-2	44	2.36	2.28
	4-3-3	88	2.24	1.97
	4-5-1	43	2.07	1.89
	4-2-3-1	112	2.40	2.22
	3-4-3	85	1.47	1.74
F	4-4-2	18	1.17	1.69
	4-4-2 dia.	57	1.75	1.98
	4-2-2-2	48	1.35	1.68
	4-3-3	74	0.54	0.83
	4-5-1	22	0.95	1.62
	4-2-3-1	54	1.22	1.19
	3-4-3	43	1.44	1.39
	3-5-2	67	1.51	1.53
passes short [quantity]				
CB	4-4-2	32	8.22	4.80
	4-4-2 dia.	121	9.69	8.05
	4-2-2-2	89	10.57	8.03
	4-3-3	209	13.86	10.14
	4-5-1	85	10.14	6.25
	4-2-3-1	195	14.77	9.37
	3-4-3	212	13.57	9.33
	3-5-2	184	13.26	8.63
FB	4-4-2	29	8.62	4.46
	4-4-2 dia.	110	13.99	7.88
	4-2-2-2	79	14.63	8.66
	4-3-3	183	18.11	11.71
	4-5-1	82	12.65	7.62
	4-2-3-1	181	21.49	13.42
	3-4-3	131	14.29	7.57
	3-5-2	118	13.39	6.16
CM	4-4-2	24	15.42	6.57
	4-4-2 dia.	83	18.17	10.69
	4-2-2-2	67	19.37	12.53
	4-3-3	221	19.80	12.04
	4-5-1	101	15.30	8.69
	4-2-3-1	210	23.32	12.70

	3-4-3	98	1.58	0.38
	3-5-2	123	1.61	0.32
WM	4-4-2	11	1.62	0.22
	4-4-2 dia.	77	1.79	0.32
	4-2-2-2	44	1.48	0.22
	4-3-3	88	1.59	0.24
	4-5-1	43	1.46	0.24
	4-2-3-1	112	1.59	0.24
	3-4-3	85	1.42	0.33
F	4-4-2	18	1.41	0.39
	4-4-2 dia.	57	1.51	0.33
	4-2-2-2	48	1.48	0.25
	4-3-3	74	1.47	0.30
	4-5-1	22	1.41	0.29
	4-2-3-1	54	1.42	0.38
	3-4-3	43	1.45	0.32
	3-5-2	67	1.45	0.31
sprinting distance [km]				
CB	4-4-2	32	0.16	0.08
	4-4-2 dia.	121	0.18	0.09
	4-2-2-2	89	0.16	0.09
	4-3-3	209	0.16	0.08
	4-5-1	85	0.17	0.08
	4-2-3-1	195	0.17	0.07
	3-4-3	212	0.22	0.09
	3-5-2	184	0.22	0.10
FB	4-4-2	29	0.26	0.11
	4-4-2 dia.	110	0.37	0.13
	4-2-2-2	79	0.32	0.12
	4-3-3	183	0.35	0.11
	4-5-1	82	0.32	0.11
	4-2-3-1	181	0.37	0.14
	3-4-3	131	0.40	0.13
	3-5-2	118	0.39	0.13
CM	4-4-2	24	0.21	0.09
	4-4-2 dia.	83	0.27	0.13
	4-2-2-2	67	0.23	0.11
	4-3-3	221	0.26	0.13
	4-5-1	101	0.24	0.11
	4-2-3-1	210	0.26	0.13
	3-4-3	98	0.25	0.10
	3-5-2	123	0.27	0.12
WM	4-4-2	11	0.40	0.12
	4-4-2 dia.	77	0.33	0.12
	4-2-2-2	44	0.36	0.12
	4-3-3	88	0.41	0.14
	4-5-1	43	0.47	0.18
	4-2-3-1	112	0.43	0.17
	3-4-3	85	0.35	0.12
F	4-4-2	18	0.32	0.15
	4-4-2 dia.	57	0.43	0.11
	4-2-2-2	48	0.32	0.11
	4-3-3	74	0.31	0.13
	4-5-1	22	0.32	0.13
	4-2-3-1	54	0.32	0.11
	3-4-3	43	0.34	0.14
	3-5-2	67	0.36	0.12
max. velocity [km/h]				
CB	4-4-2	32	30.80	1.20
	4-4-2 dia.	121	30.76	1.67
	4-2-2-2	89	30.17	1.75
	4-3-3	209	30.37	1.85
	4-5-1	85	30.68	1.63
	4-2-3-1	195	30.75	2.18
	3-4-3	212	30.91	1.56
	3-5-2	184	30.97	1.67
FB	4-4-2	29	31.03	2.07
	4-4-2 dia.	110	31.44	1.45

	3-4-3	98	20.00	9.96
	3-5-2	123	16.49	7.56
WM	4-4-2	11	11.73	5.87
	4-4-2 dia.	77	18.70	9.75
	4-2-2-2	44	14.36	7.97
	4-3-3	88	16.63	11.06
	4-5-1	43	11.49	8.04
	4-2-3-1	112	18.11	10.93
	3-4-3	85	13.96	7.64
F	4-4-2	18	10.29	5.73
	4-4-2 dia.	57	14.01	9.38
	4-2-2-2	48	14.14	9.44
	4-3-3	74	16.75	11.16
	4-5-1	22	12.43	7.76
	4-2-3-1	54	19.07	12.15
	3-4-3	43	15.09	8.95
	3-5-2	67	13.93	7.54
passes middle [quantity]				
CB	4-4-2	32	33.47	14.33
	4-4-2 dia.	121	30.40	15.24
	4-2-2-2	89	29.94	16.61
	4-3-3	209	45.95	21.05
	4-5-1	85	29.28	16.20
	4-2-3-1	195	38.67	18.20
	3-4-3	212	29.21	15.09
	3-5-2	184	24.67	13.58
FB	4-4-2	29	17.90	6.07
	4-4-2 dia.	110	19.70	9.10
	4-2-2-2	79	19.57	8.38
	4-3-3	183	25.14	11.49
	4-5-1	82	17.65	7.03
	4-2-3-1	181	22.85	10.58
	3-4-3	131	16.76	7.85
	3-5-2	118	15.69	6.80
CM	4-4-2	24	24.25	9.62
	4-4-2 dia.	83	21.12	9.33
	4-2-2-2	67	24.34	11.43
	4-3-3	221	25.10	13.10
	4-5-1	101	18.65	8.66
	4-2-3-1	210	24.13	12.95
	3-4-3	98	21.10	9.31
	3-5-2	123	17.73	8.41
WM	4-4-2	11	14.91	3.65
	4-4-2 dia.	77	17.78	7.83
	4-2-2-2	44	12.64	6.68
	4-3-3	88	14.47	6.80
	4-5-1	43	10.30	4.45
	4-2-3-1	112	14.29	6.53
	3-4-3	85	9.05	6.17
F	4-4-2	18	10.22	4.25
	4-4-2 dia.	57	8.28	5.00
	4-2-2-2	48	9.25	6.33
	4-3-3	74	10.58	7.65
	4-5-1	22	6.05	2.84
	4-2-3-1	54	8.15	3.70
	3-4-3	43	11.26	7.99
	3-5-2	67	7.96	3.70
passes long [quantity]				
CB	4-4-2	32	5.53	2.96
	4-4-2 dia.	121	6.13	4.42
	4-2-2-2	89	5.54	3.66
	4-3-3	209	6.02	4.39
	4-5-1	85	5.55	3.36
	4-2-3-1	195	5.36	3.69
	3-4-3	212	5.46	3.77
	3-5-2	184	4.77	3.19
FB	4-4-2	29	4.14	2.66
	4-4-2 dia.	110	3.67	2.54

	4-2-2-2	79	31.63	1.75		4-2-2-2	79	3.70	2.75
	4-3-3	183	31.35	1.29		4-3-3	183	3.24	2.53
	4-5-1	82	31.39	1.26		4-5-1	82	3.87	2.56
	4-2-3-1	181	31.86	1.56		4-2-3-1	181	3.06	2.65
	3-4-3	131	31.72	1.45		3-4-3	131	3.08	2.28
	3-5-2	118	31.58	1.52		3-5-2	118	2.66	2.30
CM	4-4-2	24	30.20	1.41	CM	4-4-2	24	2.08	1.59
	4-4-2 dia.	83	30.89	1.72		4-4-2 dia.	83	3.35	3.21
	4-2-2-2	67	30.19	1.43		4-2-2-2	67	3.28	2.71
	4-3-3	221	30.52	1.68		4-3-3	221	3.19	2.78
	4-5-1	101	30.23	1.35		4-5-1	101	2.55	2.11
	4-2-3-1	210	30.39	1.64		4-2-3-1	210	2.67	2.74
	3-4-3	98	30.25	1.54		3-4-3	98	2.22	1.80
	3-5-2	123	30.41	2.29		3-5-2	123	2.37	2.11
WM	4-4-2	11	31.79	1.37	WM	4-4-2	11	1.36	1.36
	4-4-2 dia.	77	30.66	2.70		4-4-2 dia.	77	2.56	2.16
	4-2-2-2	44	31.70	1.30		4-2-2-2	44	1.68	1.88
	4-3-3	88	31.85	1.44		4-3-3	88	1.35	1.47
	4-5-1	43	32.10	1.04		4-5-1	43	1.26	1.38
	4-2-3-1	112	31.97	1.51		4-2-3-1	112	1.33	1.42
	3-4-3	85	31.31	1.25		3-4-3	85	1.06	1.37
F	4-4-2	18	30.87	1.41	F	4-4-2	18	0.56	0.86
	4-4-2 dia.	57	32.20	1.15		4-4-2 dia.	57	0.53	0.85
	4-2-2-2	48	30.88	1.76		4-2-2-2	48	0.75	1.49
	4-3-3	74	30.92	1.37		4-3-3	74	1.01	1.65
	4-5-1	22	31.40	1.71		4-5-1	22	0.36	0.73
	4-2-3-1	54	31.08	1.31		4-2-3-1	54	0.50	0.75
	3-4-3	43	31.32	1.39		3-4-3	43	1.09	1.25
	3-5-2	67	31.65	1.55		3-5-2	67	0.57	0.82
accelerations [quantity]					**ball-possession phases [quantity]**				
CB	4-4-2	32	481.13	39.12	CB	4-4-2	32	64.81	18.48
	4-4-2 dia.	121	471.07	34.78		4-4-2 dia.	121	63.16	19.59
	4-2-2-2	89	471.78	32.14		4-2-2-2	89	62.30	21.20
	4-3-3	205	489.76	35.77		4-3-3	209	80.54	27.28
	4-5-1	85	480.66	38.31		4-5-1	85	60.91	20.15
	4-2-3-1	190	482.94	37.26		4-2-3-1	195	73.88	24.21
	3-4-3	212	478.80	35.26		3-4-3	212	64.45	19.75
	3-5-2	176	474.84	36.46		3-5-2	184	59.86	18.24
FB	4-4-2	29	507.83	34.56	FB	4-4-2	29	58.62	13.44
	4-4-2 dia.	110	492.22	37.03		4-4-2 dia.	110	65.67	15.83
	4-2-2-2	79	503.23	38.15		4-2-2-2	79	65.48	16.82
	4-3-3	180	510.58	38.29		4-3-3	183	72.81	19.49
	4-5-1	82	499.50	39.93		4-5-1	82	59.44	14.06
	4-2-3-1	175	505.46	37.49		4-2-3-1	181	74.67	19.39
	3-4-3	131	501.37	34.46		3-4-3	131	62.49	14.60
	3-5-2	112	504.22	33.75		3-5-2	118	58.69	13.33
CM	4-4-2	24	533.71	25.53	CM	4-4-2	24	57.38	13.41
	4-4-2 dia.	83	497.87	36.03		4-4-2 dia.	83	61.58	16.94
	4-2-2-2	67	522.12	28.93		4-2-2-2	67	64.85	20.75
	4-3-3	217	515.96	42.49		4-3-3	221	64.18	22.84
	4-5-1	101	512.51	38.93		4-5-1	101	52.68	15.74
	4-2-3-1	206	511.36	40.43		4-2-3-1	210	66.23	21.72
	3-4-3	98	526.88	41.93		3-4-3	98	60.94	16.35
	3-5-2	119	514.52	37.65		3-5-2	123	54.74	14.27
WM	4-4-2	11	516.82	50.88	WM	4-4-2	11	48.36	9.27
	4-4-2 dia.	77	512.94	32.86		4-4-2 dia.	77	56.51	14.52
	4-2-2-2	44	499.61	36.72		4-2-2-2	44	47.59	13.94
	4-3-3	86	485.56	37.63		4-3-3	88	51.91	17.97
	4-5-1	43	483.44	36.64		4-5-1	43	42.00	14.06
	4-2-3-1	109	504.14	40.59		4-2-3-1	112	53.32	15.98
	3-4-3	85	463.78	45.92		3-4-3	85	42.35	13.05
F	4-4-2	18	486.56	47.29	F	4-4-2	18	35.56	8.37
	4-4-2 dia.	57	466.16	40.54		4-4-2 dia.	57	37.75	8.60
	4-2-2-2	48	480.79	36.78		4-2-2-2	48	38.81	12.23
	4-3-3	72	478.85	32.94		4-3-3	74	40.70	14.58
	4-5-1	22	466.27	37.66		4-5-1	22	31.32	7.29
	4-2-3-1	51	478.65	44.76		4-2-3-1	54	36.83	11.04
	3-4-3	43	477.09	40.56		3-4-3	43	46.09	12.93

	3-5-2	64	459.13	43.17		3-5-2	67	37.88	9.55

[dia. = diamond; CB = Center Back; FB = Full Back; CM = Central Midfielder; WM = Wide Midfielder; F = Forward]

Paper IV. Supplementary Table 2. Descriptive values (mean ± SD) depending on the tactical formation.

formation	sample	Mean	SD	Formation	Stichprobe	Mean	SD
total distance [km]				**dribblings [quantity]**			
4-4-2	114	10.9	0.92	4-4-2	114	0.78	1.22
4-4-2 dia.	448	10.93	0.85	4-4-2 dia.	448	0.93	1.32
4-2-2-2	327	10.91	0.86	4-2-2-2	327	0.91	1.47
4-3-3	775	11.09	0.81	4-3-3	775	0.75	1.22
4-5-1	333	10.88	0.93	4-5-1	333	0.81	1.31
4-2-3-1	752	10.96	0.9	4-2-3-1	752	1.00	1.44
3-4-3	569	10.82	0.85	3-4-3	569	0.85	1.27
3-5-2	492	10.86	0.93	3-5-2	492	0.91	1.38
high-intensity distance [km]				**passes short [quantity]**			
4-4-2	114	1.26	0.36	4-4-2	114	10.29	5.73
4-4-2 dia.	448	1.39	0.37	4-4-2 dia.	448	14.01	9.38
4-2-2-2	327	1.29	0.35	4-2-2-2	327	14.14	9.44
4-3-3	775	1.38	0.37	4-3-3	775	16.75	11.16
4-5-1	333	1.29	0.38	4-5-1	333	12.43	7.76
4-2-3-1	752	1.36	0.36	4-2-3-1	752	19.07	12.15
3-4-3	569	1.36	0.36	3-4-3	569	15.09	8.95
3-5-2	492	1.35	0.36	3-5-2	492	13.93	7.54
sprinting distance [km]				**passes middle [quantity]**			
4-4-2	114	0.25	0.13	4-4-2	114	22.11	12.56
4-4-2 dia.	448	0.30	0.14	4-4-2 dia.	448	21.07	12.60
4-2-2-2	327	0.26	0.13	4-2-2-2	327	20.92	13.56
4-3-3	775	0.28	0.14	4-3-3	775	28.14	18.73
4-5-1	333	0.28	0.15	4-5-1	333	19.21	12.35
4-2-3-1	752	0.29	0.15	4-2-3-1	752	24.98	15.93
3-4-3	569	0.29	0.13	3-4-3	569	20.58	13.47
3-5-2	492	0.29	0.13	3-5-2	492	18.51	11.43
max. velocity [km/h]				**passes long [quantity]**			
4-4-2	114	30.84	1.58	4-4-2	114	3.26	2.90
4-4-2 dia.	448	31.11	1.86	4-4-2 dia.	448	3.69	3.57
4-2-2-2	327	30.84	1.76	4-2-2-2	327	3.41	3.22
4-3-3	775	30.86	1.67	4-3-3	775	3.55	3.50
4-5-1	333	30.95	1.53	4-5-1	333	3.33	2.96
4-2-3-1	752	31.12	1.85	4-2-3-1	752	3.11	3.15
3-4-3	569	31.07	1.55	3-4-3	569	3.37	3.24
3-5-2	492	31.07	1.85	3-5-2	492	3.09	2.89
accelerations [quantity]				**ball-possession phases [quantity]**			
4-4-2	114	503.29	42.63	4-4-2	114	55.46	17.01
4-4-2 dia.	448	487.80	39.43	4-4-2 dia.	448	59.11	18.37
4-2-2-2	327	494.76	38.95	4-2-2-2	327	58.17	20.50
4-3-3	760	500.66	40.70	4-3-3	775	66.99	25.41
4-5-1	333	494.37	41.22	4-5-1	333	53.65	18.07
4-2-3-1	731	499.20	41.08	4-2-3-1	752	66.21	23.21
3-4-3	569	489.91	43.52	3-4-3	569	58.70	18.58
3-5-2	471	489.72	42.26	3-5-2	492	55.31	16.77

[dia. = diamond]

Paper IV. Supplementary Table 3. Descriptive values (mean ± SD) depending on the playing position.

position	sample	Mean	SD	position	sample	Mean	SD
total distance [km]				**dribblings [quantity]**			
CB	1127	10.24	0.64	CB	1127	0.20	0.50
FB	913	10.90	0.65	FB	913	1.09	1.31
CM	927	11.67	0.69	CM	927	0.80	1.12
WM	460	11.21	0.82	WM	460	1.96	1.97
F	383	10.95	0.81	F	383	1.24	1.51
high-intensity distance [km]				**passes short [quantity]**			
CB	1127	1.00	0.22	CB	1127	12.72	9.04
FB	913	1.41	0.27	FB	913	16.03	10.35
CM	927	1.57	0.33	CM	927	19.40	11.24
WM	460	1.57	0.29	WM	460	16.03	9.84
F	383	1.46	0.32	F	383	12.14	6.09
Sprinting distance [km]				**passes middle [quantity]**			
CB	1127	0.19	0.09	CB	1127	33.52	18.33
FB	913	0.36	0.13	FB	913	20.22	9.80
CM	927	0.25	0.12	CM	927	22.35	11.49
WM	460	0.39	0.15	WM	460	13.42	7.12
F	383	0.34	0.13	F	383	9.07	5.86
max. velocity [km/h]				**passes long [quantity]**			
CB	1127	30.69	1.79	CB	1127	5.52	3.82
FB	913	31.56	1.49	FB	913	3.28	2.54
CM	927	30.42	1.70	CM	927	2.79	2.57
WM	460	31.59	1.72	WM	460	1.52	1.67
F	383	31.33	1.50	F	383	0.71	1.18
accelerations [quantity]				**ball-possession phases [quantity]**			
CB	1110	479.71	36.37	CB	1127	67.75	23.21
FB	898	503.45	37.17	FB	913	66.73	17.85
CM	915	514.80	39.76	CM	927	61.44	19.88
WM	455	492.49	42.79	WM	460	49.83	15.97
F	375	473.21	40.52	F	383	38.81	11.76

[CB = Center Back; FB = Full Back; CM = Central Midfielder; WM = Wide Midfielder; F = Forward]

Paper IV. Supplementary Table 4. Number of players per position (center back, full back, central midfielder, wide midfielder, forward) depending on the tactical formation.

		position				
		center back	full back	central midfielder	Wide midfielder	forward
formation	4-4-2	2	2	2	2	2
	4-4-2 dia.	2	2	2	2	2
	4-2-2-2	2	2	2	2	2
	4-3-3	2	2	3	2	1
	4-5-1	2	2	3	2	1
	4-2-3-1	2	2	3	2	1
	3-4-3	3	2	2	2	1
	3-5-2	3	2	3	0	2
	3-4-3 dia.	3	2	2	2	1

dia. = diamond

Paper IV. Supplementary File 1. Distribution of the playing positions in the different tactical formations.

Paper V. Supplementary Table 1. Number of players per position (center back, full back, central midfielder, wide midfielder, forward) depending on the tactical formation.

		playing position				
		center back	full back	central midfielder	Wide midfielder	forward
tactical formation	4-4-2	2	2	2	2	2
	4-4-2 diamond	2	2	2	2	2
	4-2-2-2	2	2	2	2	2
	4-3-3	2	2	3	2	1
	4-5-1	2	2	3	2	1
	4-2-3-1	2	2	3	2	1
	3-4-3	3	2	2	2	1
	3-5-2	3	2	3	0	2

Paper V. Supplementary Table 2. Descriptive values (mean ± SD), t-test results, and ES of each player of the study sample for dribblings, short passes, medium passes, long passes, and ball possessions.

	Position 1	**Position 2**	**t-value**	**df**	**p-value**	**ES**
Player 1	**CM (4222) [n=9]**	**CB (343) [n=4]**				
Dribblings	0.11 ±0.31	0.00 ±0.00	0.65	11	0.53	0.28
Short Passes	8.56 ±5.04	12.00 ±2.35	-1.20	11	0.26	1.66
Medium Passes	23.89 ±12.82	22.00 ±7.58	0.25	11	0.81	0.55
Long Passes	2.56 ±1.83	3.75 ±3.03	-0.81	11	0.44	0.81
Ball Possessions	50.67 ±14.84	48.75 ±6.72	0.23	11	0.82	0.54
Player 2	**CM (4231) [n=5]**	**CB (451) [n=6]**				
Dribblings	0.00+0.00	0.00 ±0.00	0.00	9	>0.99	0.00
Short Passes	13.00 ±3.79	7.17 ±4.52	2.07	9	0.07	2.85
Medium Passes	25.40 ±7.39	33.67 ±16.19	-0.95	9	0.37	2.36
Long Passes	1.60 ±1.02	3.50 ±2.06	-1.70	9	0.12	1.50
Ball Possessions	57.40 ±10.19	58.33 ±19.11	-0.89	9	0.93	0.24
Player 3	**CB (4231) [n=9]**	**FB (4231) [n=6]**				
Dribblings	0.44 ±0.68	2.00 ±1.15	-3.04	13	<0.01	1.67
Short Passes	20.44 ±9.89	32.00 ±9.64	-2.08	13	0.06	3.69
Medium Passes	40.33 ±14.77	27.50 ±11.79	1.66	13	0.12	3.47
Long Passes	4.78 ±2.20	2.17 ±1.07	2.52	13	0.03	1.97
Ball Possessions	79.11 ±17.60	90.17 ±21.08	-1.02	13	0.33	2.54
Player 4	**WM (451) [n=4]**	**FB (352) [n=4]**				
Dribblings	1.75 ±1.30	1.25 ±0.43	0.63	6	0.55	0.54
Short Passes	7.75 ±1.79	12.25 ±8.32	-0.92	6	0.40	2.00
Medium Passes	9.50 ±4.27	10.75 ±5.31	-0.32	6	0.76	0.57
Long Passes	1.75 ±1.79	3.25 ±0.83	-1.32	6	0.24	1.31
Ball Possessions	37.00 ±4.18	48.50 ±11.28	-1.66	6	0.15	4.14
Player 5	**CM (442 diamond) [n=7]**	**F (433) [n=8]**				
Dribblings	2.14 ±1.46	0.75 ±0.97	2.05	13	0.06	1.27
Short Passes	24.71 ±4.59	18.38 ±3.46	2.83	13	0.01	3.18
Medium Passes	25.00 ±7.73	22.63 ±5.17	0.66	13	0.52	0.94
Long Passes	4.43 ±2.50	4.38 ±2.39	0.39	13	0.97	0.03
Ball Possessions	78.86 ±7.38	63.38 ±9.91	2.75	13	0.01	4.56
Player 6	**WM (4222) [n=8]**	**CM (352) [n=6]**				
Dribblings	1.13 ±0.93	1.17 ±1.21	-0.07	12	0.95	0.04
Short Passes	19.13 ±6.21	19.00 ±4.00	0.04	12	0.97	0.05
Medium Passes	15.63 ±7.16	18.00 ±7.87	-0.55	12	0.60	0.87
Long Passes	3.38 ±2.50	3.17 ±2.19	0.15	12	0.88	0.14

Ball Possessions	57.63 ±5.27	57.67 ±6.52	-0.01	12	0.99	0.02
Player 7	**CM (442 diamond) [n=6]**	**WM (442 diamond) [n=10]**				
Dribblings	0.67 ±0.75	2.00 ±1.61	-1.78	14	0.10	1.17
Short Passes	21.17 ±9.17	17.90 ±7.88	0.75	14	0.49	1.13
Medium Passes	20.83 ±10.25	12.10 ±5.26	2.10	14	0.05	3.29
Long Passes	4.50 ±3.20	1.70 ±1.00	2.40	14	0.03	2.09
Ball Possessions	63.50 ±18.73	49.80 ±10.57	1.75	14	0.10	3.73
Player 8	**WM (442 diamond) [n=7]**	**CM (433) [n=12]**				
Dribblings	0.29 ±0.45	0.83 ±0.80	-1.57	17	0.13	0.67
Short Passes	18.29 ±6.32	16.25 ±7.07	0.60	17	0.56	0.78
Medium Passes	20.86 ±6.75	21.17 ±9.55	-0.07	17	0.94	0.11
Long Passes	2.29 ±1.83	1.50 ±1.61	0.92	17	0.37	0.61
Ball Possessions	57.29 ±11.35	55.17 ±18.68	0.26	17	0.80	0.53
Player 9	**WM (442 diamond) [n=7]**	**CM (433) [n=7]**				
Dribblings	0.86 ±0.64	0.43 ±0.49	1.30	12	0.22	0.57
Short Passes	22.14 ±6.20	15.14 ±2.80	2.52	12	0.03	3.30
Medium Passes	14.14 ±2.10	18.00 ±3.85	-2.15	12	0.05	2.24
Long Passes	1.57 ±1.68	2.00 ±0.93	-0.55	12	0.59	0.38
Ball Possessions	53.71 ±6.54	50.29 ±8.78	0.77	12	0.46	1.24
Player 10	**WM (442 diamond) [n=4]**	**CM (433) [n=5]**				
Dribblings	2.25 ±1.30	2.80 ±2.40	-0.36	7	0.73	0.40
Short Passes	23.50 ±8.53	26.00 ±17.30	-0.23	7	0.82	0.68
Medium Passes	18.25 ±6.68	21.00+5.76	-0.58	7	0.58	1.11
Long Passes	4.00 ±2.12	4.20 ±3.66	-0.08	7	0.93	0.12
Ball Possessions	71.50 ±13.39	77.20 ±15.65	-0.51	7	0.63	1.49
Player 11	**WM (433) [n=5]**	**CM (4231) [n=11]**				
Dribblings	2.80 ±1.47	1.64 ±1.07	1.67	14	0.12	1.07
Short Passes	43.00 ±24.39	25.55 ±6.51	2.06	14	0.06	5.12
Medium Passes	24.80 ±7.88	17.82 ±8.99	1.40	14	0.18	2.37
Long Passes	1.60 ±1.02	2.09 ±1.38	-0.67	14	0.52	0.43
Ball Possessions	88.60 ±28.95	63.00 ±10.00	2.44	14	0.03	6.52
Player 12	**WM (433) [n=8]**	**F (352) [n=5]**				
Dribblings	1.50 ±1.80	1.20 ±1.47	0.29	11	0.78	0.23
Short Passes	12.63 ±4.85	11.20 ±4.35	0.49	11	0.63	0.66
Medium Passes	10.50 ±4.53	7.00 ±2.28	1.48	11	0.17	1.82
Long Passes	0.25 ±0.66	0.20 ±0.40	0.14	11	0.89	0.07
Ball Possessions	36.50 ±10.07	32.80 ±4.45	0.71	11	0.49	1.31
Player 13	**F (433) [n=9]**	**WM (4231) [n=4]**				
Dribblings	0.78 ±1.03	1.75 ±1.79	-1.14	11	0.28	0.87
Short Passes	11.33 ±4.27	15.50 ±7.53	-1.16	11	0.27	1.83
Medium Passes	9.11 ±4.75	16.00 ±4.90	-2.20	11	0.05	3.15
Long Passes	1.00 ±0.67	2.00 ±1.58	-1.48	11	0.17	1.04
Ball Possessions	39.33 ±7.73	48.75 ±10.66	-1.65	11	0.13	3.22

[CB = Center Back; FB = Full Back; CM = Central Midfielder; WM = Wide Midfielder; F = Forward]

Paper V. Supplementary Table 3. Descriptive values (mean ± SD) per position (center back, full back, central midfielder, wide midfielder, forward) depending on the tactical formation (normative data).

Position	Formation	Sample	Mean	SD	Position	Formation	Sample	Mean	SD
Ball Possessions					**Dribblings**				
center back	4-4-2	32	64.81	18.48	center back	4-4-2	32	0.31	0.54
	4-4-2 diamond	121	63.16	19.59		4-4-2 diamond	121	0.23	0.57
	4-2-2-2	89	62.30	21.20		4-2-2-2	89	0.20	0.48
	4-3-3	209	80.54	27.28		4-3-3	209	0.19	0.45
	4-5-1	85	60.91	20.15		4-5-1	85	0.09	0.40
	4-2-3-1	195	73.88	24.21		4-2-3-1	195	0.19	0.46
	3-4-3	212	64.45	19.75		3-4-3	212	0.23	0.56
	3-5-2	184	59.86	18.24		3-5-2	184	0.22	0.54
full back	4-4-2	29	58.62	13.44	full back	4-4-2	29	0.79	0.94
	4-4-2 diamond	110	65.67	15.83		4-4-2 diamond	110	1.09	1.24
	4-2-2-2	79	65.48	16.82		4-2-2-2	79	0.90	1.10
	4-3-3	183	72.81	19.49		4-3-3	183	0.77	1.11
	4-5-1	82	59.44	14.06		4-5-1	82	0.80	1.06
	4-2-3-1	181	74.67	19.39		4-2-3-1	181	1.17	1.28
	3-4-3	131	62.49	14.60		3-4-3	131	1.38	1.45
	3-5-2	118	58.69	13.33		3-5-2	118	1.51	1.68
central midfielder	4-4-2	24	57.38	13.41	central midfielder	4-4-2	24	0.33	0.64
	4-4-2 diamond	83	61.58	16.94		4-4-2 diamond	83	0.94	1.18
	4-2-2-2	67	64.85	20.75		4-2-2-2	67	0.61	1.09
	4-3-3	221	64.18	22.84		4-3-3	221	0.75	1.05
	4-5-1	101	52.68	15.74		4-5-1	101	0.84	1.23
	4-2-3-1	210	66.23	21.72		4-2-3-1	210	0.80	1.07
	3-4-3	98	60.94	16.35		3-4-3	98	0.65	0.90
	3-5-2	123	54.74	14.27		3-5-2	123	1.04	1.38
wide mdifielder	4-4-2	11	48.36	9.27	wide mdifielder	4-4-2	11	2.45	1.81
	4-4-2 diamond	77	56.51	14.52		4-4-2 diamond	77	1.18	1.32
	4-2-2-2	44	47.59	13.94		4-2-2-2	44	2.36	2.28
	4-3-3	88	51.91	17.97		4-3-3	88	2.24	1.97
	4-5-1	43	42.00	14.06		4-5-1	43	2.07	1.89
	4-2-3-1	112	53.32	15.98		4-2-3-1	112	2.40	2.22
	3-4-3	85	42.35	13.05		3-4-3	85	1.47	1.74
forward	4-4-2	18	35.56	8.37	forward	4-4-2	18	1.17	1.69
	4-4-2 diamond	57	37.75	8.60		4-4-2 diamond	57	1.75	1.98
	4-2-2-2	48	38.81	12.23		4-2-2-2	48	1.35	1.68
	4-3-3	74	40.70	14.58		4-3-3	74	0.54	0.83
	4-5-1	22	31.32	7.29		4-5-1	22	0.95	1.62
	4-2-3-1	54	36.83	11.04		4-2-3-1	54	1.22	1.19
	3-4-3	43	46.09	12.93		3-4-3	43	1.44	1.39
	3-5-2	67	37.88	9.55		3-5-2	67	1.51	1.53
Medium Passes					**Short Passes**				
center back	4-4-2	32	33.47	14.33	center back	4-4-2	32	8.22	4.80
	4-4-2 diamond	121	30.40	15.24		4-4-2 diamond	121	9.69	8.05
	4-2-2-2	89	29.94	16.61		4-2-2-2	89	10.57	8.03
	4-3-3	209	45.95	21.05		4-3-3	209	13.86	10.14
	4-5-1	85	29.28	16.20		4-5-1	85	10.14	6.25
	4-2-3-1	195	38.67	18.20		4-2-3-1	195	14.77	9.37
	3-4-3	212	29.21	15.09		3-4-3	212	13.57	9.33
	3-5-2	184	24.67	13.58		3-5-2	184	13.26	8.63
full back	4-4-2	29	17.90	6.07	full back	4-4-2	29	8.62	4.46
	4-4-2 diamond	110	19.70	9.10		4-4-2 diamond	110	13.99	7.88
	4-2-2-2	79	19.57	8.38		4-2-2-2	79	14.63	8.66
	4-3-3	183	25.14	11.49		4-3-3	183	18.11	11.71
	4-5-1	82	17.65	7.03		4-5-1	82	12.65	7.62
	4-2-3-1	181	22.85	10.58		4-2-3-1	181	21.49	13.42
	3-4-3	131	16.76	7.85		3-4-3	131	14.29	7.57
	3-5-2	118	15.69	6.80		3-5-2	118	13.39	6.16
central midfielder	4-4-2	24	24.25	9.62	central midfielder	4-4-2	24	15.42	6.57
	4-4-2 diamond	83	21.12	9.33		4-4-2 diamond	83	18.17	10.69
	4-2-2-2	67	24.34	11.43		4-2-2-2	67	19.37	12.53

	4-3-3	221	25.10	13.10
	4-5-1	101	18.65	8.66
	4-2-3-1	210	24.13	12.95
	3-4-3	98	21.10	9.31
	3-5-2	123	17.73	8.41
wide mdifielder	4-4-2	11	14.91	3.65
	4-4-2 diamond	77	17.78	7.83
	4-2-2-2	44	12.64	6.68
	4-3-3	88	14.47	6.80
	4-5-1	43	10.30	4.45
	4-2-3-1	112	14.29	6.53
	3-4-3	85	9.05	6.17
forward	4-4-2	18	10.22	4.25
	4-4-2 diamond	57	8.28	5.00
	4-2-2-2	48	9.25	6.33
	4-3-3	74	10.58	7.65
	4-5-1	22	6.05	2.84
	4-2-3-1	54	8.15	3.70
	3-4-3	43	11.26	7.99
	3-5-2	67	7.96	3.70
Long Passes				
center back	4-4-2	32	5.53	2.96
	4-4-2 diamond	121	6.13	4.42
	4-2-2-2	89	5.54	3.66
	4-3-3	209	6.02	4.39
	4-5-1	85	5.55	3.36
	4-2-3-1	195	5.36	3.69
	3-4-3	212	5.46	3.77
	3-5-2	184	4.77	3.19
full back	4-4-2	29	4.14	2.66
	4-4-2 diamond	110	3.67	2.54
	4-2-2-2	79	3.70	2.75
	4-3-3	183	3.24	2.53
	4-5-1	82	3.87	2.56
	4-2-3-1	181	3.06	2.65
	3-4-3	131	3.08	2.28
	3-5-2	118	2.66	2.30
central midfielder	4-4-2	24	2.08	1.59
	4-4-2 diamond	83	3.35	3.21
	4-2-2-2	67	3.28	2.71
	4-3-3	221	3.19	2.78
	4-5-1	101	2.55	2.11
	4-2-3-1	210	2.67	2.74
	3-4-3	98	2.22	1.80
	3-5-2	123	2.37	2.11
wide mdifielder	4-4-2	11	1.36	1.36
	4-4-2 diamond	77	2.56	2.16
	4-2-2-2	44	1.68	1.88
	4-3-3	88	1.35	1.47
	4-5-1	43	1.26	1.38
	4-2-3-1	112	1.33	1.42
	3-4-3	85	1.06	1.37
forward	4-4-2	18	0.56	0.86
	4-4-2 diamond	57	0.53	0.85
	4-2-2-2	48	0.75	1.49
	4-3-3	74	1.01	1.65
	4-5-1	22	0.36	0.73
	4-2-3-1	54	0.50	0.75
	3-4-3	43	1.09	1.25
	3-5-2	67	0.57	0.82

	4-3-3	221	19.80	12.04
	4-5-1	101	15.30	8.69
	4-2-3-1	210	23.32	12.70
	3-4-3	98	20.00	9.96
	3-5-2	123	16.49	7.56
wide mdifielder	4-4-2	11	11.73	5.87
	4-4-2 diamond	77	18.70	9.75
	4-2-2-2	44	14.36	7.97
	4-3-3	88	16.63	11.06
	4-5-1	43	11.49	8.04
	4-2-3-1	112	18.11	10.93
	3-4-3	85	13.96	7.64
forward	4-4-2	18	10.29	5.73
	4-4-2 diamond	57	14.01	9.38
	4-2-2-2	48	14.14	9.44
	4-3-3	74	16.75	11.16
	4-5-1	22	12.43	7.76
	4-2-3-1	54	19.07	12.15
	3-4-3	43	15.09	8.95
	3-5-2	67	13.93	7.54

Paper V. Supplementary Table 4. Descriptive values (mean ± SD) depending on the playing position (normative data).

position	sample	Mean	SD	position	sample	Mean	SD
Ball Possessions				**Dribblings**			
center back	1127	67.75	23.21	center back	1127	0.20	0.50
full back	913	66.73	17.85	full back	913	1.09	1.31
central midfielder	927	61.44	19.88	central midfielder	927	0.80	1.12
wide midfielder	460	49.83	15.97	wide midfielder	460	1.96	1.97
forward	383	38.81	11.76	forward	383	1.24	1.51
Medium Passes				**Short Passes**			
center back	1127	33.52	18.33	center back	1127	12.72	9.04
full back	913	20.22	9.80	full back	913	16.03	10.35
central midfielder	927	22.35	11.49	central midfielder	927	19.40	11.24
wide midfielder	460	13.42	7.12	wide midfielder	460	16.03	9.84
forward	383	9.07	5.86	forward	383	12.14	6.09
Long Passes							
center back	1127	5.52	3.82				
full back	913	3.28	2.54				
central midfielder	927	2.79	2.57				
wide midfielder	460	1.52	1.67				
forward	383	0.71	1.18				

Paper V. Supplementary Table 5. Descriptive values (mean ± SD) depending on the tactical formation (normative data).

formation	sample	Mean	SD	Formation	sample	Mean	SD
Ball Possessions				**Dribblings**			
4-4-2	114	55.46	17.01	4-4-2	114	0.78	1.22
4-4-2 diamond	448	59.11	18.37	4-4-2 diamond	448	0.93	1.32
4-2-2-2	327	58.17	20.50	4-2-2-2	327	0.91	1.47
4-3-3	775	66.99	25.41	4-3-3	775	0.75	1.22
4-5-1	333	53.65	18.07	4-5-1	333	0.81	1.31
4-2-3-1	752	66.21	23.21	4-2-3-1	752	1.00	1.44
3-4-3	569	58.70	18.58	3-4-3	569	0.85	1.27
3-5-2	492	55.31	16.77	3-5-2	492	0.91	1.38
Medium Passes				**Short Passes**			
4-4-2	114	22.11	12.56	4-4-2	114	10.29	5.73
4-4-2 diamond	448	21.07	12.60	4-4-2 diamond	448	14.01	9.38
4-2-2-2	327	20.92	13.56	4-2-2-2	327	14.14	9.44
4-3-3	775	28.14	18.73	4-3-3	775	16.75	11.16
4-5-1	333	19.21	12.35	4-5-1	333	12.43	7.76
4-2-3-1	752	24.98	15.93	4-2-3-1	752	19.07	12.15
3-4-3	569	20.58	13.47	3-4-3	569	15.09	8.95
3-5-2	492	18.51	11.43	3-5-2	492	13.93	7.54
Long Passes							
4-4-2	114	3.26	2.90				
4-4-2 diamond	448	3.69	3.57				
4-2-2-2	327	3.41	3.22				
4-3-3	775	3.55	3.50				
4-5-1	333	3.33	2.96				
4-2-3-1	752	3.11	3.15				
3-4-3	569	3.37	3.24				
3-5-2	492	3.09	2.89				

Paper V. Supplementary Table 6. Contextual factors (mean ± SD) depending on the tactical formation.

formation	games	mean	SD
own team ranking (end of the season)			
4-4-2	16	13.50	2.48
4-4-2 dia.	63	9.70	3.99
4-2-2-2	46	10.50	5.72
4-3-3	109	6.38	4.50
4-5-1	46	13.43	4.01
4-2-3-1	106	7.53	5.63
3-4-3	78	11.12	4.16
3-5-2	69	10.55	4.37
opposition team ranking (end of the season)			
4-4-2	16	8.44	5.27
4-4-2 dia.	63	9.70	4.78
4-2-2-2	46	10.67	4.94
4-3-3	109	9.71	5.09
4-5-1	46	7.70	5.41
4-2-3-1	106	9.86	5.09
3-4-3	78	9.55	5.15
3-5-2	69	8.83	5.68
net game time [min]			
4-4-2	16	58.91	4.38
4-4-2 dia.	63	56.23	3.94
4-2-2-2	46	56.98	4.19
4-3-3	109	58.73	4.25
4-5-1	46	57.84	3.90
4-2-3-1	106	58.30	4.65
3-4-3	78	56.46	4.00
3-5-2	69	56.32	3.91
points per game [quantity]			
4-4-2	16	1.00	1.26
4-4-2 dia.	63	1.71	1.33
4-2-2-2	46	1.67	1.38
4-3-3	109	1.51	1.33
4-5-1	46	0.87	1.20
4-2-3-1	106	1.68	1.35
3-4-3	78	0.97	1.23
3-5-2	69	1.17	1.21
ball-possession [%]			
4-4-2	16	45.55	6.37
4-4-2 dia.	63	50.05	7.35
4-2-2-2	46	48.09	8.17
4-3-3	109	53.92	9.13
4-5-1	46	44.32	8.32
4-2-3-1	106	51.98	8.99
3-4-3	78	50.09	8.01
3-5-2	69	46.63	7.65
venue (home [1] / away [2])			
4-4-2	16	1.50	0.52
4-4-2 dia.	63	1.49	0.50
4-2-2-2	46	1.50	0.51
4-3-3	109	1.50	0.50
4-5-1	46	1.46	0.50
4-2-3-1	106	1.52	0.50
3-4-3	78	1.50	0.50
3-5-2	69	1.51	0.50

dia. = diamond

Paper V. Supplementary Table 7. Contextual information about the players of the study sample.

Player	League games played	Nationality	Team (table position end of the season)	Involved in international competition
Player 1	24	Germany	SC Freiburg [13]	No
Player 2	30	Germany	FC Augsburg [15]	No
Player 3	28	Senegal	Borussia Dortmund [2]	Champions League
Player 4	18	Germany	Fortuna Düsseldorf [10]	No
Player 5	32	Germany	SV Werder Bremen [8]	No
Player 6	30	Austria	RB Leipzig [3]	Europa League
Player 7	31	Ivory Coast	FSV Mainz 05 [12]	No
Player 8	24	Germany	SV Werder Bremen [8]	No
Player 9	33	Netherlands	SV Werder Bremen [8]	No
Player 10	26	Germany	TSG 1899 Hoffenheim [9]	Champions League
Player 11	34	Germany	Bayer 04 Leverkusen [4]	Europa League
Player 12	34	France	Borussia Mönchengladbach [5]	No
Player 13	34	Germany	Bayer 04 Leverkusen [4]	Europa League

Paper VI. Supplementary File 1. Passing angle in playing direction. Classification of the passes into forward, backward, and horizontal.

Paper VI. Supplementary Table 1. Spearman correlation between results based on the formula of Kempe et al. (2014), the formula based on the expert rating, and the formula based on the weighting according to the results of the principle component analysis [PCA]. Based on the results of the three alternating calculations teams were ranked on a continuum between counter-attacking- and ball possession-oriented. The table shows the rank correlation [ρ] between the results of the three different calculations, the significance value [p] and the 95% confidence interval [95% CI].

	based on Kempe et al.	**based on expert rating**	**based on PCA**
based on Kempe et al.		ρ=0.97; 95% CI=0.87-0.99; p<0.01	ρ=0.97; 95% CI=0.88-0.99; p<0.01
based on expert rating	ρ=0.97; 95% CI=0.87-0.99; p<0.01		ρ=0.93; 95% CI=0.77-0.97; p<0.01
based on PCA	ρ=0.97; 95% CI=0.88-0.99; p<0.01	ρ=0.93; 95% CI=0.77-0.97; p<0.01	

Paper VI. Supplementary Table 2. Means ± SD for parameters (z-transformed values) included in the formula for the playing style coefficient [PSC] for every team.

	Passes per action		Forward passing		Target player passes		Passing success rate		Forward passing success rate		Ball possession rate	
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
team 1	1.11	1.16	0.02	0.85	0.56	0.55	0.80	0.77	0.84	0.83	0.54	0.87
team 2	0.45	1.04	-0.10	1.37	0.50	0.75	0.38	0.90	0.42	0.93	0.16	0.97
team 3	0.35	0.45	-0.27	0.86	0.72	0.54	0.80	0.48	0.70	0.59	0.57	1.00
team 4	0.68	1.65	-0.04	0.82	0.39	0.37	0.63	0.56	0.56	0.62	0.86	0.87
team 5	-0.35	0.88	-0.05	1.12	-0.13	1.08	-0.18	0.70	-0.26	0.72	0.21	0.89
team 6	-0.10	0.55	-0.34	0.88	0.11	0.54	0.00	0.77	0.05	0.81	-0.29	0.67
team 7	-0.07	0.67	0.61	0.75	0.51	0.78	0.34	0.85	0.44	0.93	0.29	0.70
team 8	-0.20	0.70	-0.70	1.03	-0.46	0.83	-0.14	0.78	-0.28	0.89	-0.24	0.93
team 9	0.13	1.66	-0.09	0.79	-0.31	0.81	-0.14	0.67	-0.31	0.64	-0.38	1.00
team 10	-0.25	0.58	0.11	1.12	-0.02	0.79	0.08	0.73	-0.04	0.91	0.06	0.91
team 11	-0.38	0.57	-0.15	0.86	-0.48	1.18	-1.10	1.16	-1.08	1.06	-0.86	0.91
team 12	-0.40	0.45	0.09	0.93	-0.27	0.91	-0.25	0.83	-0.29	0.88	-0.49	0.82
team 13	-0.29	0.52	-0.36	0.88	-0.62	1.25	-0.37	0.72	-0.33	0.64	-0.31	0.84
team 14	0.07	1.08	0.56	1.15	0.44	0.56	0.30	0.54	0.36	0.59	0.18	0.94
team 15	-0.85	0.55	0.98	0.90	-1.00	1.35	-1.43	1.04	-1.19	0.91	-0.72	0.92
team 16	0.04	0.58	-0.29	0.96	0.29	0.65	0.40	0.68	0.33	0.71	0.21	0.79
team 17	0.79	1.02	0.14	0.65	0.74	0.57	0.95	0.51	1.04	0.59	1.07	0.65
team 18	-0.73	0.45	-0.12	0.96	-0.97	1.23	-1.06	0.93	-0.96	0.94	-0.87	0.74
	Distance per attack		**Relative attacking time**		**Mean attacking time**		**Running distance in relation to the time of an attack**		**Mean passes per attack**		**PSC**	
	mean	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
team 1	1.00	1.18	-0.86	0.92	1.08	1.26	-0.71	0.91	1.11	1.16	2.76	2.82
team 2	0.23	1.07	-0.26	0.91	0.31	1.09	-0.44	1.02	0.45	1.04	1.11	2.66
team 3	0.14	0.48	-0.27	0.84	0.14	0.42	-0.28	0.53	0.35	0.45	1.33	1.22
team 4	0.50	1.52	-0.66	1.15	0.45	1.52	-0.01	0.79	0.68	1.65	1.76	3.27
team 5	-0.26	0.93	-0.35	0.80	-0.27	0.94	0.22	1.05	-0.35	0.88	-0.47	2.34
team 6	0.08	0.80	0.15	0.92	0.07	0.72	-0.13	1.03	-0.10	0.55	-0.07	1.84
team 7	-0.05	0.67	-0.34	0.55	-0.05	0.62	-0.11	0.75	-0.07	0.67	0.49	1.89
team 8	-0.13	0.71	0.30	0.82	-0.11	0.74	-0.04	1.06	-0.20	0.70	-0.60	1.97
team 9	0.36	1.76	0.41	1.35	0.09	1.66	1.12	0.87	0.13	1.66	-0.49	3.43

team 10	-0.17	0.71	0.11	0.86	-0.18	0.66	0.06	0.77	-0.25	0.58	-0.32	1.94
team 11	-0.31	0.60	0.71	1.10	-0.21	0.65	-0.28	1.22	-0.38	0.57	-1.68	2.28
team 12	-0.47	0.54	0.56	0.88	-0.54	0.55	0.70	0.92	-0.40	0.45	-1.37	1.72
team 13	-0.13	0.62	0.21	0.74	-0.20	0.59	0.30	0.72	-0.29	0.52	-0.91	1.68
team 14	-0.06	0.86	-0.05	1.04	-0.02	0.92	-0.19	0.76	0.07	1.08	0.44	2.23
team 15	-0.89	0.74	0.59	0.71	-0.87	0.62	0.40	0.89	-0.85	0.55	-2.81	1.97
team 16	0.14	0.73	-0.09	0.67	0.08	0.71	0.13	0.95	0.04	0.58	0.48	1.82
team 17	0.57	1.06	-0.91	0.79	0.83	1.09	-1.28	0.64	0.79	1.02	2.78	2.14
team 18	-0.54	0.66	0.76	0.68	-0.60	0.55	0.52	0.66	-0.73	0.45	-2.41	1.70

Paper VI. Supplementary Table 3. Means ± SD for the parameters (total values) included in the formula for the playing style coefficient [PSC] for every team.

	Passes per action		Forward passing		Target player passes		Passing success rate		Forward passing success rate		Ball possession rate	
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
team 1	6.63	1.76	0.58	0.03	0.98	0.01	0.86	0.05	0.82	0.06	0.59	0.15
team 2	5.64	1.56	0.58	0.04	0.98	0.01	0.84	0.05	0.79	0.07	0.53	0.17
team 3	5.49	0.68	0.57	0.03	0.98	0.01	0.86	0.03	0.81	0.04	0.60	0.17
team 4	5.99	2.50	0.58	0.03	0.98	0.00	0.85	0.03	0.80	0.05	0.65	0.15
team 5	4.44	1.32	0.58	0.03	0.97	0.01	0.80	0.04	0.74	0.05	0.54	0.15
team 6	4.82	0.82	0.57	0.03	0.98	0.01	0.81	0.05	0.76	0.06	0.45	0.11
team 7	4.86	1.01	0.60	0.02	0.98	0.01	0.83	0.05	0.79	0.07	0.55	0.12
team 8	4.66	1.05	0.56	0.03	0.97	0.01	0.80	0.05	0.73	0.07	0.46	0.16
team 9	5.16	2.50	0.58	0.02	0.97	0.01	0.80	0.04	0.73	0.05	0.44	0.17
team 10	4.58	0.88	0.58	0.03	0.98	0.01	0.82	0.04	0.75	0.07	0.51	0.16
team 11	4.38	0.86	0.57	0.03	0.97	0.01	0.75	0.07	0.68	0.08	0.35	0.16
team 12	4.36	0.68	0.58	0.03	0.97	0.01	0.80	0.05	0.73	0.06	0.42	0.14
team 13	4.53	0.78	0.57	0.03	0.97	0.01	0.79	0.04	0.73	0.05	0.45	0.14
team 14	5.07	1.62	0.60	0.03	0.98	0.01	0.83	0.03	0.78	0.04	0.53	0.16
team 15	3.69	0.83	0.61	0.03	0.97	0.01	0.73	0.06	0.67	0.07	0.38	0.16
team 16	5.02	0.88	0.57	0.03	0.98	0.01	0.84	0.04	0.78	0.05	0.54	0.13
team 17	6.16	1.54	0.58	0.02	0.98	0.01	0.87	0.03	0.83	0.04	0.68	0.11
team 18	3.87	0.68	0.58	0.03	0.97	0.01	0.75	0.06	0.68	0.07	0.35	0.13
	Distance per attack		**Relative attacking time**		**Mean attacking time**		**Running distance in relation to the time of an attack**		**Mean passes per attack**		**PSC**	
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
team 1	478.12	121.08	-5.89	6.36	19.64	5.81	24.71	1.63	6.63	1.76	2.76	2.82
team 2	399.19	109.54	-1.79	6.27	16.05	5.02	25.19	1.83	5.64	1.56	1.11	2.66
team 3	389.67	49.63	-1.85	5.76	15.31	1.92	25.47	0.94	5.49	0.68	1.33	1.22
team 4	426.99	155.30	-4.51	7.90	16.73	7.01	25.96	1.41	5.99	2.50	1.76	3.27
team 5	348.93	95.19	-2.38	5.53	13.39	4.33	26.36	1.88	4.44	1.32	-0.47	2.34
team 6	383.94	82.39	1.01	6.30	14.97	3.33	25.75	1.85	4.82	0.82	-0.07	1.84
team 7	370.36	69.04	-2.35	3.77	14.42	2.86	25.77	1.34	4.86	1.01	0.49	1.89
team 8	362.49	72.88	2.04	5.67	14.15	3.40	25.90	1.90	4.66	1.05	-0.60	1.97
team 9	412.15	180.81	2.80	9.26	15.06	7.66	27.98	1.55	5.16	2.50	-0.49	3.43

team 10	358.46	72.89	0.75	5.91	13.82	3.05	26.07	1.38	4.58	0.88	-0.32	1.94
team 11	344.02	61.57	4.88	7.58	13.68	2.99	25.46	2.18	4.38	0.86	-1.68	2.28
team 12	327.82	55.07	3.87	6.03	12.14	2.53	27.22	1.65	4.36	0.68	-1.37	1.72
team 13	361.85	63.93	1.42	5.10	13.72	2.74	26.51	1.29	4.53	0.78	-0.91	1.68
team 14	369.62	88.37	-0.37	7.14	14.55	4.25	25.64	1.36	5.07	1.62	0.44	2.23
team 15	283.99	75.72	4.07	4.88	10.66	2.86	26.69	1.59	3.69	0.83	-2.81	1.97
team 16	390.28	74.47	-0.63	4.63	15.01	3.26	26.20	1.70	5.02	0.88	0.48	1.82
team 17	433.83	108.59	-6.29	5.42	18.46	5.05	23.68	1.15	6.16	1.54	2.78	2.14
team 18	319.84	67.15	5.23	4.70	11.90	2.55	26.91	1.18	3.87	0.68	-2.41	1.70

Paper VI. Supplementary Table 4. Means ± SD for the technical, the physical, and the success parameters for every team.

	accelerations		accelerations in relation to time		decelerations		decelerations in relation to time		sprinting distance		sprinting distance in relation to time	
	mean	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
team 1	374.59	150.18	18.91	3.56	397.18	170.12	20.04	4.49	450.00	173.87	24.79	10.73
team 2	263.65	92.43	16.63	3.50	285.41	105.44	17.94	3.83	286.67	155.36	19.17	10.58
team 3	324.76	85.33	21.40	5.82	344.59	89.64	22.71	6.26	395.99	210.61	26.40	15.35
team 4	408.71	280.89	23.37	7.08	454.35	327.26	25.82	8.53	329.94	136.85	22.01	12.45
team 5	229.76	101.38	17.05	4.07	272.24	131.36	20.01	4.85	344.98	193.91	26.42	15.02
team 6	205.06	52.90	13.80	2.52	231.06	49.98	15.62	2.37	327.59	159.66	22.61	11.28
team 7	256.47	79.04	17.65	3.70	285.71	94.31	19.60	4.49	371.07	130.00	26.70	11.14
team 8	238.76	90.15	16.96	5.02	258.82	105.54	18.25	5.78	317.60	152.04	23.90	14.03
team 9	232.41	139.65	15.30	3.49	280.24	210.39	17.54	4.44	283.70	116.23	22.18	11.08
team 10	215.47	59.05	15.74	3.99	247.12	63.01	18.02	3.47	287.69	147.63	21.48	12.37
team 11	178.41	66.18	13.15	4.12	188.35	77.79	13.77	4.78	186.55	68.50	14.35	6.24
team 12	189.88	54.53	16.16	4.98	205.41	59.30	17.44	5.35	285.00	130.20	24.46	12.48
team 13	226.12	63.25	16.52	3.58	245.18	82.25	17.82	4.83	299.12	116.70	22.87	11.24
team 14	271.00	129.92	18.25	4.47	289.06	122.93	19.63	4.60	344.43	121.21	24.42	9.04
team 15	149.88	38.13	14.36	3.14	172.76	47.30	16.43	3.34	242.70	118.30	22.99	9.52
team 16	286.82	78.24	19.27	4.29	303.12	85.21	20.40	5.09	281.24	96.91	19.51	7.19
team 17	379.00	102.79	21.01	5.11	403.65	102.90	22.31	4.58	367.64	137.11	21.71	12.10
team 18	168.06	63.89	13.93	4.07	194.94	78.71	16.13	5.02	241.17	88.84	20.81	7.77
	high-intensity distance		**high-intensity distance in relation to time**		**percentage short passes**		**success rate passes short**		**percentage medium passes**		**success rate passes medium**	
	mean	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
team 1	1116.13	280.40	59.48	14.01	0.38	0.06	1.11	0.05	0.55	0.06	1.15	0.06
team 2	810.49	323.94	54.08	23.81	0.41	0.06	1.10	0.04	0.52	0.06	1.21	0.08
team 3	962.72	307.41	63.28	20.09	0.37	0.08	1.08	0.02	0.55	0.06	1.15	0.04
team 4	1034.04	374.63	65.41	22.13	0.39	0.09	1.10	0.04	0.55	0.10	1.18	0.06
team 5	820.57	284.83	62.94	19.86	0.30	0.09	1.17	0.07	0.58	0.11	1.23	0.07
team 6	741.43	256.52	50.39	16.42	0.33	0.08	1.14	0.04	0.55	0.08	1.18	0.08
team 7	878.42	206.42	61.06	9.04	0.46	0.10	1.12	0.05	0.46	0.09	1.21	0.09
team 8	750.43	272.24	55.39	22.07	0.33	0.09	1.13	0.05	0.55	0.10	1.21	0.08
team 9	874.64	289.62	63.59	19.40	0.39	0.12	1.13	0.06	0.50	0.12	1.24	0.10
team 10	800.28	222.33	59.20	16.88	0.35	0.09	1.12	0.05	0.54	0.07	1.20	0.07
team 11	530.71	129.86	40.17	11.46	0.27	0.06	1.21	0.08	0.57	0.08	1.29	0.18

team 12	819.26	254.89	69.43	20.19	0.43	0.07	1.12	0.04	0.44	0.05	1.27	0.10
team 13	844.18	248.70	62.58	18.66	0.37	0.09	1.16	0.08	0.53	0.10	1.23	0.09
team 14	902.24	263.93	63.13	16.18	0.40	0.08	1.13	0.04	0.52	0.08	1.19	0.06
team 15	611.73	263.96	56.89	19.88	0.33	0.08	1.20	0.08	0.54	0.10	1.35	0.10
team 16	940.77	232.25	64.55	18.23	0.45	0.11	1.10	0.04	0.46	0.11	1.21	0.10
team 17	994.76	201.16	56.93	17.76	0.36	0.07	1.10	0.02	0.58	0.07	1.14	0.05
team 18	607.42	207.80	51.41	16.00	0.38	0.10	1.15	0.05	0.45	0.11	1.30	0.11
	percentage long passes		**success rate passes long**		**percentage horizontal passes**		**success rate passes horizontally**		**percentage backward passes**		**success rate passes backward**	
	mean	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
team 1	0.07	0.03	1.87	0.41	0.52	0.05	0.95	0.03	0.13	0.01	0.90	0.04
team 2	0.07	0.04	2.34	0.78	0.49	0.06	0.93	0.04	0.13	0.02	0.90	0.03
team 3	0.08	0.03	2.13	0.51	0.50	0.05	0.96	0.02	0.15	0.02	0.91	0.03
team 4	0.06	0.02	2.44	0.66	0.50	0.05	0.95	0.03	0.14	0.02	0.89	0.03
team 5	0.12	0.03	1.94	0.42	0.48	0.06	0.93	0.04	0.13	0.02	0.87	0.04
team 6	0.11	0.04	2.46	0.54	0.44	0.05	0.95	0.03	0.14	0.02	0.89	0.03
team 7	0.08	0.04	2.43	0.68	0.47	0.06	0.96	0.03	0.13	0.02	0.89	0.04
team 8	0.12	0.04	2.45	0.68	0.44	0.06	0.91	0.04	0.13	0.02	0.89	0.04
team 9	0.11	0.04	2.53	0.54	0.44	0.05	0.95	0.03	0.14	0.02	0.88	0.03
team 10	0.11	0.05	2.41	0.63	0.43	0.06	0.93	0.04	0.14	0.02	0.89	0.03
team 11	0.16	0.05	2.41	0.58	0.39	0.07	0.93	0.04	0.14	0.02	0.84	0.08
team 12	0.13	0.04	2.17	0.39	0.44	0.06	0.94	0.03	0.13	0.02	0.87	0.03
team 13	0.10	0.04	2.99	0.67	0.44	0.05	0.93	0.05	0.12	0.02	0.88	0.02
team 14	0.08	0.03	2.40	0.47	0.47	0.04	0.93	0.03	0.13	0.02	0.89	0.03
team 15	0.13	0.05	3.08	1.29	0.38	0.06	0.94	0.06	0.11	0.02	0.83	0.06
team 16	0.10	0.03	2.01	0.44	0.46	0.05	0.96	0.02	0.15	0.02	0.89	0.04
team 17	0.07	0.02	1.83	0.50	0.52	0.04	0.95	0.03	0.14	0.01	0.91	0.02
team 18	0.17	0.05	2.85	0.92	0.41	0.05	0.92	0.05	0.12	0.02	0.86	0.05
	passing velocity		**dribblings**		**success rate dribblings**		**x goals**		**goals**		**points**	
	mean	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
team 1	50.88	1.61	9.94	2.75	0.72	0.14	1.81	0.78	2.24	0.75	2.24	1.25
team 2	48.16	1.49	9.00	4.57	0.69	0.22	1.36	0.97	1.71	1.45	1.18	1.42
team 3	51.51	1.51	16.71	6.27	0.62	0.13	1.18	0.70	1.18	1.42	1.18	1.29
team 4	48.59	1.14	6.94	4.51	0.66	0.28	1.70	0.70	1.65	1.17	1.71	1.45
team 5	52.61	2.37	7.71	4.04	0.55	0.17	1.20	0.31	1.82	1.13	1.88	1.41
team 6	49.39	1.99	8.18	3.78	0.63	0.20	1.04	0.61	1.12	1.27	1.35	1.46

team 7	49.45	1.24	8.94	5.03	0.63	0.21	1.54	0.85	2.00	1.22	1.82	1.33
team 8	52.83	1.89	11.76	3.77	0.64	0.16	1.12	0.64	0.94	1.03	1.00	1.22
team 9	50.19	2.28	7.00	4.50	0.58	0.29	1.27	0.78	0.94	0.90	1.47	1.23
team 10	51.21	1.91	10.53	5.50	0.68	0.18	1.24	0.65	0.94	1.03	1.00	1.37
team 11	52.00	1.97	7.88	3.79	0.63	0.20	0.98	0.70	0.59	0.87	1.00	1.22
team 12	49.02	1.82	7.59	2.85	0.58	0.23	0.95	0.43	0.88	0.93	0.88	1.11
team 13	50.32	1.61	10.71	6.27	0.68	0.20	0.74	0.70	0.65	1.06	0.53	1.01
team 14	48.42	1.46	11.06	7.24	0.74	0.20	1.12	0.76	1.29	1.21	1.24	1.39
team 15	49.28	1.84	7.41	3.02	0.59	0.19	1.27	0.68	1.24	1.15	1.71	1.31
team 16	50.61	1.83	9.41	5.48	0.62	0.21	1.39	0.71	1.35	1.17	1.65	1.37
team 17	50.08	1.55	13.41	7.42	0.76	0.15	2.13	0.77	2.71	1.49	2.24	1.25
team 18	50.68	1.86	7.71	4.51	0.56	0.23	0.99	0.51	1.00	0.94	1.06	1.34