Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Medicine and Health Sciences
Department of Circulation and Medical Imaging

Andreas Forer

Creating goal scoring opportunities in soccer

Role of velocity and acceleration metrics of runs in behind the oponents defensive line

Master's thesis in Physical Activity and Health - Exercise Physiology
Supervisor: Ulrik Wisløff
Co-supervisor: Vetle Veierød
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List of Abbreviations

Acc_{max}	Maximal acceleration
ES	Effect size
GPS	Global Positioning System
GSO	Goal scoring Opportunity
HIR	High intensity running
IQR	Interquartile range
RIB	Run in behind the opponents’ defensive line
SD	Standard deviation
TTMA	Time to maximal acceleration
V_{max}	Maximal velocity

Preface

I wrote this master's thesis as part of my degree in exercise physiology at the Norwegian University of Science and Technology.

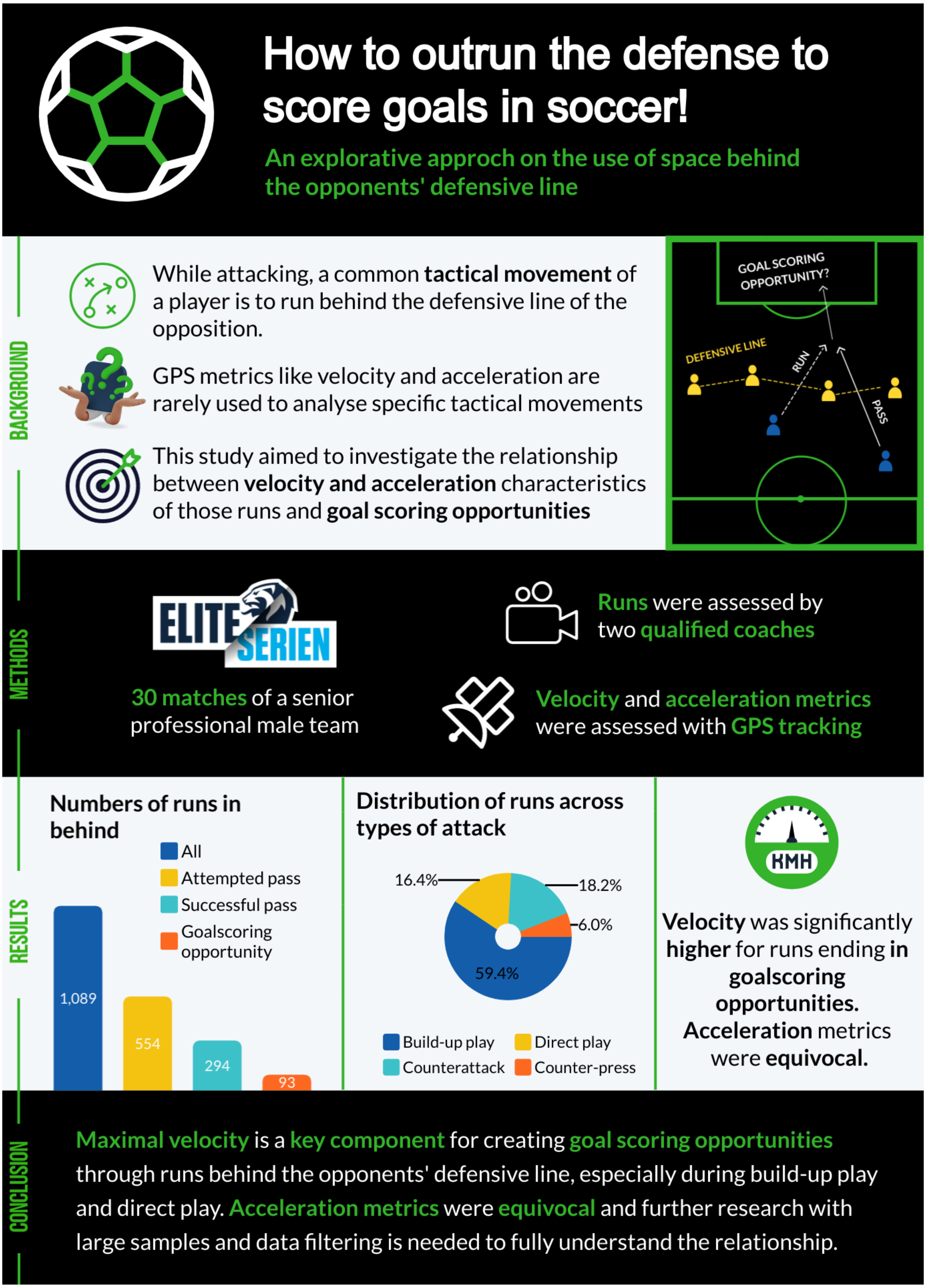
I played football for many years and was always surrounded by the sport. I started working as a strength and conditioning coach in elite football during my bachelor's and continue to this date. Luckily, I got to discuss football with many high-level coaches. With them, I was constantly exchanging thoughts on physical performance development, as my goal has always been to help individual players perform during competition. Throughout the discussions, together with my co-supervisor, we realized that the physical performance data often lacks tactical context. Although tactical context might not be needed to monitor total physical load, it might be useful when monitoring specific movements. During my introduction to the club that was analyzed in my thesis, the coaching staff were discussing runs behind the opponent's defensive line. Thoughts and ideas around speed and acceleration of such runs were shared. As we realized that no physical performance data on such runs exists, the idea for this thesis arose.

I would like to thank my family, especially my parents, who made my studies possible and supported me in all my decisions. I would also like to thank Prof. Ulrik Wisløff for his guidance and scientific supervision of the project. Special thanks go to Vetle Veierød for his support throughout the entire project, the constructive discussions which allowed for flexibility, and the insights into the performance department of the club. I would like to extend my gratitude to Per Jarle Dalum for introducing me to and supporting me with the video analysis process.

Trondheim, May 2024

Andreas Forer

1 Infographic



2 Abstract

Background: Soccer is dynamic and characterized by continual changes in physical and tactical movements. While having ball-possession and attacking, a common tactical movement of a player is to run behind the defensive line of the opposition. This movement aims to disrupt the defensive structure of the opposing team and gain positional advantage. A run behind the opponents' defensive line, also known as run in behind [RIB] might end in a one versus one situation with the goalkeeper, which significantly increases the opportunity to score a goal. There is a gap in literature analysing the efficiency of such running behaviour, determined by the creation of goal scoring opportunities [GSO]. Moreover, GPS metrics like velocity and acceleration are rarely used to analyse specific tactical movements. This study aimed to investigate the relationship between velocity and acceleration characteristics of RIBs and GSOs in professional soccer matches. This was further examined for different types of attacks.

Methods: A senior professional male team of the Norwegian Eliteserien was followed across 30 matches of the 2023 season. Video was used to classify movements as RIBs by two qualified coaches. RIBs were further classified in "pass attempted" when a pass to the player was attempted, "pass successful" when the player gained control over the ball after the pass, and "goal scoring opportunity" when the player had a significant involvement in an attack where a GSO was created. Furthermore, each RIB was categorized into one of the four types of attack: build-up play, direct play, counterattack, counter-press. The difference in maximal velocity, maximal acceleration, and time to maximal acceleration between RIBs ending in GSOs and RIBs not ending in GSOs were assessed. This was done using the independent samples t-test or alternatively the Mann-Whitney U test. Effect sizes [ES] of differences were reported as Cohens'd or the point-biserial correlation r respectively. Furthermore, inter-group differences for RIBs grouped by types of attack were investigated. This was done using the Kruskal-Wallis test. The ES of inter-group differences was reported as the point-biserial correlation r.

Results: Out of the 1089 RIBs, 59.4% were classified as build-up play, 16.4% as direct play, 18.2% as counterattack and 6.0% as counter-press. The proportion of RIBs ending in GSOs ranged from 7.26% to 10.10% across types of attack. Maximal velocity was higher for RIBs ending in GSOs for all attacks together ($p < 0.001$; $r = 0.17$, small ES) as well as for RIBs during build-up play ($p < 0.001$; $r = 0.2$, small ES) and direct play ($p = 0.022$; $r = 0.17$, small ES). Time to maximal acceleration was higher for RIBs ending in GSOs for all attacks together ($p = 0.007$; $r = 0.08$, less than small ES) as well as for RIBs during build-up play ($p = 0.019$; $r = 0.09$, less than small ES). Inter-group differences for types of attack were found for maximal velocity for all RIBs ($p < 0.001$), where maximal velocity was higher in counterattack compared to build-up play ($p < 0.001$, $r = 0.13$, small ES), direct play ($p < 0.001$, $r = 0.37$, moderate ES), and counter-press ($p = 0.001$; r = 0,23, small ES). Maximal velocity was also higher in direct play compared to build-up play. Significant differences were also found for RIBs ending in GSOs ($p = 0.027$), with counterattack showing significantly higher maximal velocity than build-up play ($p = 0.042$; r = 0,1, small ES). Inter-group differences for types of attack were also found for time to maximal acceleration for all RIBs ($p < 0.001$), where time to maximal acceleration was significantly lower in build-up play compared to counterattack ($p = 0.028$; $r = 0.1$, small ES) and counter-press ($p = 0.004$; $r = 0.13$, small ES).

Conclusions: The results indicate that maximal velocity was a key component in creating GSOs. This was especially notable during build-up play and direct play. Differences in acceleration characteristics were present but due to sample size and many outliers the interpretation of the results is limited. Data processing techniques such as filtering are suggested for acceleration data. Further research should include larger sample sizes across several teams. This may allow to estimate regression models and give a more comprehensive understanding of the relationship between physical metrics and creation of GSOs through RIBs. The findings from this explorative approach are limited but might still be taken in consideration for training design, player selection and match strategy.

3 Introduction

Soccer is characterized by continual changes in the diversity and intensity of activities, including standing, walking, running, and sprinting with frequent changes in direction, as well as jumping, kicking, tackling, and sustaining forceful contractions to maintain balance with or without the ball and/or opponents (Stølen et al., 2005). The evolution of professional soccer has shown an increase in such physical demands on English Premier League players (Barnes et al., 2014), Chinese Soccer Super League (Zhou et al., 2020) and players of the top two divisions in Spain (Pons et al., 2021).

Monitoring physical performance in training and matches has become common practice in professional soccer (Carling, 2013). Ever since wearables were allowed by the International Football Association in 2015, devices based on global positioning system [GPS] technology have been used to monitor physical performance in competitive matches. A wearable's position on the soccer pitch is calculated by connecting to several satellites. Its speed can then be calculated by tracking the positional change over time (Rago et al., 2020). The distance covered and time spent in different types of motion, ranging from walking to sprinting have been used as performance metrics for the past four decades (Barnes et al., 2014).

Two of the most commonly used metrics are time and distance spent in high-intensity running [HIR] (19.8 to 25.1 km/h) and sprinting (>25.2 km/h) (Bradley et al., 2009; Bush et al., 2015; Caldbeck & Dos'Santos, 2022; Di Salvo et al., 2009). Across seven seasons in the English Premier League, the distance covered with HIR increased significantly for every player position. The last monitored season (2012/2013) showed that central defenders covered 193±86 m while full-backs covered 503±181 m and wide midfielders covered 710±171 m with HIR (Bush et al., 2015). Similar findings were observed when the running intensities were defined as a relative value to the players' maximal running velocity (Abbott et al., 2018). This emphasizes the importance of analyzing an individual's profile as physical performance varies based on the player's position in elite soccer (Abbott et al., 2018; Bush et al., 2015). Individual profiles can be used to create specific training strategies and design tailored drills (Buchheit et al., 2014).

Furthermore, physical performance data correlates to team performance (Chmura et al., 2022; Di Salvo et al., 2009; Modric et al., 2022; Rampinini et al., 2009). In the 2004/2005 Italian Serie A league, distance covered at high intensity as well as distance at lower speed and total distance were greater in the last five teams (final ranking) compared to the teams ending up in the top 5 positions (Rampinini et al., 2009). Similar findings were discovered in the English Premier League from the 2003/2004 to the 2005/2006 season. HIR distance from wide midfielders was higher in teams ending the seasons in the middle and bottom compared to teams ending at the top of the table. However, wide midfielders in top-of-the-table teams had higher HIR distances than wide midfielders in lower-ranked teams when their team were in ball possession (Di Salvo et al., 2009). Interestingly, contradicting findings were found in the German Bundesliga season of 2017/2018 and 2018/2019, where teams ending in the first six ranks of the final season table covered higher total distance and sprinting distance with the ball and had a higher amount of sprints with the ball (Chmura et al., 2022). When analyzing 20 matches of the UEFA Champions League 2020/21, the players running performance was poorly related to the team advancing into the knockout stage of the tournament (Modric et al., 2022).

Therefore, it becomes clear that physical performance data should be linked to specific tactical components of the game (Carling, 2013). Carling (2013) discussed previously that variables such as the frequency of ball possession, attempted short and long passes, completed short and long passes, shots, and shots on target had a higher correlation towards team performance. Moreover, the raw physical data had an inverse correlation with team performance. It was shown that greater HIR and sprint distances were covered by teams ranking lower in the league table in the highest professional leagues in Italy and England. (Carling, 2013).

In recent years, researchers have tried to put HIR and sprinting into a tactical context (Ade et al., 2016; Caldbeck & Dos'Santos, 2022; Filter et al., 2023; Ju et al., 2021; Kai et al., 2018; Oliva-Lozano et al., 2022). Tactical movements can be divided into movements in and out of possession. HIR and sprinting out of possession can happen during a "close down". This involves the player either running directly towards the opponent receiving the ball or moving towards unoccupied areas to obstruct passing channels. These actions also occur when intercepting passes. Additionally, HIR or sprinting is commonly employed by players to rapidly regain their position on the field. In possession, HIR and sprints can happen while running with the ball, but also when over/underlapping (i.e., running from behind the ball-receiving player to their front) or breaking into the box (i.e., entering the opposition's box). A player running behind the opponent's defensive line to exploit open space is classified as a "run-in-behind" [RIB], commonly achieved through HIR or sprinting (Ju et al., 2021).

The linkage between sprints and their tactical context was investigated in 10 matches of the English Premier League season 2017/18. The research suggests that players in different positions engaged in sprints during different tactical actions. During in-possession phases, wide midfielders and center forwards had most of their sprints while "running the channel" (16% and 23% respectively) which implies running on the lateral parts of the field but not in behind. Center forwards engaged in sprints primarily in RIBs (18%). Full-backs primarily sprinted in overlaps (14%), while central midfielders and defenders had limited sprint involvements in any offensive context (Caldbeck & Dos'Santos, 2022). Similar distribution patterns for sprints were seen in 30 matches of the Spanish LaLiga season 2021/22 (Oliva-Lozano et al., 2022). In addition, matching distribution patterns were observed when analyzing the high-intensity efforts (running speed exceeding 21 km/h for more than 1 second) of 20 individual English Premier League players across 46 matches from the 2010/11 to the 2013/14 season (Ade et al., 2016). Thus, research suggests RIBs being a key tactical movement often executed by sprinting (Ade et al., 2016; Caldbeck & Dos'Santos, 2022; Oliva-Lozano et al., 2022).

Although the tactical context of HIR and sprints is known (Filter et al., 2023), the previous findings (Di Salvo et al., 2009; Rampinini et al., 2009) suggest that the relation between HIR and team performance is not straightforward. Performance might be interpreted from many points of view, but the main aim in soccer is to win matches. The International Football Association Board defines "the team scoring the greater number of goals" as the winner (The International Football Association Board, 2022). Faude et al. (2014) investigated the relationship between scored goals and player actions requiring power and speed in the second half of the German Bundesliga (1st national league) season 2007/08. Out of all analyzed goals, 45% were preceded by a straight sprint from the scoring player. Moreover, most sprints were conducted without the ball. Strikers and midfielders scored after a straight sprint 62 and 70% of the time respectively. Similarly, the assisting player conducted a straight sprint in 67% of the assisted goals. This suggests that sprinting might be important in decisive situations i.e., goals, in professional soccer. Faude et al. (2014) evaluated sprinting actions subjectively rather than by objective GPS data. Nonetheless, distances covered above HIR were correlated with score-box possession (i.e., ball possession in the area near the opponent's goal) by Kai et al., (2018). Higher score-box possession implies better goal scoring opportunities [GSO] (Kai et al., 2018; Tenga et al., 2010).

To contextualize the importance of specific running behavior in soccer, physical performance data should be put into a tactical context (Filter et al., 2023) and analyzed for its effectiveness (Schulze et al., 2022). Schulze et al. (2022) explored the relationship between GSOs, and the distance covered above 14.5 km/h in the 5 minutes and 1 minute before the shot. The analysis included 33 matches of the 4th national league in Germany. The results observed a significant positive correlation between the distance covered above 14.5 km/h in in the minute prior to the GSO, and the outcome being a goal. This highlights the importance of running behavior in GSOs (Schulze et al., 2022).

Research analyzing running behavior preceding GSOs and goals has highlighted the importance of movement patterns in the attacking phase of soccer matches (Faude et al., 2014; Schulze et al., 2022). Such movement patterns are attributed to the tactical principle of depth mobility. The concept of depth mobility involves the attacking players who don't have the ball actively seeking optimal positions to receive it. This includes the movement of a player behind the last defensive player of the opposing team (i.e., between the last opponent and the opponent's goal). This tactic aims to disrupt the defensive actions of the opposing team and significantly increase the opportunities to score a goal (Teoldo da Costa et al., 2009).

While previous research (Faude et al., 2014; Schulze et al., 2022) related GSO to running behavior, it predominantly focused on its physical aspects. The tactical context of the intense effort is often neglected or simplified. Contrary, the relationship between GSO and types of attack has been investigated without taking physical aspects into consideration. Thus, GSOs were analyzed in specific types of offensive actions such as organized attacks, counterattacks and set-plays, but not individual movements. (Gonzalez-Rodenas et al., 2018) As a result, a gap in the literature emerges, where the efficiency and effectiveness of specific tactical movements remain unexplored. Moreover, it is unclear if the effectiveness is dependent on the velocity or acceleration characteristics of the movement as the timing of RIBs is detrimental. The run often starts before the pass is executed. If the players' head, body or feet is in the opponents' half and any of these parts is nearer to the opponents' goal line than both the ball and the second-last opponent when the ball is played, an offside offence is committed and an indirect free-kick is awarded to the opponent (The International Football Association Board, 2022). Therefore, it is hypothesized that maximal velocity, maximal acceleration, and the time until maximal acceleration might influence the efficiency and effectiveness of RIBs. Such relationships are also unexplored regarding different types of attacks. Understanding the impact of runs "behind" the defensive line of the opposition and their potential to lead to GSO is essential for developing tactical insights and strategies that can maximize a team's offensive capabilities.

Knowledge of the relationship between offensive running behavior, running intensity, and GSO allows practitioners to increase the specificity of training drills and facilitate the transfer to match-play (Caldbeck & Dos'Santos, 2022; Carling, 2013). Moreover, it is theorized that linking physical performance with tactical behavior in a competitive match might close the gap between the tactical and physical coaches' interpretation of individual performance. Lastly, monitoring the tactical-physical performance might facilitate to not only determine the physical (Buchheit et al., 2014) but also the tactical progress of an individual player.

This study aimed to investigate the relationship between velocity and acceleration characteristics of RIBs and GSOs in soccer matches. This was further examined for different types of attacks. Using an explorative approach based on a tactical viewpoint, the research aimed to provide insights into the efficiency of these movements and their potential impact on a team's offensive capabilities.

It was hypothesized that maximal velocity and maximal acceleration are higher and time to maximal acceleration is lower in RIBs leading to GSOs for all RIBs as well as across types of attack. Moreover, it was hypothesized that maximal acceleration was similar across types of attack, and time to maximal acceleration was lower in counterattack and counter-press compared to build-up play and direct play. Furthermore, maximal velocity was expected to be higher in counterattack and counter-press compared to build-up play and direct play.

4 Methods

In this prospective cohort study a senior professional male team was followed throughout the Norwegian Eliteserien (highest national league) in the 30 matches of the 2023 season. Every player provided consent for the collection and the anonymous use of their GPS and video data. The study was approved by the Norwegian Agency for Shared Services in Education and Research.

The GPS data, together with the video feed of the matches was provided by the club. The tactical video feed of each match was analyzed twice. The classification of the players' movement as a RIB as well as all other sub-classifications were agreed on by two qualified coaches following predefined criteria. A RIB is defined as a run ending behind the nearest player in the opponent's defensive line when the mentioned opponent is not out of position (e.g., a run behind a fullback that pushed up into the attacking-line is not classified as a RIB). Moreover, no deceleration is present before ending the run behind the defender unless the defender itself reacts quickly to run on parallel to the player trying to perform a RIB. Such reaction would provoke disbalance in the opponent's defense. The run must start before the ball is passed. Furthermore, the movement must be done with intention. This was determined by the player having at least three accelerating steps. Exclusion criteria were runs outside of the box when the defender was standing on level with the 5.5-meter line or lower. Inside the box, RIBs were excluded when starting on level or higher than the penalty spot. Further exclusion criteria were movements when receiving the ball from throw-ins. Furthermore, movements during free-kicks and corners were excluded.

Each RIB was then further categorized as "pass attempted" when a pass to the player performing the RIB was executed. A further categorization into "pass successful" was done when the player performing the run gained control over the ball passed to him. RIBs ending in GSOs were defined by the players possibility of shooting or heading on target and a goal is the potential outcome. Thus, shots from further than 30m were not included unless the oppositions goalkeeper was out of position. A classification into "GSO" was also done when the GSO was not achieved by the player performing the RIB, but the RIB having a significant impact in the build-up of the GSO (e.g., assist, dragging out a defender, etc.). The ending of a RIB was defined as either the first contact with the ball or the first active deceleration step of the player when control over the ball could not be gained.

Furthermore, each RIB was then categorized into four different types of attack: direct play, build-up play, counter-press, and counterattack. The definitions of the different types of attack are specified in Table 1.

Table 1: *Definitions of the different types of attack*

Type of attack	Definition
Direct play	The RIB is performed when the opponent defends in an organized structure. An initial pass is executed by the keeper or a player in the defensive line towards a player positioned around the opponents' defensive line. The initial pass is executed in the own half of the pitch. The pass to the player performing the RIB must be executed no more than 3 passes after the initial pass. No more than 6 touches towards the own goal could be executed by any player involved.
Build-up play	The RIB is performed when the opponent defends in an organized structure. The criteria for direct play are not met.
Counterattack	The ball possession was gained while the opponent was attacking in an organized structure. The RIB must be executed before the opponent can organize in its defensive structure.
Counter-press	The ball possession was lost to the opponent. Ball possession is regained before the opponent can organize in its offensive structure. The RIB must be executed before the opponent can organize in its defensive structure.

Note: GSO, goal scoring opportunity

During the matches each player wore an individually assigned GPS tracker (Vector® 10 Hz GPS tracker, Catapult, Melbourne, Australia). The assessed variables were maximal velocity [V_{max}] measured in km/h, maximal acceleration [Acc_{max}] measured in m/s^2, and time to maximal acceleration [TTMA] measured in seconds.

The primary outcome is the mean difference of the GPS variables during RIBs, grouped by the dichotomous variable GSO. This was performed for both, all RIBs as well as for RIBs classified as pass successful only. An independent samples t-test was employed when the assumptions were met. Alternatively, the Mann-Whitney U test was used.

Moreover, the mean difference of the GPS variables during RIBs, grouped by the dichotomous variable GSO was conducted for distinct cohorts based on the four types of attack.

The secondary outcome was investigated the mean difference of the GPS variables in RIBs between the four types of attack. This was then repeated for RIBs leading to GSOs only. The Kruskal-Wallis test was employed due to the distribution of the GPS variables.

Effect sizes [ES] of differences were reported as Cohens'd or the point-biserial correlation r respectively and interpreted according to Cohen (1988). Descriptive statistics of the GPS variables were provided as means and standard deviation [SD] or median and interquartile range [IQR]. SPSS Statistics was used for all statistical tests (version 29. IBM, Chicago, IL, USA).

5 Results

A total of 1130 RIBs were detected across 30 matches. Due to technical issues with the hardware, GPS data was missing in 41 cases (3.6%) and thus, the final number of RIBs included in the analysis was 1089. The characteristics of the included cases can be seen in Table 2. The average number of RIBs per game are displayed in Table 3. Out of the 1089 RIBs, 59.4% were classified as build-up play, 16.4% as direct play, 18.2% as counterattack and 6.0% as counter-press. The proportion of RIBs ending in GSOs was similar across types of attack, with counterattacks recording the highest proportion with 10.10% followed by 9.23% for counter-press, 8.35% for build-up play, and 7.26% for direct play.

As seen in Table 3. the Mann-Whitney U test revealed that RIBs ending in GSOs had significantly higher mean ranks for V_{max} ($p < 0.001$) and TTMA ($p = 0.007$) compared to all other RIBs. In contrast, no significant difference was detected for Acc_{max}. The ES for V_{max} ($r = 0.17$) showed a small effect while the ES for Acc_{max} ($r = 0.03$) and TTMA ($r = 0.08$) did not reach the threshold to be defined as small effect.

Table 2: *Frequencies of RIBs for the different classifications and by type of attack*

Type of attack	Classifications				
	Pass not attempted	Pass attempted	Pass successfull	GSO	Total
Build-up play	338	309	173	54	647
Direct play	72	107	56	13	179
Counterattack	94	104	46	20	198
Counter-press	31	34	19	6	65
Total	535	554	294	93	1089

Note: Shows RIBs included in the analysis (n = 1089). GSO, goal scoring opportunity

Table 3: *Description of RIBs per game for the different classifications and by type of attack*

Type of attack	Total RIBs	Classifications			
		Pass not attempted	Pass attempted	Pass successfull	GSO
Build-up play	22.20 (SD 11.22)	12.00 (IQR 5.50 – 18.00)	10.43 (SD 5.57)	6.00 (IQR 2.75 – 8.00)	2.00 (IQR 1.00 – 3.00)
Direct play	6.00 (IQR 4.00 - 7.75)	2.50 (IQR 1.00 – 3.00)	3.70 (SD 2.20)	2.00 (IQR 0.75 – 3.00)	0.00 (IQR 0.00 – 1.00)
Counterattack	6.97 (SD 4.33)	3.00 (IQR 1.00 – 5.25)	3.57 (SD 2.24)	1.00 (IQR 1.00 – 3.00)	0.00 (IQR 0.00 – 1.00)
Counter-press	2.00 (IQR 1.00 – 3.00)	1.00 (IQR 0.00 – 2.00)	1.00 (IQR 0.00 – 2.00)	0.00 (IQR 0.00 – 1.00)	0.00 (IQR 0.00 – 0.00)
All types of attack	37.67 (SD 10.92)	18.83 (SD 7.56)	18.83 (SD 5.49)	9.93 (SD 4.185)	3.20 (SD 1.79)

Note: RIBs are reported as mean and standard deviation or median and interquartile range respectively. Shows all RIBs (n = 1130). RIB, run in behind; GSO, goal scoring opportunity; IQR, interquartile range; SD, standard deviation.

Table 4: Test of difference for V_{max}, Acc_{max}, and TTMA between RIBs ending in GSOs and RIBs not ending in GSOs for the cohorts of all RIBs and differentiated by type of attack

Cohort	Variable	Groups		Test statistics and ES
		RIBs ending in GSOs	RIBs not ending in GSOs	
All (n=1089)	V_{max}	26.45 (IQR 23.94 - 28.76)	23.32 (IQR 20.03 - 26.56)	**p < 0.001** r = 0.17
	Acc_{max}	2.51 (SD 0.96)	2.34 (IQR 1.73 - 3.04)	p = 0.338 r = 0.03
	TTMA	1.60 (Q1: 1.40; Q3: 1.90)	1.50 (IQR 1.30 - 1.80)	**p = 0.007** r = 0.08
Build up paly (n=647)	V_{max}	25.90 (IQR 22.72 - 28.38)	22.2 (IQR 19.18 - 25.25)	**p < 0.001** r = 0.2
	Acc_{max}	2.62 (SD 0.88)	2.33 (IQR 1.76 - 3.06)	p = 0.162 r = 0.05
	TTMA	1.60 (IQR 1.30 - 1.83)	1.50 (IQR 1.20 - 1.70)	**p = 0.019** r = 0.09
Direct play (n=179)	V_{max}	27.82 (IQR 24.15 -29.83)	23.69 (SD 4.47)	**p = 0.022** r = 0.17
	Acc_{max}	2.54 (SD 0.87)	2.3 (IQR 1.78 - 3.01)	p = 0.653 r = 0.03
	TTMA	1.60 (IQR 1.30 - 2.40)	1.60 (IQR 1.30 - 1.80)	p = 0.282 r = 0.08
Counterattack (n=198)	V_{max}	27.89 (SD 2.14)	26.61 (IQR 23.2 - 29.05)	p = 0.098 r = 0.12
	Acc_{max}	2.26 (SD 1.06)	2.28 (SD 1.06)	p = 0.934 C'd 0.02
	TTMA	1.63 (SD 0.57)	1.60 (IQR 1.30 - 1.90)	p = 0.713 r = 0.03
Counter-press (n=65)	V_{max}	25.03 (SD 4.71)	23.72 (SD 4.62)	p = 0.749 r = 0.04
	Acc_{max}	2.27 (SD 0.65)	2.52 (SD 0.94)	p = 0.513 r = 0.08
	TTMA	2.23 (SD 0.76)	1.60 (IQR 1.40 – 2.00)	p = 0.112 r = 0.2

Note: Description of the variables V_{max} in km/h, Acc_{max} in m/s2 and TTMA in seconds reported as mean and standard deviation or median and interquartile range respectively. The test statistics for differences between RIBs ending in GSOs and RIBs not ending in GSOs is reported and marked in bold when reaching the significance level of $p < 0.05$. The ES is reported as Cohens'd or the point-biserial correlation r respectively. Results are reported for all RIBs and for the different types of attack. RIB, run in behind; GSO, goal scoring opportunity; ES, effect size; V_{max}, Maximal velocity; Acc_{max}, Maximal acceleration; TTMA, Time to maximal acceleration; IQR, interquartile range; SD, standard deviation.

When only including RIBs in the cohort build-up play, RIBs ending in GSOs had significantly higher mean ranks for V_{max} ($p < 0.001$) and TTMA ($p = 0.019$) while not reaching significant levels for Acc_{max} ($p = 0.162$). The ES for V_{max} ($r = 0.2$) showed a small effect while the ES for Acc_{max} ($r = 0.05$) and TTMA ($r = 0.09$) did not reach the threshold to be defined as small effect. In the cohort direct play, RIBs ending in GSOs had significantly higher mean ranks for V_{max} ($p = 0.022$) while no significant difference for Acc_{max} ($p = 0.653$) and TTMA ($p = 0.282$) was observed. A small effect was observed for V_{max} ($r = 0.17$) while the Acc_{max} ($r = 0.03$) and TTMA ($r = 0.08$) did not reach the threshold. V_{max} ($p = 0.098$; $r= 0.12$), Acc_{max} ($p = 0.934$; $d = 0.02$), and TTMA ($p = 0.713$; $r = 0.03$) did not show significant differences in mean ranks between the groups in the cohort counterattack. The ES reached the threshold to be defined a small effect for V_{max} but not for TTMA. The ES for Acc_{max} is classified as very small. Similarly, no differences in mean ranks for V_{max} ($p = 0.749$; $r = 0.04$), Acc_{max} ($p = 0.513$; $r = 0.08$), and TTMA ($p = 0.112$; $r = 0.2$) were observed in the cohort counter-press. Only TTMA reached the threshold to be defined a small effect.

Table 5 shows that RIBs ending in GSOs did not differ in mean ranks for V_{max} ($p = 0.123$), Acc_{max} ($p = 0.442$) or TTMA ($p = 0.09$) compared to all other RIBs in the cohort successful pass. The ES for V_{max} ($d = 0.19$) and Acc_{max} ($d = 0.1$) are by definition very small, whilst the ES for TTMA ($r = 0.09$) did not reach the minimum threshold for classification.

Table 5: Test of difference for V_{max}, Acc_{max}, and TTMA between RIBs ending in GSOs and RIBs not ending in GSOs for the cohort of RIBs classified as pass successful

Cohort	Variable	Groups		Test statistics and ES
		RIBs ending in GSOs (n=93)	RIBs not ending in GSOs (n=201)	
Pass successful (n=294)	V_{max}	25.91 (SD 4.08)	25.13 (SD 3.98)	p = 0.123 C’d 0.19
	Acc_{max}	2.51 (SD 0.96)	2.42 (SD 0.87)	p = 0.442 C’d 0.1
	TTMA	1.60 (IQR 1.35 - 1.90)	1.60 (IQR 1.30 - 1.80)	p = 0.135 r = 0.09

Note: Description of the variables V_{max} in km/h, Acc_{max} in m/s2 and TTMA in seconds reported as mean and standard deviation or median and interquartile range respectively. The test statistics for differences between RIBs ending in GSOs and RIBs not ending in GSOs is reported and marked in bold when reaching the significance level of $p < 0.05$. The ES is reported as Cohens’d or the point-biserial correlation r respectively. Results are reported for all RIBs classified as pass successful. RIB, run in behind; GSO, goal scoring opportunity; ES, effect size; V_{max}, Maximal velocity; Acc_{max}, Maximal acceleration; TTMA, Time to maximal acceleration; IQR, interquartile range; SD, standard deviation.

Table 6 shows the results for inter-group differences of V_{max}, Acc_{max} and TTMA between types of attack, for the cohort with all RIBs and the cohort with RIBs ending in GSOs only.

When all RIBs are included, significant differences in mean ranks of V_{max} ($p = 0.001$) and TTMA ($p = 0.09$) but not Acc_{max} ($p = 0.01$) were observed across the types of attack. Several significant inter-group differences were observed for V_{max} and TTMA (see Table 6 and Figures 1-6).

In the cohort of RIBs leading to GSOs, significant differences in mean ranks of V_{max} ($p = 0.027$), but not TTMA ($p = 0.524$) and Acc_{max} ($p = 0.339$) were observed across the types of attack. Moreover, a significant inter-group difference was only observed for V_{max} ($p = 0.042$) with a moderate ES ($r = 0.37$) between build-up play and counterattack. No other inter-group comparisons reached significant levels (see Table 6 and Figures 1-6).

Table 6: *Pairwise and cross-sample comparison of distributions of V_{max}, Acc_{max} and TTMA*

Cohort	Variable	Pairwise comparison						Cross-sample comparison
		BU - DP	BU - CA	BU - CP	DP - CA	DP - CP	CA - CP	
All (n = 1089)	V_{max}	**p < 0.001** r = 0.13	**p < 0.001** r = 0.37	p = 0.071 r = 0.09	**p < 0.001** r = 0.26	p = 1 r < 0.01	**p = 0.001** r = 0.23	**p < 0.001**
	Acc_{max}	p = 1 r = 0.01	p = 0.367 r = 0.06	p = 1 r = 0.02	p = 1 r = 0.06	p = 1 r = 0.05	p = 0.609 r = 0.1	p = 0.227
	TTMA	p = 0.193 r = 0.07	**p = 0.028** r = 0.1	**p = 0.004** r = 0.13	p = 1 r = 0.02	p = 0.441 r = 0.11	p = 0.85 r = 0.09	**p < 0.001**
RIBs ending in GSOs (n = 93)	V_{max}	p = 0.773 r = 0.18	**p = 0.042** r = 0.31	p = 1 r = 0.06	p = 1 r = 0.12	p = 1 r = 0.31	p = 0.306 r = 0.38	**p = 0.027**
	Acc_{max}	p = 1 r = 0.04	p = 1 r = 0.15	p = 1 r = 0.12	p = 1 r = 0.12	p = 1 r = 0.14	p = 1 r = 0.02	p = 0.524
	TTMA	p = 1 r = 0.08	p = 1 r = 0.01	p = 0.466 r = 0.23	p = 1 r = 0.08	p = 1 r = 0.26	p = 0.703 r = 0.31	p = 0.339

Note: The test statistics for differences in distributions is reported and marked in bold when reaching the significance level of $p < 0.05$. The effect size is reported as the point-biserial correlation r. The tests are performed for all RIBs and for RIBs ending in GSOs. BU, Build-up play, DP, Direct play; CA, counterattack; CP, counter-press; V_{max}, Maximal velocity; Acc_{max}, Maximal acceleration; TTMA, Time to maximal acceleration; RIB, run in behind; GSO, goal scoring opportunity

Figure 1: *Differences in maximal velocity of all runs behind the opponents' defensive line (n = 1089) between types of attack*

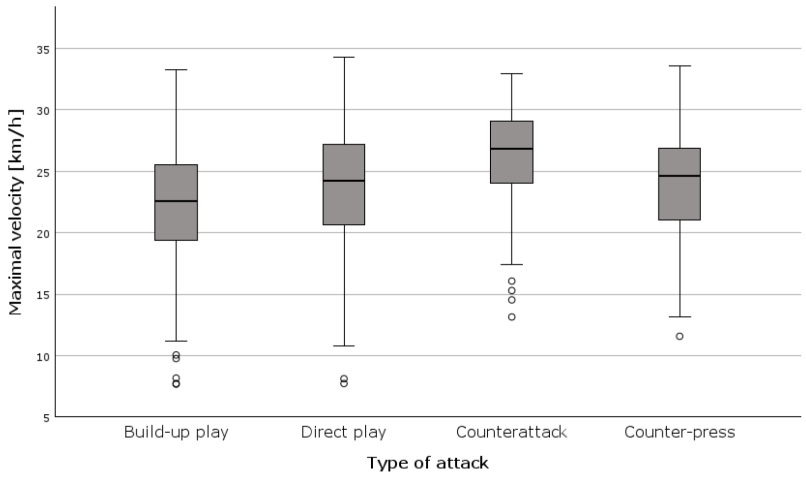


Figure 2: *Differences in maximal velocity of runs behind the opponents' defensive line ending in goal scoring opportunities (n = 93) between types of attack*

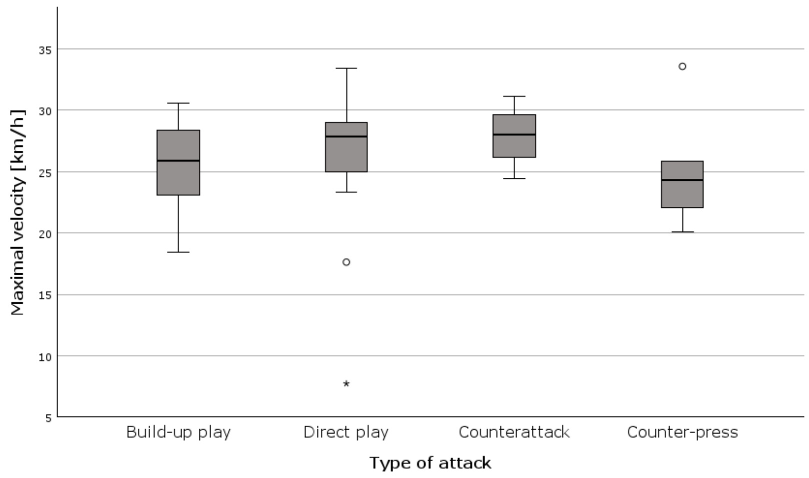


Figure 3: *Differences maximal acceleration of all runs behind the opponents' defensive line (n = 1089) between types of attack*

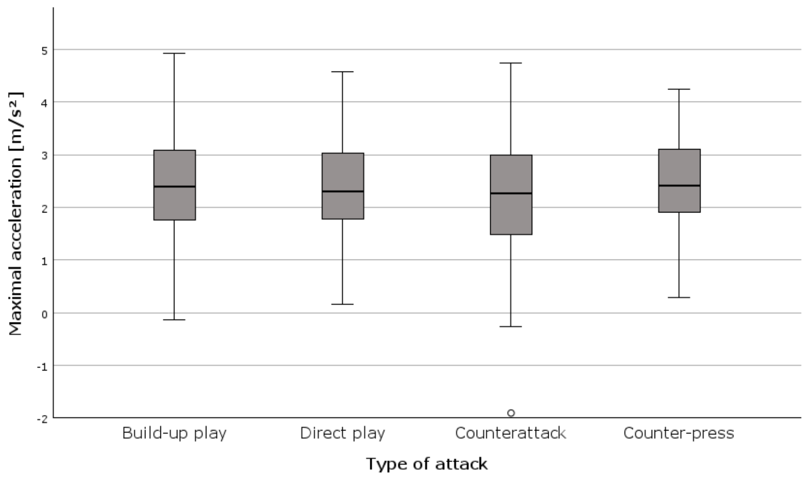


Figure 4: *Differences in maximal acceleration of runs behind the opponents' defensive line leading to goal scoring opportunities (n = 93) between types of attack*

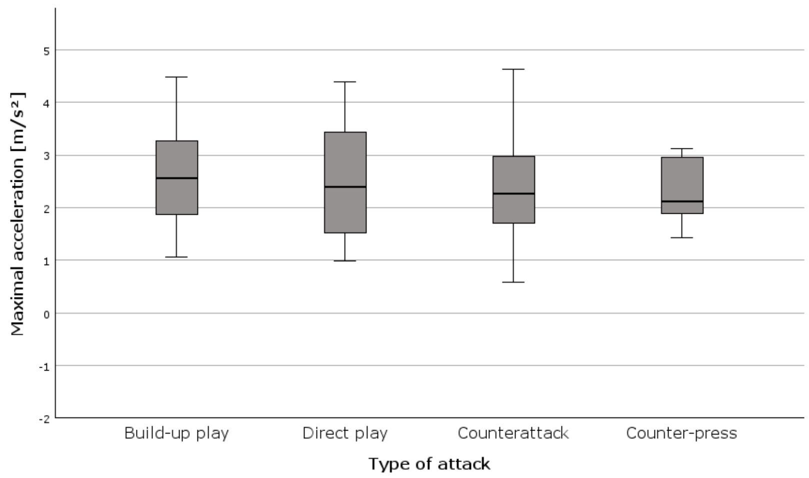


Figure 5: *Differences in time to maximal acceleration of all runs behind the opponents' defensive line (n = 1089) between types of attack*

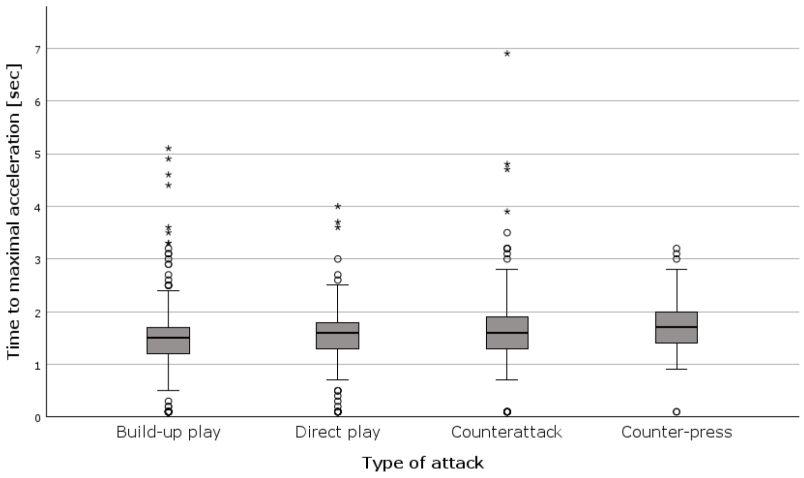
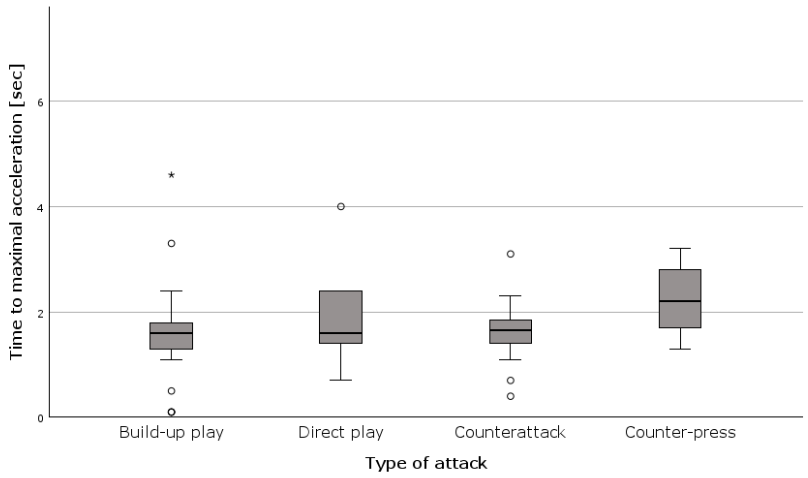


Figure 6: *Differences in time to maximal acceleration for runs behind the opponents' defensive line leading to goal scoring opportunities (n = 93) between types of attack*



6 Discussion

The aim of this study was to investigate the relationship between physical parameters measured by GPS tracking systems and RIBs as a specific tactical movement potentially leading to a GSO. Moreover, such relationship was contextualized for different types of attack, mainly defined by preceding phases of play and structural organization for both teams.

Across 30 league matches, 1089 RIBs were included in the analysis. The results showed that 59.4% of all RIBs were classified as build up-play and 16.4% as direct-play. This corresponds to a total of 75.8% of all RIBs. Thus, most of the RIBs result from prolonged phases of possession. This is supported by previous research in the same professional soccer league, where out of 1703 observations of possession, 59.2% of them were classified as attacks from "possession play". The category used by Tenga et al. (2010) corresponds to the combination of the categories build-up play and direct play used in this study (Tenga et al., 2010). However, Mitrotasios et al. (2019) observed high variation in the proportions of types of attack during the 2017/2018 seasons in Spanish La Liga, English Premier league, German Bundesliga, and Italian Serie A. Higher build-up play attacks were observed in the Spanish La Liga, while the English Premier League showed more attacks from direct play. Counterattack were predominant in the German Bundesliga while short counterattacks and direct play attacks were predominant in the Italian Serie A (Mitrotasios et al., 2019). Therefore, the present results must be interpreted based on the playing style of the different leagues and teams.

Although the proportion of GSOs did not differ drastically across types of attack, counterattacks and counter-press recorded the highest values with 10.10% and 9.23% respectively. This suggests that when the oppositions' defense is unorganized, the outcome of a GSO might be more likely to occur after a RIB. When Tenga et al. (2010) investigating the occurrence of score-box possession, such relationship was present. Attacks classified as "counterattack", presupposing an imbalance in the opponents' defensive structure, were more likely to end in score-box possession (Tenga et al., 2010).

It was shown before, that sprinting without the ball is the most common movement preceding goals in the first German national league (Faude et al., 2012), corresponding to 81% of all goals. Faude et al. (2012) defined sprints as very high intensity runs at near maximal velocity, which is in line with the average V_{max} found in RIBs leading to GSOs in this study (Median: 26.45 km/h; IQR: 23.94 to 28.76 km/h). The results show that V_{max} was significantly higher for RIBs leading to GSOs compared to all other RIBs. This difference was also found for build-up play and direct-play, but not for counterattack and counter-press when differentiated by type of attack. Although the effect was small across cohorts, this might suggest that V_{max} plays a key role in the creation of GSOs through RIBs in situations where the opponent is defending in an organized structure (i.e., RIBs during build-up play and direct play). This does however not imply that V_{max} is unimportant in attacks where the opponent defends in an unorganized structure, as V_{max} was higher in counterattacks compared to build-up play. This was observed for all RIBs as well as for those ending in GSOs only, showing a medium effect. The oppositions' movement is suggested as a partial explanation, as the opponent might seek an organized defensive structure during counterattacks. Thus, opponent players potentially start their recovery runs before the RIB is performed and the attacking player is required to run faster to outrun the opponent and get in the space behind him. However, such causality would have to be investigated in future research. When only investigating RIBs with a successful pass to the player, a very small effect was observed with no significant difference in V_{max}. Therefore, V_{max} might not explain the outcome of a RIB when the pass to the player performing it was successful.

It was hypothesized that Acc_{max} and TTMA were important for the outcome of RIBs. The results did not support this statement for Acc_{max} as no significant differences were found for neither all RIBs nor when differentiated by types of attack. ESs did not reach the threshold to be defined as small. These findings were mirrored when investigating Acc_{max} for successful passes only. No significant difference was observed when analyzing inter-group differences of RIBs ending in GSOs, with ESs varying from not definable to small (see Table 6). This might suggest that Acc_{max} does not significantly influence the outcome of GSO. However, the lack of such results might be tracked back to technical issues mentioned in the limitations.

Significantly higher TTMA were found in RIBs leading to GSOs compared to all other RIBs. Mirrored results were observed for the cohort build-up play. The ES did not reach the threshold to be defined as small in any of the cohorts, except for counter-press. It was hypothesized that a shorter TTMA is rather beneficial for the outcome, as the movement is more explosive, and the opponent might have less time to react. However, the contrary result is seen for all RIBs and for the cohort build-up play only, which makes up 59.4% of the general cohort. A cursory explanation may suggest that during phases where the opponent is defending in an organized structure, the pass is executed from a closer distance, compared to the cohort direct play. This suggests that the opposition has less time to react once the pass is executed. Thus, the first part of the RIB might be executed with sub-maximal acceleration, and maximal acceleration is first enacted after the execution of the pass. Because of the short reaction time, the player performing the RIB might still obtain spatial advantage while carrying out sub-maximal acceleration in the initial phase of the run. The lower TTMA in RIBs not leading to GSOs would then be explained by the player interrupting the run earlier as the pass is not executed and thus, Acc_{max} is reached in the first phase of the run already. However, the indifference in Acc_{max} for the cohort build-up play does not support such explanation. No significant difference in TTMA was observed for the cohort successful pass, with the ES not reaching the minimal threshold to be defined. The inter-group comparison showed significant differences, with lower TTMA in build-up play compared to counterattack and counter-press when all RIBs were included. The ESs were small. No other inter-group differences were significant and ESs did not reach the threshold to be defined, except for the comparison of direct play with counter-press, showing a small effect. No significant differences were noticed when analyzing RIBs leading to GSOs only. ESs ranged from non-definable to moderate. Results regarding TTMA should be interpreted cautiously as many outliers were present across several cohorts. As of today, no research has investigated Acc_{max} or TTMA in RIB previously. Consequently, further research is needed to fully understand the influence of acceleration characteristics on RIBs.

The main limitation of the study is that it only included data collected from a single team throughout a single season. Not only does this limit the transferability to other teams in the same league, but the results might hardly be generalizable for teams playing in different leagues at different levels. It was shown before that actions leading to GSOs are highly dependent on tactical characteristics of individual teams and specific leagues. The use of wide areas in previous actions to GSOs was higher in the Major League Soccer (highest professional soccer division in the United States of America) season of 2014 than in the World Cup 2010 (Gonzalez-Rodenas et al., 2018). This highlights the different use of space in goal creation phases. Moreover, previous research highlighted the difference of running behavior based on player position on the field (Ade et al., 2016; Di Salvo et al., 2009). Thus, it is suggested to include player position and differentiate RIBs by areas on the pitch in future research.

Furthermore, this study potentially violates the independence of observations. Previous findings show that the match status (i.e., winning, drawing or losing) significantly influences the teams possession in the final third of the pitch (Lago, 2009) and score-box possession (Lago-Ballesteros et al., 2012). Thus, leading in a competitive match resulted in the team playing in a more defensive style and having less attacking phases (Lago, 2009; Lago-Ballesteros et al., 2012). Although this might suggest a lower frequency of RIBs when winning, it is unclear whether the match status has an influence on V_{max}, Acc_{max} or TTMA of those RIBs. Nonetheless, controlled interventional studies where the match status as confounder is eliminated are unrealizable in elite soccer when investigating tactical movements in competitive matches.

It should be mentioned that this study uses a video-based approach to assess RIBs as well as to classify them into different type of attacks. This approach may by prone to subjective bias. This suggests that inter-observer consistency should be evaluated by kappa statistics. However, definitions of RIBs and classification criteria for type of attack were either unpresented or lacking specificity in previous research. Thus, such definitions were constructed during the analysis process and no disagreement was present between the observers. Therefore, the study refers to report kappa statistics.

The lack of significant results in most of the comparisons of acceleration metrics might be explained using raw acceleration data in this study. The acceleration is calculated with an interval of 0.1 seconds in the raw data and no filter is applied. This often causes noise in the data and therefore many manufacturers use filters such as moving average, mean and exponential filters (Malone et al., 2017). The raw data is unsmoothed and thus, the noisy data might explain the lack of significant differences in Acc_{max} and TTMA. Especially the high number of outliers in TTMA might be counteracted by filtering the raw acceleration data. Moreover, the use of acceleration efforts is suggested for further research. An acceleration effort would be calculated by the acceleration metric being above a certain threshold for a pre-defined time interval (e.g., acceleration above 1 m/s^2 for at least 0.6 seconds). Such acceleration efforts are often used when handling acceleration metrics (Malone et al., 2017).

As the results show that V_{max} was significantly higher in RIBs where a GSO was the outcome, it highlights the importance of speed in this specific tactical movement. Especially in build-up play and direct play V_{max} was higher when a GSO was the outcome. Additionally, V_{max} was higher for GSOs occurring after RIBs in counterattacks compared to build-up play, which implies that achieving high V_{max} is generally desirable for RIBs. The conclusions must be interpreted with caution as ESs were generally small or very small. No general conclusions could be drawn for Acc_{max} and TTMA, as the results were equivocal. Acceleration characteristics of RIBs have shown to be of minor importance when creating GSOs through RIBs. However, this might come down to sample size and data processing of the current study. Thus, it might provide an incentive for future research, with larger studies and filtered data.

The present findings might influence the selection of players and strategies for competition where RIBs are part of the match strategy. When using RIBs in the match strategy or tactical philosophy is employed, players with the capability to reach higher speeds might be preferred. In addition, the importance of physical capacity and intelligent pacing that was highlighted before (Schulze et al., 2022), is supported by the current findings.

7 Conclusion

The aim of this study was to investigate the relationship between velocity and acceleration characteristics of RIBs and GSOs in soccer matches. This was further examined for different types of attacks.

The hypothesis that V_{max} is higher in RIBs leading to GSOs for all RIBs was confirmed. When differentiated by types of attack, this hypothesis was only confirmed for build-up play and direct play. This might be explained by the anticipatory movement of the opposition during counter-press and counterattacks. Contrary to the hypothesized relationship between TTMA and RIBs leading to GSOs, higher TTMA were observed for RIBs leading to GSOs. This might be explained by the players performing the first part of a RIB with sub-maximal acceleration during build-up play and direct play, which make up to 59.4% of all RIBs. The hypothesized influence of Acc_{max} was not observed in the present results, as Acc_{max} did not differ between RIBs leading to GSOs and all other RIBs.

As expected, maximal acceleration was similar across types of attack for all RIBs and RIBs leading to GSOs. The TTMA was found to be higher in counterattack and counter-press compared to build-up play and direct play, which is contrary to the initial hypothesis. Due to the noise within the data, the study refers to draw any conclusions. As expected, V_{max} was higher in counterattack compared to build-up play and direct play when analyzing all RIBs. Additionally, V_{max} was higher in counterattack compared to counter-press when analyzing all RIBs. When only RIBs leading to GSOs were analyzed, maximal velocity was higher in counterattack compared to build-up play. This supports the hypothesis that RIBs during counterattacks are performed at higher velocities.

To confirm and further explore the relationship of speed and acceleration characteristics on the occurrence of GSOs after RIB, larger sample size studies are required. Moreover, several teams should be included to give more generalizable recommendations. With large enough samples and filtered data, regression models could be estimated to give a more comprehensive understanding of the influence of physical parameters RIBs and their outcome. This paper used an explorative approach based on a tactical viewpoint, to provide insights into the efficiency of RIBs. The current data may enhance training design, player selection and match strategy.

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