Master's thesis

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

Nikolai Buer Haugen

Locomotor Activities Before Scoring in Norwegian Semi-Professional Soccer Players

Master's thesis in Physical Activity and Health - Exercise Physiology
Supervisor: Ulrik Wisløff
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HIGH-INTENSITY ACTIONS BEFORE SCORING IN SOCCER

AIMS

#1 Analyse the performance of locomotor categories in the last involved players preceding scorings.

#2 Association between number of goals, passes completed and high-intensity performance prior to scoring.

METHODS

TIME-MOTION ANALYSIS
of the 3 last players involved in scoring

LOCOMOTOR CATEGORIES:

- Running intensity = 14.4-19.7 km/h
- High-intensity running = 19.8-25.2 km/h
- Sprinting = >25.2 km/h

RECORDED TIME INTERVAL
from winning the ball back until scoring

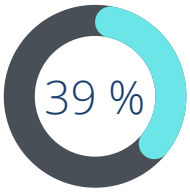
PLAYERS INVOLVED IN SCORINGS:

- Goal scorer
- Assisting player
- 2nd assisting player

VIDEO ANALYSIS

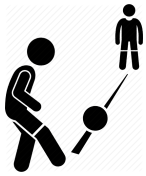
RESULTS

THE ASSISTING PLAYER
sprinted 4-6 meters before each goal, more than the other two groups.



VARIATION IN SPRINT
explained the number of goals scored

AVERAGE DURATION
from winning the ball back until scoring



3.1 ± 3.4 PASSES
completed prior scoring

CONCLUSION

- ASSISTING PLAYER
  ran on average 8.5-10.7 meters in high-intensity actions before each goal.
- EMPHASIS ON SPRINTING
  performance in goal situations
- 0 TO 4 PASSES
  completed before the majority of goals

Abstract

Purpose: The present study aimed to analyse and quantify various locomotor categories and physical performance variables prior scoring in Norwegian semi-professional male soccer players. A secondary aim was to explore the association between number of goals scored with number of passes completed prior to scoring and performance of high-intensity actions. **Methods:** Nineteen players (25 ± 3 years) playing in the 2nd highest level in Norway were included. A sample of 43 goals scored in domestic home matches (*n*= 16) during the 2020 season was analysed using time-motion analysis (ZXY Sports Tracking system) in combination with video analysis. The included variables were distance covered in running intensity (14.4 to 19.7 km·h^{-1}), high-intensity running (HIR (19.8 to 25.2 km·h^{-1})) and sprinting (≥25.2 km·h^{-1}), total distance covered, total number of accelerations, number of HIR and sprints undertaken. The three last players involved in the goals were characterised as *goal scorer, assisting player* or *2nd assisting player.* All variables were manual recorded in the time intervals from winning the ball back until scoring. **Results:** The number of passes completed before scoring was 3.1 ± 3.4 in a time interval of 20.2 ± 16.4 seconds from winning the ball back until scoring. Preceding scoring the assisting player ran longer distances in the included locomotor categories than goal scorer and 2nd assisting player. Results showed that 39.4% of the sprinting variation could explain the number of goals. 52.1% of the assisted passes from the wide midfielders was preceded by a sprint. Players in lateral positions were found to cover significant longer sprinting distance and greater number of sprints compared to central positions prior to scoring (p <0.05). **Conclusions:** These findings provide knowledge about the presence of high-intensity actions preceding scoring. The last sequence from winning the ball back until scoring lasted 20.2 ± 16.4 seconds with 3.1 ± 3.4 passes completed. In that same period ran the assisting player on average 10.7 and 8.5 meters in HIR and sprinting intensity before each goal. The physical performance of the assisting player indicates to play an uttermost important role in scoring situations.

Key words: *Soccer, high-intensity running, sprinting, prior scoring, time-motion analysis, goal involvement, passing performance.*

Norsk abstrakt

Formål: Denne studien hadde som mål å analysere og kvantifisere ulike bevegelseskategorier og fysiske prestasjonsvariabler før skåring i norske semi-profesjonelle mannlige fotballspillere. Et sekundært mål var å analysere sammenhengen mellom antall skårede mål med antall suksessfulle pasninger før skåring og distansen løpt i høyintensitet og sprinting. **Metode:** Nitten spillere (25 ± 3 år) fra et lag i den nest høyeste divisjonen i Norge var inkludert i denne studien. Et utvalg av 43 skårede mål i hjemmekamper (*n*= 16) i løpet av 2020 sesongen ble analysert med bevegelsesanalyse (ZXY Sports Tracking system) kombinert med videoanalyse. De inkluderte variablene var distanse i løpeintensitet (14.4 to 19.7 km·h^{-1}), løping i høyintensitet (HIR (19.8 to 25.2 km·h^{-1})) og sprinting (≥25.2 km·h^{-1}), total distanse, antall akselerasjoner, antall løp i høyintensitet og antall sprinter. De tre siste spillerne som var involvert i målene ble definert som *målskårer, målgivende spiller* eller *2. målgivende spiller.* Alle variablene ble manuelt registrert i tidsrommet fra ballen ble vunnet tilbake og fram til skåring. **Resultat:** Antall pasninger før skåring var 3.1 ± 3.4 i en tidsperiode på 20.2 ± 16.4 sekunder fra ballen ble vunnet tilbake og fram til skåring. Før skåring løp den målgivende spilleren lengre distanser i de inkluderte bevegelseskategoriene sammenlignet med målskåreren og den 2. målgivende spilleren. Resultater viste at 39.4% av sprintvariasjonen kunne forklare antall skårede mål. 52.1% av de målgivende pasningene fra kantspillerne ble utført direkte etter en sprint. Spillere i kantposisjoner dekket betydelig lengre sprint distanse og høyere antall sprinter sammenlignet med spillere i sentrale posisjoner forut for skåring (p< 0.05). **Konklusjon:** Den målgivende spillerens fysiske prestasjon ser ut til å spille en ytterst viktig rolle i skåringssituasjoner. Den siste sekvensen fra ballen ble vunnet tilbake og fram til skåring var i gjennomsnitt 20.2 ± 16.4 sekunder med 3.1 ± 3.4 pasninger gjennomført. I den samme perioden løp den målgivende spilleren i gjennomsnitt 10.7 og 8.5 meter i høyintensitet og sprint før hvert mål. Disse resultatene vil gi bedre kunnskap om høyintensitets handlinger i den siste fasen før skåringer.

Nøkkelord: *Fotball, høyintensitetsløping, sprinting, før skåring, bevegelsesanalyse, målinvolvering, pasnings prestasjon*.

FREQUENTLY USED ABBREVIATIONS

2^{nd}AP = 2^{nd} assisting player

AP = Assisting player

CB = Center backs

CDM = Central defensive midfielders

CM = Central midfielders

FB = Full-backs

GS = Goal scorer

HIR = High-intensity running

ST = Strikers

WM = Wide midfielders

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1 INTRODUCTION

Soccer is a team sport highly dependent on individual attributes. Thus, high levels of individual physical, technical and tactical skills are considered important for team success. Today's soccer has developed into a more rapid and dynamic game with quicker transitions, increased high-intensity running (HIR), passing tempo, and more accelerations and sprints (1, 2). This has led to increased physical and tactical demands for the individual player (3). Analysis of game speed and playing patterns from World Cup final games between 1966-2010 found that passes per minute and ball speed increased by 35% and 15% over the 44 year period (3). A recent study by Bush et al., (2) examined the evolution of physical and technical performance in the English FA Premier League throughout seven seasons with a particular focus upon game speed (2006-07 to 2012-13). Interestingly, the overall sprinting distances were found to be increased by about 50%, with positional differences ranging between 36-63% in that timespan.

To obtain and better understand the physical aspects of soccer, modern time-motion technology is commonly used by professional and elite clubs (4, 5). It enables clubs to keep track of the players´ physical efforts during matches and training sessions. Greater information about physical actions allows for the adaptation of training sessions into more individualized and adjusted physical conditioning programs, as physical demands vary by playing position (6, 7). The data can be used to quantify the performance of the individual player, which has practical value for practitioners (8, 9). Studies using time-motion analysis have found that soccer players cover about 8-13 km during a 90-minute match, depending on playing position (10-12).

The use of time-motion analysis has provided insight into the alternating intensity level. It is commonly accepted that the vast majority of the game is made up of long periods of lower intensity. While shorter periods of movement of high-speed components such as sprinting, HIR, accelerations, decelerations, change of direction, and other explosive actions more dependent on anaerobic energy release are critical in decisive moments of the game. (4, 11, 13, 14). Although aerobic metabolism dominates activity profiles (11), authors have proposed anaerobic components such as HIR and sprinting as the most appropriate variables evaluating and interpreting physical performance (15-18). Every 60 to 90 seconds soccer players perform a high-intensity action, lasting about 2 to 4 seconds (11, 19, 20).

Despite being an important measure of performance multiple studies have found that HIR and sprinting accounts for only 10% (8, 16, 21) and 10-12% (10, 11, 22) of the total distance covered, respectively. Faude et al., (19) analysed 360 goals in the German Bundesliga where straight sprints were the most frequent action performed by the scoring and assisting players. At least one powerful action (defined as straight sprints, change-in-direction sprints, jumps, and rotations) was observed in 83% of the goals. Before scoring, 75% of the straight sprints by the scoring players were done without the ball, while the dominant action was sprinting with the ball in 64% of the goals by the assisting player (19). However, only descriptive data were analysed, which included counts and percentages of sprinting actions in goal situations. Despite this, analysis of activity profile in an Italian club participating in the Champions League (2004-2005 season) showed that the average sprint duration lasted 2.2 seconds, and 93% of the high-intensity and sprinting actions were between 2 and 19 meters (23).

The physical variations within playing positions are well accepted in the existing research literature. Previous studies have found that wide midfielders (WM) and full-backs (FB) perform more HIR compared to other positions (5, 12, 24). Analysis of physical performance data from 67 European Champions League and UEFA Cup (2002-2006 seasons) matches showed that wide midfielders (WM), strikers (ST), and full-backs (FB) ran longer sprinting distance than central midfielders (CM) and center backs (CB), according to Di Salvo et al., (22). Chmura et al., (25) pointed out that physical differences were related to match outcome. Results showed that WM and ST covered significant longer distances in high-intensity running (21 to 23.99 $km \cdot h^{-1}$) and sprinting (>24 $km \cdot h^{-1}$) during won matches than drawn or lost. This represents that high-intensity actions could play a role in influencing the match outcome. Furthermore, the lateral positions (WM and FB) tend to accelerate the most (13, 26). Also, players in lateral positions have shown to produce the greatest increase in sprinting distances of 54% and 63%, over a seven-year period (2). Midfielders have also been shown to perform a substantially greater number of sprints between 2 and 9 meters, and between 30 and 40 meters compared to other positions (23). On the other hand, CB does less sprinting and HIR than any other position (24). Bush et al., (2) found a moderate increase in total HIR and sprinting distance for all positions, with the FB having the most significant ($p < 0.001$) increase of 35% and 62%, respectively, over seven seasons.

In addition to physical performance, team success also depends on technical factors such as number of shots and shots on goal, ball possession, and rate of effective passes (27). Teams that can maintain longer passing sequences have been suggested to increase the chances of scoring (28). Redwood-Brown (29) investigated the passing performance in the 5 minutes before the goals scored in 120 English FA Premier League matches (2004-2005 season). On average, the scoring team conducted 22.5 ± 8.8 passes which had a significantly higher passing accuracy in those 5 minutes before scoring compared to the average for that half the goal was scored in. Whereas, the passing sequence preceding scoring included a long pass in 34.1% of the goals and was the most frequent action before goal scoring during the 2004 European Championship (30). Studies conducted in Norwegian soccer have used passing performance as indicators to assess goal opportunity and scoring patterns with various approaches. Findings from the Norwegian men´s professional football league (2004 season) analysing passing performance related to entering the oppositions scoring area indicated that longer passing sequences with more than 5 passes were more effective than shorter sequences with less than 2 passes. However, entering the "score-box" was discussed as a less appropriate outcome variable compared to prior to goals scored (31). Nevertheless, there seem to be contradicting results about the length of passing sequences leading to goal scoring. Both shorter passing sequences of one to four passes (32) as well as longer sequences of five or more are an effective way of scoring more goals both in professional Norwegian (31) and elite Australian football (33).

In the existing literature, few studies have used time-motion analysis to analyse high-intensity actions at the same competitive level as the present study. Sæterbakken et al., (34) included teams from the same competitive level as the present study when comparing running performance in Norwegian soccer players. However, the objective was to analyse physical performance across full 90-minute matches. Although analysis of speed abilities has been described in scoring situations (19), only frequency of powerful actions was included. Nonetheless, to better understand how high-intensity performance can contribute to decisive scoring situations, quantifying high-intensity parameters would provide players,

coaches, and sports practitioners what physical actions occurs before each goal. Further, little is known about the association between the number of scored goals, successful passing sequences, and the high-intensity activity before scoring in Norwegian soccer players.

The primary goal of this research was to quantify various locomotor categories (total distance covered, distance running, high-intensity running, and sprinting) as well as physical performance variables (number of accelerations, high-intensity runs, and sprints) in semi-professional male soccer prior to scoring. A secondary aim was to analyse the relationship between the number of goals scored and the corresponding performance in HIR and sprinting. Further, we explored the relationship between the number of passes completed before each goal with performance in HIR and sprinting. The hypothesis was that the assisting player (AP) would cover longer distances in the high-intensity categories (HIR and sprinting) than any other goal involvement group. Positional differences were also predicted for the locomotor categories, number of accelerations, HIR, and sprints with FB and WM positions eliciting better results.

2 METHODS

2.1 Study design and Methodology

2.1.1 ZXY Sport Tracking System

Movements were captured by a fully automatic radiofrequency-based sports tracking system (ZXY Sport Tracking AS; ChyronHego, Trondheim, Norway) (13), to determine the players´ physical performance during match play over a full season. The players were equipped with a small body-worn sensor located at the lumbar region during matches that constantly tracked their actions and movements on the field (4, 35). The following physiological performance variables were collected from the ZXY Sport Tracking System: distance covered in running intensity, high-intensity running (HIR), sprints, total distance (includes all intensities), the total number of accelerations, HIR, and sprints within a given time interval. Data were transferred by a microwave radio channel to a stationary RadioEye® sensor (ZXY Sport Tracking AS; ChyronHego, Trondheim, Norway) mounted at the team´s home stadium. Player movement was registered at 10 Hz (36). The reliability of the ZXY Sport Tracking system has previously been addressed in several studies, indicating good reliability for the x and y positions (4, 13, 26, 35, 37).

2.1.2 Combined ZXY and video analysis

TV-images (captured from discoveryplus.no) were used to manually note the time (minutes and seconds) from when the team won back ball possession and until scoring goals. To synchronize the players´ dynamic behaviours on the field with the TV-images, ZXY´s post-match analysis program, ZXY Replayer, provided access to recognize the scoring situations and recording of the desired time interval (36). The time interval for goals scored from a set-piece (e.g. corner, direct free kick, penalty) followed the same procedure as a "normal" goal but ended as the ball possession sequence lead to a set piece (e.g. foul leading to penalty/free kick or ball out of play for corner). All analysed data were collected in the time interval before scoring. To determine and record the start of the desired time interval, the definition of the concept "ball possession" from Pollard & Reep (38) was used:

A team possession starts when a player gains possession of the ball by any means other than from a player of the same team. The player must have enough control over the ball to be able to have a deliberate influence on its subsequent direction. The team possession may continue with a series of passes between players of the same team but ends immediately when one of the following events occurs: a) the ball goes out of play; b) the ball touches a player of the opposing team (by means of a tackle, an intercepted pass or a shot being saved). A momentary touch that does not significantly change the direction of the ball is excluded.

2.2 Subjects and match data

Nineteen male semi-professional soccer players (25 ± 3 years) participated in this study. The present team competed in the Norwegian 1st division (OBOS-league, 2nd highest level in Norway), secured a spot amongst the teams fighting for promotion to the Norwegian top league, and made it to the penultimate qualifying round. Only the domestic home matches (*n* = 16) throughout a full season were used for data analysis as the ZXY-system was not installed at other stadiums and were not portable. All matches were played on an artificial grass surface with rubber shavings. The data set were collected from players across six playing positions: central backs (CB, *n*= 3); full-backs (FB, *n*= 3); central defensive midfielders (CDM, *n* = 2); central midfielders (CM, *n*= 5); wide midfielders (WM, *n*= 3) and strikers (ST, *n*= 3). Due to the different nature of activity of the goalkeepers, this playing position was excluded from the analysis in this study (*n*= 2). The start of the season was delayed due to the Covid-19 pandemic, resulting in a tighter match schedule than expected. The team had an average of 4.6 ± 2.6 days of rest between all league and qualifying matches (*n*= 32) before the next match (only counting a full 24h day in between the previous and next match).

A total of 43 goals were analysed, of those, 38 got a pass from an assisting player (AP) that provided the goal. While 19 of the 43 goals, in addition to an assisting pass, had a 2nd assisting player (2ndAP) involved in the goals. A total of 693 individual observations were undertaken on outfield players across seven physiological match variables (distance covered in running intensity, HIR, sprinting and total distance cover, the total number of accelerations, HIR and sprint runs). Additionally, only the three last players that were involved in the scoring were analysed and categorized as either *goal scorer* (GS) (*n*= 294, missing observations *n*= 126 (42.8%)*, assisting player* (AP) (*n*= 266, missing observations *n*= 70 (26.3%)*,* or *2nd assisting player* (2ndAP) (*n*= 133, missing observations *n*= 28 (21.0%). The study was approved by the Norwegian Center for Research Data (*reference number 139892*).

2.2.1 Locomotor categories with defined cut-off values

The ZXY Sport Tracking system had pre-defined cut-off values for the selected locomotor categories: distance (included all intensities, measured in meters), running intensity (14.4 to 19.7 km·h^{-1}), HIR (19.8 to 25.2 km·h^{-1}), and sprinting (≥25.2 km·h^{-1}). The speed thresholds for each locomotor category are similar to previously reported studies (1, 10, 13, 21, 26, 39).

2.2.2 Accelerations

Specific cut-off values defined an acceleration by the following four criteria. Firstly, the start event of acceleration must reach at least 1 m·s^{-2}. A minimum of 2 m·s^{-2} must be

achieved to be counted as an acceleration. The acceleration had to stay above the limit of 2 $m \cdot s^{-2}$ for a minimum of half a second. Lastly, an acceleration ends when the minimum limit of 1 $m \cdot s^{-2}$ passes (13, 26).

2.3 Statistical analysis

The descriptive statistics were calculated and reported as median and interquartile range (IQR) was used to display the distribution for the locomotor activities and the goal involvements (GS, AP & 2ndAP) (Fig. 2). Normal distribution revealed that 11 of 12 data samples were not normally distributed and were therefore controlled by a Shapiro-Wilk test ($p < 0.05$). Only the *total distance* in the AP-group showed a normally distributed sample ($p = 0.186$). A Kruskal-Wallis *H* test was used to determine any statistical differences for each locomotor category across the three goal involvement conditions.

2.3.1 Passing and goals correlation with high-intensity actions

Spearman´s correlation was computed to investigate the strength of the relationship between the number of goals scored in matches ($n = 11$, missing= 4), the number of passes completed from the team winning the ball back until scoring, with the distance covered in HIR and sprinting. Data were examined using a scatterplot with linear regression, correlation coefficient (*r*), and the regression equation was calculated to determine the relationship between the variables. Effect size values of 0.2, 0.5, and >0.8 were interpreted to represent weak, moderate, and strong correlation, respectively. Due to the low number of observations in each playing position, the sample were grouped into central positions (center backs, central defensive midfielders, central midfielders, and strikers) and lateral positions (full-backs and wide midfielders). Descriptive statistics revealed a skewed distribution in the locomotor categories in both positional groups. Further, the differences between the two groups were investigated using independent samples t-tests (Mann-Whitney U test). All statistical analyses were made using IBM SPSS 26.0 (SPSS Inc., Chicago, IL, USA).

3 RESULTS

During the study period, a total of 43 goals were scored across 16 home matches. The average recorded time interval from winning the ball back until scoring was 20.2 ± 16.4 seconds and the number of completed passes in that same period was 3.1 ± 3.4.

3.1 Locomotor actions preceding scoring

Before scoring the GS ran a total of 284 meters and 62 meters in HIR and sprinting, AP covered a total of 300 meters and 238 meters in HIR, and sprinting with corresponding values for 2ndAP were 132 and 65 meters. This showed a trend of AP averagely sprinting longer distance (4-6 meters) than GS and 2ndAP preceding each goal ($p = 0.065$) (Fig. 1). In the last sequence from winning the ball back before scoring, we observed a moderate significant association between the performance in the following speed intensities and goal involvement groups: 1) distance covered in HIR between GS and AP ($r = 0.559$, $p = 0.004$), 2) sprinting for GS and HIR for AP ($r = 0.557$, $p = 0.004$), 3) sprinting between GS and AP ($r = 0.607$, $p < 0.001$). Furthermore, a weak significant association was observed between HIR for the GS and sprinting for the AP ($r = 0.426$, $p = 0.034$).

A Kruskal Wallis test showed no significant differences in the distances covered in the various locomotor categories (total distance regardless of speed, running intensity, HIR, and sprinting) between the goal involvement groups before scoring, $X^2(2)= 0.557$, $p= 0.757$; $X^2(2)= 0.683$, $p= 0.711$; $X^2(2)= 0.572$, $p=0.751$; $X^2(2)= 5.505$, $p= 0.064$, respectively (Fig. 2).

3.2 Influence of HIR and sprinting performance on number of goals scored

10 of the 43 goals were characterized as counter-attacks (CA). We observed a small to medium, non-significant correlation between HIR in the time interval before scoring and the number of goals scored ($r= 0.421$, $n= 11$, $p= 0.197$) (Fig. 3A). Similarly, sprinting performance in the time interval before scoring and the number of goals had a small to medium, non-significant correlation ($r= 0.431$, $n= 11$, $p= 0.186$) (Fig. 3B). Interestingly, the sprinting distance performance before scoring were found to explain a higher proportion of variance of the number of scored goals compared to the distance covered in HIR ($r^2= 0.394$ vs $r^2= 0.193$).

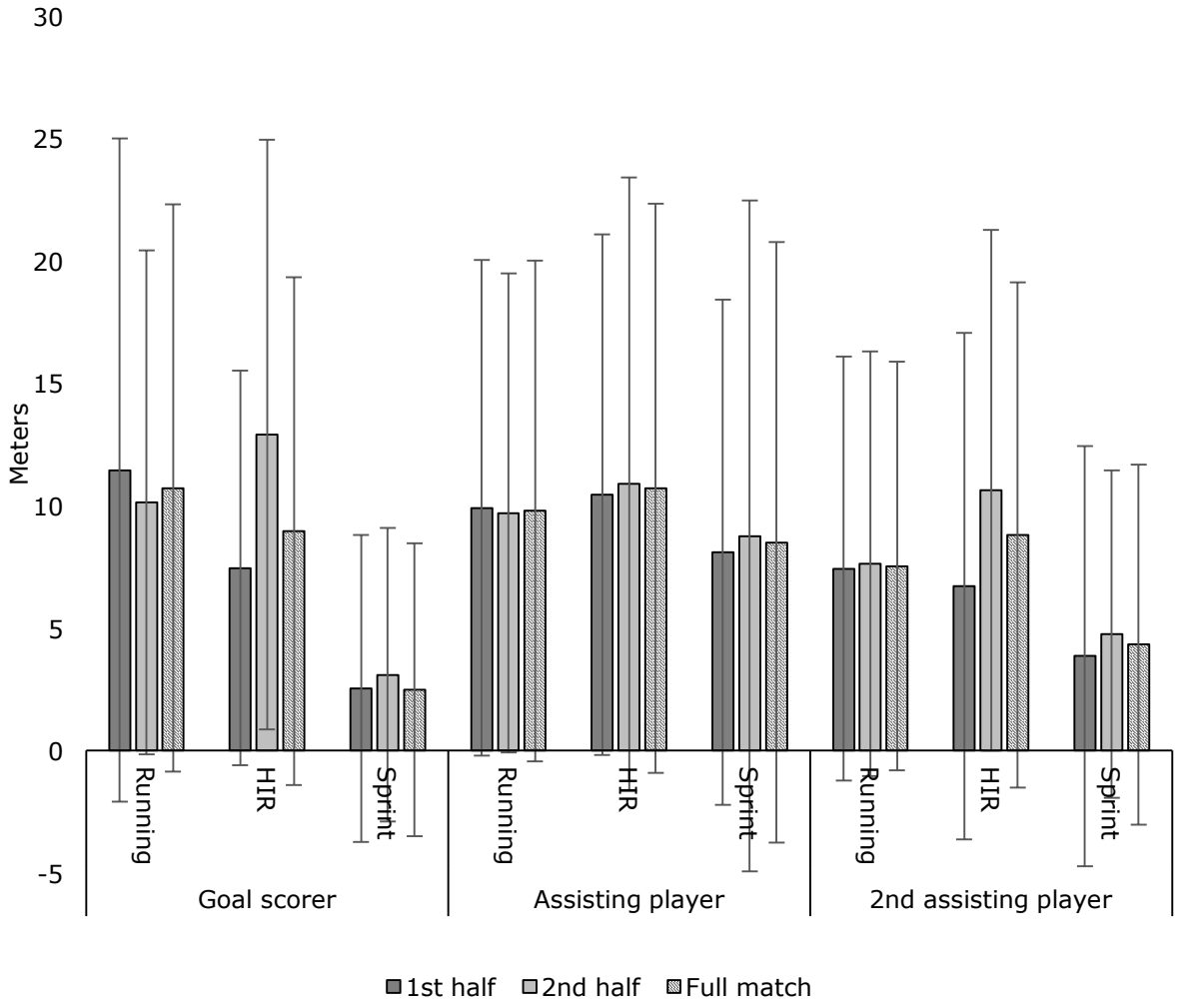
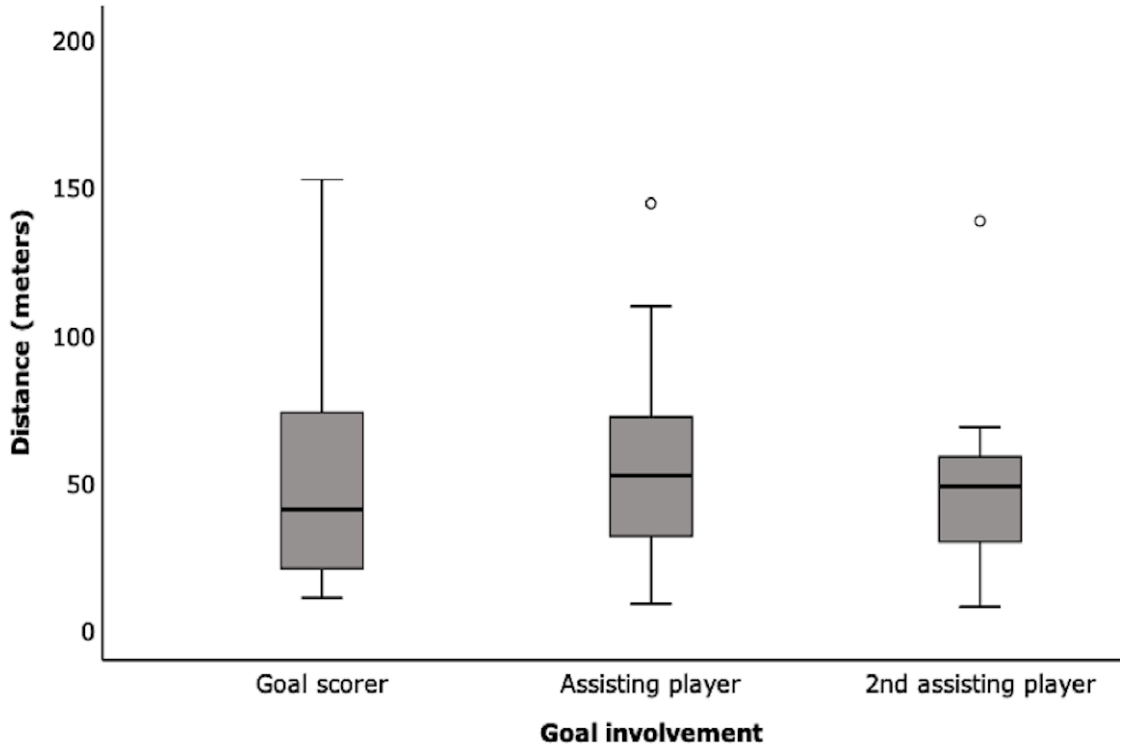
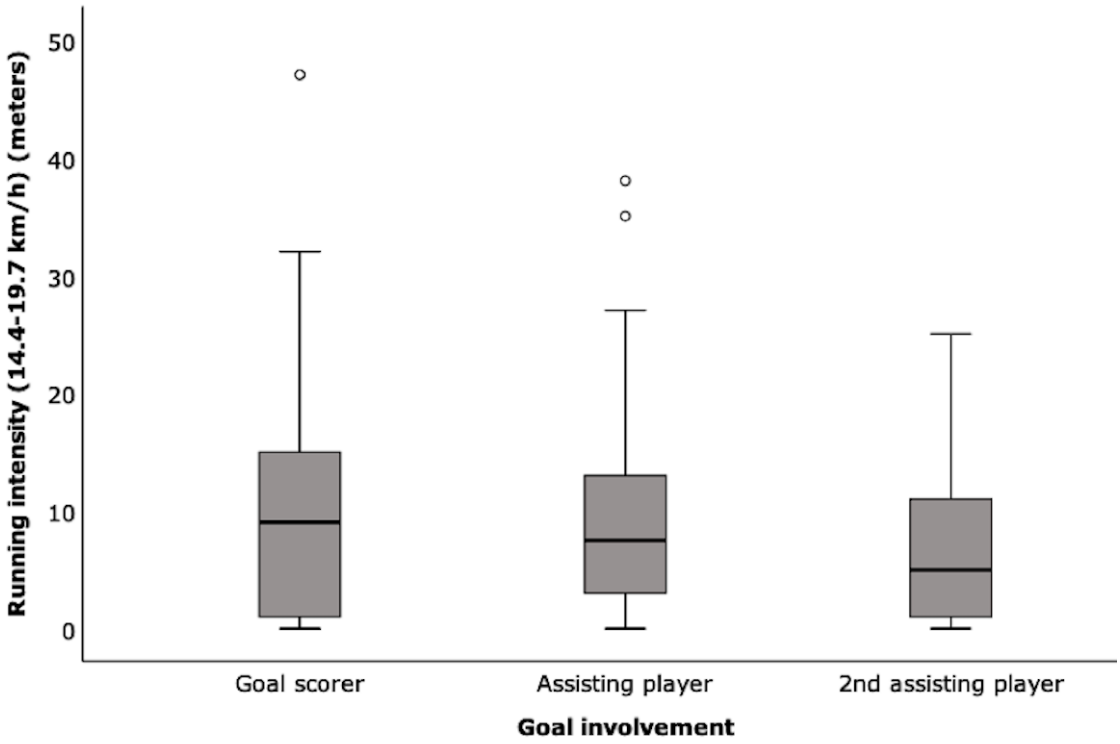


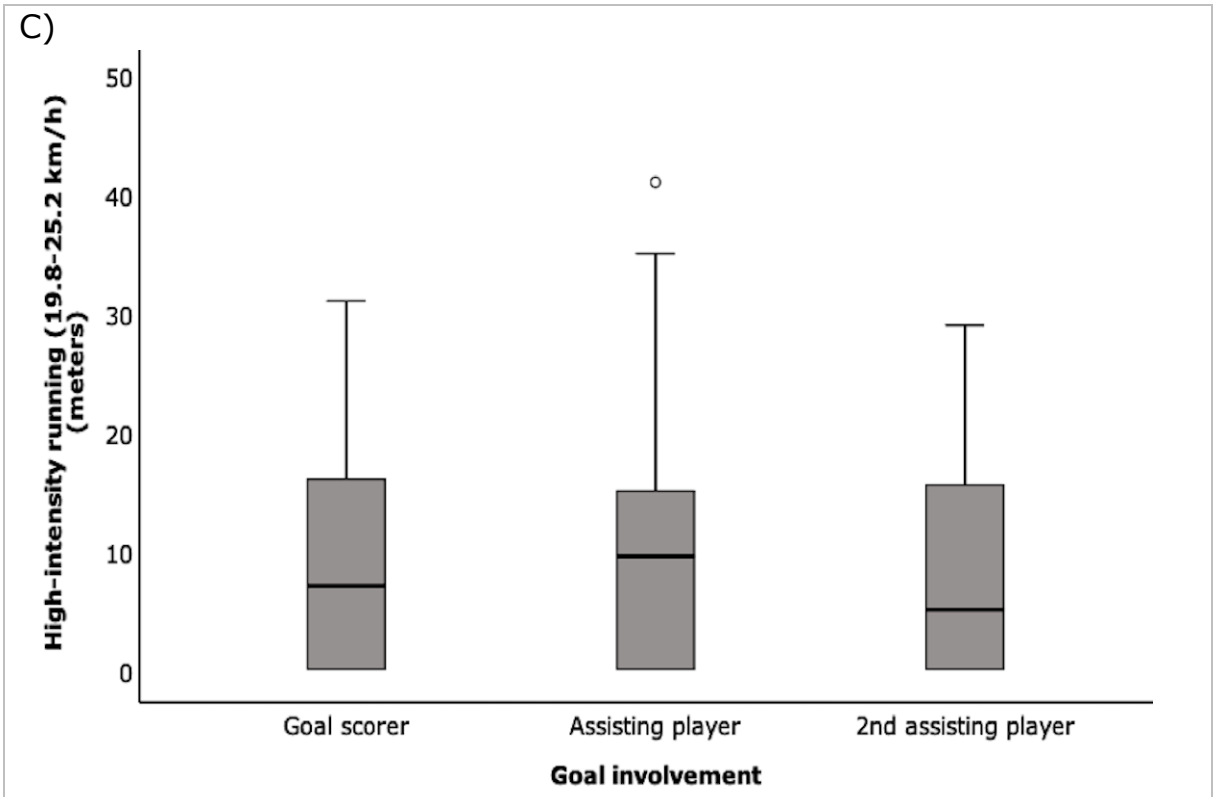
***Fig. 1**: Distance (meters) covered in various speed thresholds (running, HIR, and sprinting) for the goal scorers, assisting player, and 2nd assisting player before scoring goals), divided into 1st and 2nd half. Data are presented as mean ± SD.*
Running = 14,4 to 19.7 km·h^{-1}; HIR = High-intensity running (19.8 to 25.2 km·h^{-1}); Sprint = ≥25.2 km·h^{-1}

A)


200
150
100
50
0
Distance (meters)
Goal scorer
Assisting player
2nd assisting player
Goal involvement

B)


50
40
30
20
10
0
Running intensity (14.4-19.7 km/h) (meters)
Goal scorer
Assisting player
2nd assisting player
Goal involvement



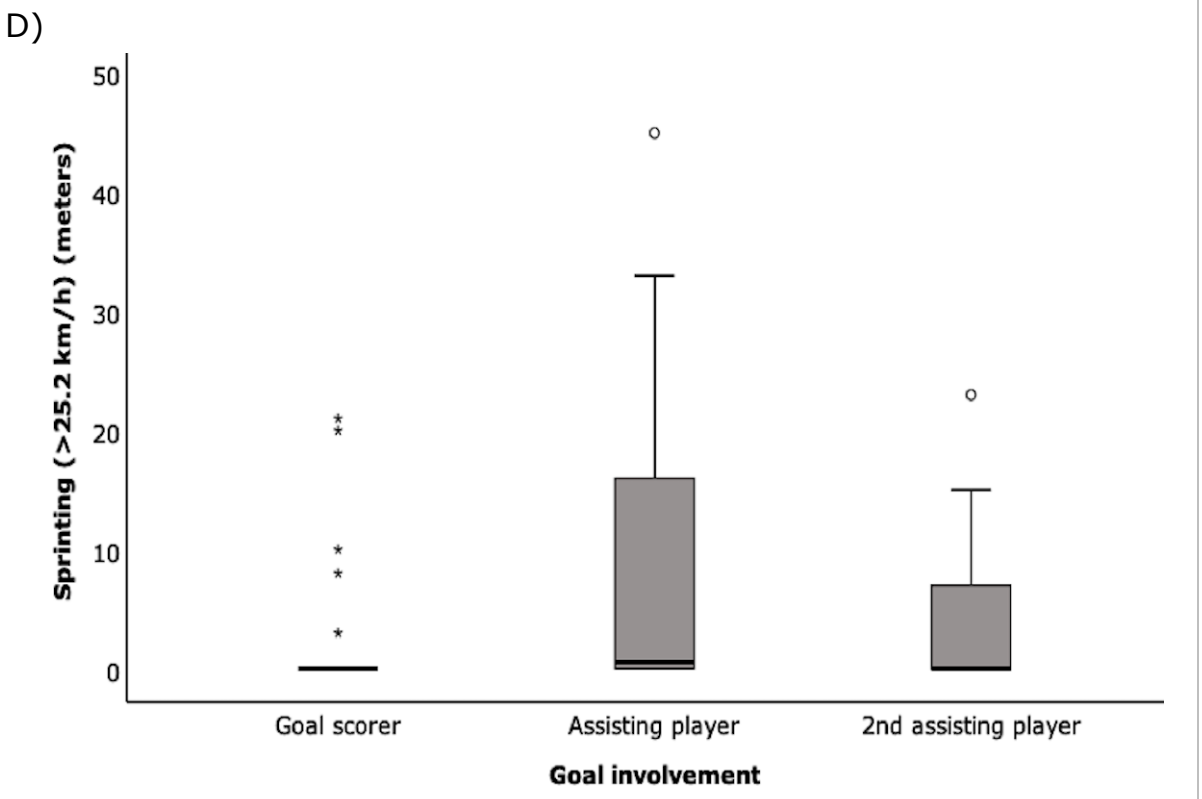


***Fig. 2**: Box and whisker plots with median values, interquartile ranges and outliers for the distances covered in the various speed intensities across goal scorer (n=25), assisting player (n=28), and 2nd assisting player (n=15). A) Total distance covered regardless of speed, B) Total distance covered in running intensity (14.4 to 19.7 km·h^{-1}), C) Total distance covered in high-intensity running (HIR) 19.8 to 25.2 km·h^{-1}). D) Total distance covered in sprinting (≥25.2 km·h^{-1}).*
** Extreme values 3.0 times> IQR. ° Outliers 1.5 to 3.0 times > IQR*

3.3 Number of passes and high-intensity activity before scoring

Regression analysis was used to analyse the relationship between the number of passes completed before each goal with performance in HIR and sprinting. The results indicated a weak correlation between the number of passes completed and the distance covered in HIR before scoring, however not statistically significant (r= 0.313, n= *11,* p= 0.348) (Fig. 4A). Similarly, there was a weak correlation between the number of passes completed and the sprinting distance before scoring, but was not statistically significant (r= 0.385, n= *11,* p= 0.242) (Fig. 4B). The majority of goals were scored after passing sequences between 0 to 4 passes. The performance in HIR also explained a small proportion of variance in the number of passes completed (r^2= 0.130). While the sprinting distance seemed to explain an even smaller proportion of variance in the number of passes completed preceding scoring (r^2= 0.091).

3.4 Influence of playing position on high-intensity activity before scoring

From winning the ball back and until scoring, results showed that the lateral positions (FB & WM) covered 227% longer sprinting distance (p= 0.039*)* and 300% higher number of sprints (p= 0.002*)* compared to the central positions (Table 1). Lateral players covered longer distances in running intensity and HIR, higher number of HIR, despite this, none of these findings were statistically significant (Table 1). WM covered the longest distance in all three intensities (running, HIR, and sprinting), followed by the CM and ST (Table 1). However, no significant differences were made between playing positions. Interestingly, the WM contributed with the assisting pass in 60.5% of the scored goals (23/38). The WM performed a sprint count in 56.5% (13/23) of the assisted goals. On average, WM sprinted 16.5 ± 13.6 meters before each assisting pass.

Table 1: *Total distances covered (meters) in running intensity, HIR, sprinting and total distance covered regardless of speed, counts (n) of HIR and sprinting across player positions and when grouped into central and lateral positions from winning the ball back and until scoring goals. Statistical differences were considered between central and lateral positions.*

		Center backs (n= 3)	Full-backs (n= 3)	Central defensive midfielders (n= 2)	Central midfielders (n= 5)	Wide midfielders (n= 3)	Strikers (n= 3)	Central positions (n=*31*)	Lateral positions (n=*38*)
Running	Distance	6 ± 4.2	56 ± 16.6	0 ± 0	169 ± 13.0	336 ± 8.8	89 ± 9.4	264 ± 11.0	392 ± 9.7
HIR	Distance	0 ± 0	36 ± 10.1	0 ± 0	140 ± 8,5	354 ± 11.9	126 ± 11.3	266 ± 9.7	390 ± 11.6
	Counts	0 ± 0	3 ± 0.5	0 ± 0	9 ± 0.5	25 ± 0.8	7 ± 0.6	16 ± 0.5	29 ± 0.8
Sprint	Distance	0 ± 0	10 ± 3.0	0 ± 0	54 ± 7.1	267 ± 12.0	34 ± 5.8	88 ± 6.0†	288 ± 11.4†
	Counts	0 ± 0	3 ± 0.5	0 ± 0	3 ± 0.4	16 ± 0.5	2 ± 0.4	5 ± 0.3*	20 ± 0.6*
Accelerations	Counts	1 ± 0.7	3 ± 0.5	0 ± 0	9 ± 0.8	29 ± 0.7	5 ± 0.5	15 ± 0.6†	32 ± 0.7†
Total	Distance	141 ± 43.1	237 ± 41.1	31 ± 4.0	791 ± 32.9	1750 ± 32.9	466 ± 22.0	1429 ± 31,54	1987 ± 33.3

**. Statistical significant differences between groups at a p <0.01 level.*

† Statistical significant differences between groups at a p <0.05 level.

Running = 14.4 to 19.7 km·h^{-1}; HIR = High-intensity running (from 19.8 to 25.2 km·h^{-1}); sprint = ≥25.2 km·h^{-1}.

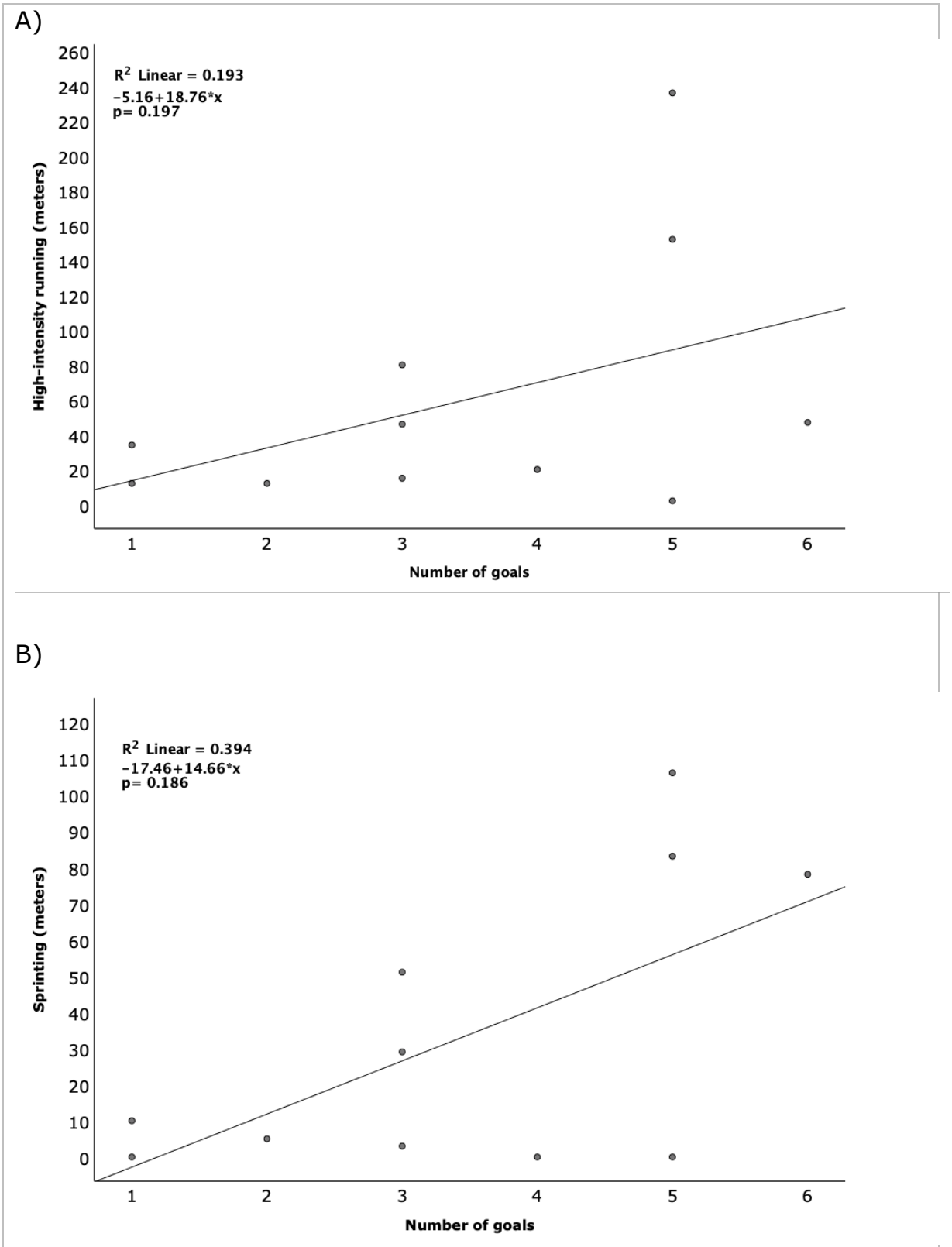


***Fig. 3**: Linear regression equation between the total number of goals scored in each match (n= 11) and the corresponding total distance covered in A) HIR (19.8 to 25.2 km·h^{-1}), and B) sprinting (≥25.2 km·h^{-1}), by the players involved in the scored goals.*

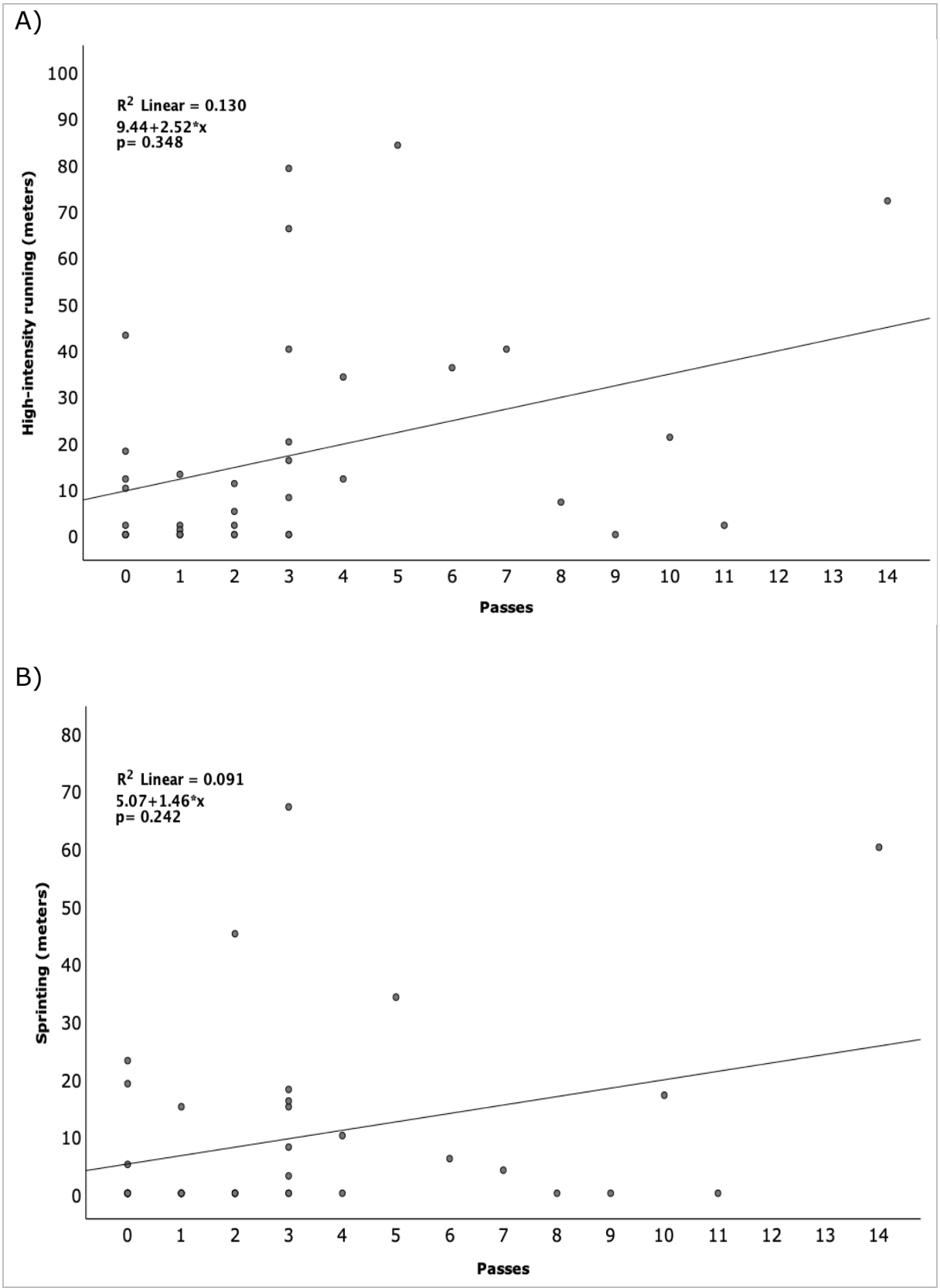


Fig. 4: *Linear regression equation between the number of passes completed from winning the ball back prior to scoring goals and the total distance covered in A) HIR, and B) sprinting, from the involved players (GS, AP, and 2ndAP). Each observation displays the number of passes with the corresponding distances performed in either HIR or sprinting before every scored goal (n= 43) throughout the season.*

4 DISCUSSION

To the best of our knowledge, no studies have analysed and quantified the high-intensity actions preceding scoring. The main findings of the present study showed that in the time interval before from winning the ball back until scoring, the AP ran on average 10.7 meters and 8.5 meters in HIR and sprinting. Further, GS ran on average 9 meters in HIR and 2.5 meters in sprinting, with corresponding values for 2ndAP were 8.8 meters and 4.3 meters in HIR and sprint (Fig. 1). The AP covered longer distances in the following locomotor categories compared with the GS and the 2ndAP: *running intensity* (2.2% and 142.5%), *HIR* (33.9% and 127.3%), and *sprinting* (283.9% and 266.2%), respectively, which confirms our hypothesis.

4.1 Locomotor actions preceding scoring

Our results showed that the average HIR distance before scoring was between 8.5 and 10.7 meters across the three goal involvement groups (Fig. 1). Our finding corresponds to the findings from Vigne et al., (23) who discovered that the majority of the high-intensity actions ranged between 2 to 19 meters. The current results indicate that, in accordance with the latter study, that bouts of high-intensity are often used before scoring. However, the authors (23) used a lower intensity threshold of both HIR (16-19 km·h^{-1}) and sprinting (>19 km·h^{-1}) than the cut-off values used in the present study. Further, we observed a non-significant tendency of greater sprinting distance of 4-6 meters by the AP than the other two groups. Arguably, an increased number of observations from more goals would positively affect the statistical power.

The AP was the most active player in the time interval leading to scoring with longer distances covered in HIR and sprinting compared to GS and 2ndAP. A sprint was performed by the AP in 14 of the goals, which suggests that high-intensity actions are beneficial to improve the AP´s field position and pass to teammates in a better scoring position. Over half of the goals were assisted by the WM. In addition, a sprint was performed before scoring in 56.5% of those. These results point towards a tendency that many of the goals came after a sprinting performance in the wide areas of the field. The latter findings are similar to other studies reporting that the assisting player performed a powerful action in 55% of the goals (19). However, a *powerful action* included several variables such as straight sprints, change-in-direction sprints, jumps, and rotations. Notably, the authors did not distinguish between the mentioned variables in the results, which probably decreases the number of sprints, and make comparison between studies somewhat difficult. Regardless, these findings demonstrate the importance of high-intensity activity before scoring.

We observed a medium correlation between sprinting for GS and HIR for AP which may be explained by the AP´s attempt to dribble or use physical strength to beat a defender. A consequence of this might be a natural decrease in speed velocity before delivering an assisting pass in space for the GS to exploit.

4.2 HIR and sprinting performance before scoring and number of goals scored

Interestingly, regression analysis displayed that the variation in sprinting could explain 39.4% of the number of goals scored (Fig. 3B). Likely, the present team´s game style and utilization of player types with explosive attributes could be an explainable factor. Throughout the season 23.3% of the goals were characterized as counter-attacks (CA) where the aim is to create structural imbalance of the opposition by high-intensity actions. Similar goal-characteristic distribution is observed in studies investigating goal scoring patterns in two European Championships (2004 and 2012) (30, 40). Such an approach is believed to increase the scoring probability and opportunities compared to elaborate attacks when the opposition´s defence is in balance (31, 41). Our obtained results showed a significant, moderate association between the number of goals scored in matches and distances covered in HIR and sprinting prior to scoring (Fig. 3). Support of our findings was observed in Wilson et al., (42) who identified the physical traits predicting goal-scoring success in elite Brazilian junior academy players. Their findings indicated a significant correlation (p= 0.014) between players´ sprint speed and the success of scoring goals. Players with faster sprinting speeds increased their chances of beating defenders in 1v1 situations, however, not improving their scoring chances. Furthermore, when replicating a counter-attacking scenario, players dribbling at faster speeds increased the probability of scoring goals (p< 0.001) (42).

4.3 Number of passes and high-intensity activity before scoring

From winning back the ball until scoring, all the analysed goals were scored within a time interval of 20.2 ± 16.4 seconds. In that same period, the average number of passes before scoring was 3.1 ± 3.4, which points to a more direct game style (e.g. counter-attacks). For instance, intercepting passes close to the opposition´s goal would suggest fewer passes completed before scoring than a goal building up from their goalkeeper. In the present study, 81.4% of the scored goals came from passing sequences between 0 to 4 passes from winning the ball back. While the remaining 8 goals were scored from sequences involved 5 passes or more. The results are in agreement with previous observations from the top teams competing in the Norwegian top professional league where passing sequences of 0 to 4 passes preceding scoring produced more goals (32). Although the latter study included teams at several competition levels in Norwegian soccer, Sæterbakken (34) found no significant difference in HIR distance (19.8 to 25.2 km·h^{-1}) between the highest and 2nd highest level in Norwegian soccer. Interestingly, players at the highest level sprinted (≥25.2 km·h^{-1}) 61% more compared to players from the 2nd highest level, which suggests that higher competitive levels are associated with greater sprinting demands. In contrast to our results, teams that maintained and completed higher number of successful passes elicited a greater frequency of goals compared to shorter passing sequences (28). The top three teams from the Norwegian top professional league across three seasons (2008-2010) scored on average 19 goals from possessions lasting ≥12 seconds (32). However, our results indicate that the number of goals has evolved in Norwegian soccer from 2008-2010 and until now. Based on the findings from Tenga et al., (32), our results showed that 24 of the goals (55.8%) came from possessions lasting ≥12 seconds. These results emphasize game style with use of prolonged and slow build-up as a tactical strategy to score goals.

A low association was observed between the number of passes completed preceding scoring and both high-intensity components (HIR and sprinting) (Fig. 4A and 4B). Interestingly enough, short bouts of high-intensity have been associated with a negative

effect on the short-pass ability observed in professional junior players (17). Arguably, it might be that the low correlation seen between the two variables (HIR/sprint and passing number) is due to the accumulated fatigue throughout matches, resulting in decrements of physical performance and lower running speeds (17, 43). Players with higher level of fitness have been shown to reflect their greater technical abilities and thus experience lower physical fatigue (17, 43).

4.4 Influence of playing position on high-intensity activity before scoring

The obtained results were as hypothesized and in line with previous studies showing that players in lateral positions (WM and FB) covered longer distances in all locomotor categories, higher number of HIR, sprints, and accelerations compared to players in central positions (Table 1) (9, 13, 26, 39). In accordance with our study, WM tends to cover the most HIR and sprinting distance (9). Nevertheless, literature speculates that the nature of the lateral playing positions gives higher availability of space to perform actions like high-intensity runs and sprints, in addition, to reach greater running velocity (5, 12). Moreover, goals are frequently scored by ST after sprinting without the ball, although it could be argued that the WM's position provides more space than ST (19). Besides, players in lateral positions are often involved in sprinting challenges with the defending full-backs (19). Interestingly, our data revealed greater distances for the WM than the ST in all locomotor categories, as well as the number of sprints. However, statistical differences between the two positions were not made due to the relatively small sample size.

4.5 Practical applications

Emphasis on high-intensity actions in the final moments prior to scoring can bring practical implications for training sessions. This study provides a new approach to investigating high-intensity actions by analysing the last moments before scoring. The results contribute to more understanding of the physical demands of the players involved in the scorings. The data would give the coaching team valuable information about the high-intensity actions in the final moments before scoring by the players involved in the goals. Individualization of sprinting training could be appropriate based on the nature and physical load of the various playing positions. Therefore, it could be argued that sprint training is more applicable to lateral players and strikers than other playing positions to replicate game situations. It is believed that specific sprinting training in addition to regular soccer training can improve sprint performance and acceleration (44). To replicate the similar movements of sprinting actions, incorporating plyometric drills with horizontal force and heavy resistance would produce higher maximal force (44).

4.6 Study limitations

The main limitation of this study is the high number of missing observations. This is most likely due to some players not wearing the sensor during matches. When collecting the data after matches, we observed a tendency of players substituted on late in the matches and were involved in the goals did not collect any data from the included variables. Likely, this is due to the players not wearing the sensor. The approach of using manual video inspection and recording of the time intervals is likely to be prone to subjective bias which could either over-or underestimate the reported values.

The approach of this study represents a small proportion of matches that requires a larger sample for more precise results (38). Investigation of contextual factors such as match

outcome (win, draw or lose), scoreline, and oppositions level was not included, which can influence the physical performance (16). When winning, a defensive strategy and direct game style (e.g. counter-attacks) are emphasized simultaneously as activity levels and work rate decrease, in addition to slower running speeds (16, 45, 46). In contrast, the prominent activity level is believed to be near-maximal intensity when losing, as the losing team takes greater risks to create scoring opportunities by moving more players forward (40, 45). Finally, the difference in time-motion technology makes generalizations difficult and interpretation of the results should therefore be done with caution (46).

5 CONCLUSION

The purpose of this study was to analyse and quantify locomotor activity in goal-scoring situations in semi-professional soccer players. This study contributes to further understanding of high-intensity actions from winning the ball back until scoring soccer. Specifically, this study demonstrated that the AP played an important role in the final moments before scoring. In support of our hypothesis, the AP performed, on average and in total, longer distances in HIR and sprinting compared to the GS and 2ndAP. It was further found that sprinting distance and number of sprints were greater for players in lateral positions before scoring compared to central positions. Also, the importance of high-intensity actions in decisive goal-scoring situations was further emphasized with the observed association between sprinting distance and the number of goals scored. Finally, most of the scored goals came from passing sequences of 0 to 4 passes, with no significant association with the performance in HIR or sprinting.

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