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Research Article

Transitional Activities in Elite Football: Frequency, Type, Effect on Match Outcome and the Novel Concept of Clusters

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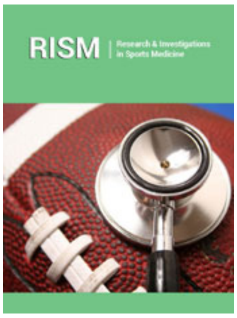

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Abstract

The aims of this study were to analyze the effect of contextual variables on physical metrics during transitions and investigate repeated transitional activities during transitions. Data was collected from 10 matches (23 elite soccer players). A total of 4249 individual observations were recorded including 1164 positive transitions (defense-to-attack), 1269 negative transitions (attack-to-defense), 1120 fast attacks, and 696 high pressure activities. Metrics per minute ($m \cdot min^{-1}$) as well as absolute variables: Total Distance (TD), high-speed running distance (HSRD, >$19.8 km \cdot h^{-1}$), sprint distance (SD, >$25.2 km \cdot h^{-1}$), relative high-speed running distance (VelB4), relative sprint distance (VelB5), acceleration distance (AccB3 Dist., distance with variations in running speed >$3 m \cdot s^{-2}$), the number of high-intensity accelerations (HI Acc, >$3 m \cdot s^{-2}$) and decelerations (HI Dec, >$3 m \cdot s^{-2}$) were quantified. Significant effects of match half were found for TD ($p < .001$; ES =.03), HSRD ($p = .023$; ES = .012), VelB4 ($p < .001$; ES = .04), and HI Dec ($p = .037$; ES = .010). Match outcome had a relation to TD (m), HSRD (m) ($p < .001$), SD (m) and VelB4 (m) ($p = .011$) as well as VelB5 (m), and AccB3 Dist. distance (m) ($p = .002$ and $p = .020$, respectively). Performance in lost matches was lower in the 2nd half ($p \leq 0.05$). This study indicates that players are exposed to repeated short and intermittent high velocity actions together, highlighting the need to move away from 90min averages and pay more attention to transitional activities in modern training design.

Keywords: Soccer; Transitions; High pressure; Peak demands; Match outcome; Repeated activities

Introduction

Soccer match play demands are well defined within literature [1,2], and the increasing demands highlighted on players continually evolves [3]. A deeper understanding of the physical demands placed on athletes during competition better informs coaches and physical performance staff of the appropriate physical and technical stimuli needed in training to better prepare players [4,5]. Modern wearable technology, which has been deemed valid, reliable, and practical has been used to measure team/individual training and match locomotor and mechanical metrics in team sports [6]. However, most studies have provided whole and average match physical metrics describing the volume of activity, yet not truly reflecting fluctuations in physical, technical, and tactical intensity, which inevitably underestimates the most demanding periods of football match play [7,8]. Recent literature in elite football has focused more attention on peak match demands, also referred to as Worst-Case-Scenarios (WCS) [9-11]. Importantly, it has been established that a shorter duration WCS generated higher intensity, raising questions regarding the physical preparation of players for these repeated increased demands in game play [7,8]. Various methods have been utilized to quantify the peak demands in football and the rolling average has been found superior over fixed length methods [7,12]. Regardless of the substantially increased body of knowledge regarding the most demanding passages and its distribution within the contemporary game, more information is needed surrounding the technical-tactical context and pattern of occurrence. Increasing this knowledge would inform practitioners of the need to adapt pitch specific conditioning and football specific training (small-sided games, technical, tactical, and positional drills) to better replicate competition and positional demands [10,13].

Analysis of transitions within elite football have detailed increased high velocity demands when compared to 90-minute game averages [8,13], often elicited when the Ball Is in Play (BIP) [9]. Transitional Activities (TA's) present as a broad context within game play, as they represent actions in/out of ball possession (ball in play) as well as depict tactical offensive and defensive team collective movements and behaviors in modern football [8]. Offensive (defense-to-attack) and defensive (attack-to-defense) transitions have been previously claimed as the key phases of play in soccer, during which many goals are scored, and risks taken [5,14]. In addition, high-pressure activities have been found to have an effective playing style to create more goals scoring chances and have been linked to greater physical demands and higher levels of fitness in football [15]. Understanding how these transitional activities are present within competition is essential to optimize the physical preparation of players to enhance performance, but also contributes to reducing injury risk. Previous authors have investigated match average physical metrics taking into consideration various contextual factors such as match half [16], match location [17] and match outcome [18,19]. However, research exploring the effect of contextual variables mentioned above on peak intensity periods is scarce [11,12]. To the author's knowledge, there are no studies exploring the effect of match half and match outcome on physical metrics during transitions in professional football. Moreover, there has been lack of research related to the number of clusters of transitional activities, which would represent repeated high-intensity specific efforts in attack and defense during the key phases of play in soccer [20]. The ability to repeatedly perform high-intensity actions has been found crucial for successful performance in elite football due to its intermittent nature [21]. A better understanding of a team/s collective performance during intensified blocks of activity might have a significant practical impact on coaches and practitioners to optimally design football-specific team and individual sessions integrating physical and technical-tactical aspects [22].

Therefore, the current study aims to:

a) Analyses the effect of match half (1st vs 2nd) and match outcome (win vs draw vs loss) on different absolute and relative physical metrics during TA's.

b) Explore the effect of match outcome on the second half physical performance.

c) Investigate repeated TA's (clusters) within contemporary match play.

Materials and Methods

Participants

GPS and accelerometry data were captured from a total of twenty-three elite soccer players (n=23), which were part of a leading team of the 1st Polish Division (Ekstraklasa) in season 2020-21. Players represented the following playing positions: center backs (n=4), full backs (n=5), central defensive midfielders (n=2), central attacking midfielders (n=2), central midfielders (n=2), wingers (n=5), and attackers (n=3). Substitutions were excluded from this investigation because they could generate greater physical demands compared to starters likely because of pacing strategies present on modern football [5]. Players who completed a minimum of 60mins were analyzed. Players received all information about the project protocol and provided informed consent for the use of match data, in accordance with the Helsinki Declaration. To ensure player confidentiality, all data was anonymized prior to its analysis. Ethical approval was provided by the host university.

Procedures

Ten competitive games from Polish domestic top division league (Ekstraklasa), were investigated between August and November of 2020. A total of 4249 individual observations were recorded including 1164 positive transitions (defense-to-attack), 1269 negative transitions (attack-to-defense), 1120 fast attacks, and 696 high pressure activities. The activity profile of players was monitored during each game using portable MEMS (10Hz; Vector S7, Catapult Sports, Melbourne, Australia). The GPS device used in this investigation was worn in each game in a purpose-designed vest, inside a mini pocket positioned between the scapulae, and thus not affecting mobility of the upper limbs. The players were familiar with this entire procedure since they wear these devices regularly in training and games. To have an optimal connection to the satellites, the GPS units were turned on 15mins before the start of the game. In accordance with previous guidelines for acceptable GPS coverage, the data was screened for satellite coverage and Horizontal Dilution of Precision (HDOP) using an inclusion criterion of >6 satellites and ≤1.0 respectively [23]. To avoid inter-unit error, each player wore the same unit for the whole study period. The accuracy of this technology has been previously shown elsewhere [6,24].

All metrics analyzed in this study were previously used by other authors [5,8,9,11]. They depicted absolute distances covered per minute ($m \cdot min^{-1}$) in the following categories: Total Distance (TD), High-Speed Running Distance (HSRD, >19.8$km \cdot h^{-1}$), sprint distance (SD, >25.2$km \cdot h^{-1}$), as well as the number of high-intensity accelerations and decelerations (A+D, >3$m \cdot s^{-2}$; $n \cdot min^{-1}$). In addition, the metrics represented absolute distanced covered in the following categories: Total Distance (TD), High-Speed Running Distance (HSRD), Sprint Distance (SD), the number of high-intensity accelerations (HI Acc, >3 $m \cdot s^{-2}$), the number of high-intensity decelerations (HI Dec, >3$m \cdot s^{-2}$) and acceleration distance (AccB3 Dist., distance with variations in running speed > 3 $m \cdot s^{-2}$). Also, the variables reflected total relative high-speed running distance (VelB4) and relative sprint distance (VelB5), which was proposed previously by other authors to represent the functional limits of endurance and sprint locomotor capacities [25]. As previously recommended [25], relative high-speed running distance (VelB4) and relative sprint distance (VelB5) were set as 100% Maximal Aerobic Speed (MAS) -30% (Anaerobic Speed Reserve) ASR and above MAS +30% ASR, respectively. An incremental running treadmill test was conducted by the club physiologist to measure VO_2max and MAS. The test was performed in the gym environment with a normal ambient temperature and took place on a mechanical treadmill (Technogym, Italy). It began with an initial speed of 10km/h^{-1} and each stage was increased by 1.5km/h^{-1}. Five stages were set. Each stage lasted 4 minutes and it was separated by 1 minute passive break. The inclination was set at 1.5%. Polar heart rate monitors (Polar, Norway) and Polar M400 are used to record HR data. Expired gases were analyzed breath-by-breath using an online automated gas analysis system (Metallizer® 3b-R2; Cortex Biophysics Gmbh, Leipzig, Germany) and accompanying software (Meta Soft® 3). Maximum oxygen uptake (VO_2max) was defined as the highest 15-s average oxygen uptake. Velocity (km/h^{-1}) during the maximum oxygen uptake (VO_2 max) was recorded and set as the MAS.

After each game was completed, TA's were identified and manually tagged by the club's analysis team in the Catapult Vision video analysis system (Catapult Sports Ltd, Melbourne, Australia). The analysis staff utilized the observational methodology REOFUT theoretical framework to identify these phases [26], which was part of the club's analysis protocols implemented daily by the analysis team. Previous literature has shown good to high intra-and inter-observer reliability of the current analysis method [14,20,27]. Data from the Catapult vision software were then downloaded and integrated into the manufacturer's software package (Open field, version 3.2.0) and finally exported into Microsoft Excel (Microsoft Corporation, USA) to make additional calculations for each transitional play and clusters. Clusters were defined as two or more transitional activities that occurred withing a period shorter than 61secs [21,28]. The transition mean average for selected metrics and cluster frequencies was calculated as the sum of all TA's, divided by their number. To get the transition/cluster peak average value, the highest values in 10 games were found, and their average was calculated as the sum of all peak values during transitions/clusters, divided by their number. Transitional activities were classified into the following categories: Positive Transition (PT), Negative Transition (NT), Fast Attack (FA) and High Pressure (HP), which were previously described in depth by other authors [8,14,27].

Statistical analysis

A descriptive analysis was used and the results are shown as mean ± Standard Deviation (SD). Statistical analyses were conducted using IBM Statistical Package for the Social Sciences (SPSS, Version 27.0, IBM Corporations, New York, USA) with the statistical significance accepted at the 0.05 level. A univariate analysis of variance (ANOVA) was conducted to quantify main effects for games, transitions and positions. Interaction effects were also quantified and any significant main effects associated with games, transitions and positions were explored using post hoc pairwise comparisons. The assumptions associated with the statistical model were assessed to ensure model adequacy. To assess residual normality for each dependent variable, q-q plots were generated using stacked standardized residuals. Scatterplots of the stacked unstandardized and standardized residuals were also utilized to assess the error of variance associated with the residuals. Mauchly's test of sphericity was also completed for all dependent variables, with a Greenhouse Geisser correction applied if the test was significant. Across all isokinetic and stabilimeter measures considered within the thesis, a sample size ≥ 14 players were required to evaluate the interactions associated with all independent variables (for statistical power>0.8; $p<0.05$). Partial eta squared (η^2) were calculated to estimate effect sizes for all significant main effects and interactions. As previously recommended [29], partial eta squared was classified as small (0.01-0.059), moderate (0.06-0.137) and large (>0.138).

Result

Analysis of TD (m) identified significant effects for game ($F=4.590$, $p< .001$, partial $\eta^2= .071$) and transition type ($F=17.097$, $p< .001$, partial $\eta^2= .109$). There were also significant effects of HSRD (m), SD (m), VelB4 (m) and VelB5 (m) for a transition type (HSRD: $F = 15.298$, $p< .001$, partial $\eta_2= .099$; SD: $F=9.916$, $p< .001$, partial $\eta^2 = .066$; VelB4: $F = 15.471$, $p< .001$, partial $\eta^2= .100$; VelB5: $F=12.614$, $p< .001$, partial $\eta^2= .083$). There was a game x time interaction for HI Acc (n) ($F=3.511$, $p = .001$, partial $\eta^2= .055$). No interactions of game, transition type, result and time were discovered for TD (m), HSRD (m), SD (m), VelB4 (m), VelB5 (m), HI Dec (n), and AccB3 distance (m) ($p> .05$). Moreover, analysis of TD (m·min^{-1}), HSRD (m·min^{-1}), SD (m·min^{-1}) and A+D (n·min^{-1}) revealed significant effects for a transition type (TD: $F=29.754$, $p< .001$, partial $\eta^2= .176$; HSRD: $F=14.441$, $p< .001$, partial $\eta^2= .094$; SD: $F=6.248$, $p< .001$, partial $\eta^2= .043$; A+D: $F=4.453$, $p = .004$, partial $\eta^2= .031$). There was a game x time interaction for A+D (n·min^{-1}) ($F = 2.178$, $p = .035$, partial $\eta^2= .035$). No interactions of game, transition type, result and time were discovered for TD (m·min^{-1}), HSRD (m·min^{-1}), SD (m·min^{-1}) ($p > .05$).

1st vs 2nd half

Statistically significant effects of time (1st vs 2nd half) were found for absolute metrics such as TD (m), HSRD (m), relative high-speed running distance (VelB4) (m) and high-intensity decelerations -HI Dec (n·min^{-1}) (TD: $F(1,419) = 12.823$, $p< .001$, partial $\eta^2= .030$; HSRD: $F(1,419)=5.244$, $p= .023$, partial $\eta^2= .012$; VelB4: $F(1,419)=17.572$, $p< .001$, partial $\eta^2= .040$; HI Dec: $F(1,419)=4.430$, $p=.037$, partial $\eta^2= .010$). No significant effects of time (1st vs 2nd half) were revealed for any metrics per minute ($p> .05$). Table 1 highlights the effect of time (0-45' and 45-90') on absolute physical metrics that occur during transitions, accompanied by the Confidence Interval (CI), p-value and effect size (η^2). The effect of time (0-45' and 45-90') on metrics per minute in all transitions across the games analyzed, accompanied with the Confidence Interval (CI), p-value and effect size (η^2) is displayed in Table 2. Table 3 highlights the mean frequency of transitional activities in clusters that occur per game, accompanied with the Confidence Interval (CI), min and max.

Table 1: Effects of time (0-45' and 45-90') on total distance (m)-(TD), high-speed running distance (m)- (HSRD, >19.8 $km \cdot h^{-1}$), sprint distance (m)-(SD, >25.2 $km \cdot h^{-1}$), relative high-speed running distance (m)- (VelB4), relative sprint distance (m)-(VelB5), high-intensity accelerations count (n)-(HI Acc, >3 $m \cdot s^{-2}$), high-intensity decelerations count (n)-(HI Dec, >3 $m \cdot s^{-2}$) and HI acceleration distance (m)-(AccB3 Dist., distance with variations in running speed > 3$m \cdot s^{-2}$) during transitional activities across 10 official matches. Data are shown as team mean ± SD and 95% confidence intervals.

Note: Significant difference (p<0.05).

	0-45'		45-90'			
	Mean ± SD	95%CI	Mean ± SD	95%CI	p - Value	Effect size η^2
TD (m)	306.0±41.0	276.7-335.3	257.7±45.2	225.4-290.0	< .001	0.3
HSRD (m)	78.1±16.6	66.2-90.0	64.5±17.1	52.3-76.7	0.023	0.12
SD (m)	22.3±6.6	17.6-27.0	20.0±7.6	14.6-25.4	0.235	0.001
VelB4 (m)	60.3±11.3	52.2-68.4	45.8±11.1	37.8-53.8	< .001	0.4
VelB5 (m)	56.8±13.6	47.1-66.5	47.4±13.1	38.0-56.8	0.091	0.007
HI Acc (n)	0.7±0.3	0.5-0.9	0.7±0.4	0.6-0.8	0.648	0
HI Dec (n)	1.1±0.4	0.8-1.4	0.8±0.2	0.6-0.9	0.037	0.01
AccB3 distance (m)	3.3±1.0	2.6-4.0	3.0±0.7	2.4-3.5	0.121	0.006

Table 2: Effects of time (0-45' and 45-90') on metrics per min: Total distance-TD ($m \cdot min^{-1}$), high-speed running distance-(HSRD > 19.8$km \cdot h^{-1}$ ($m \cdot min^{-1}$), sprint distance -SD > 25.2$km \cdot h^{-1}$ ($m \cdot min^{-1}$) and number of high-intensity accelerations/decelerations -A+D, >3 $m \cdot s^{-2}$ ($n \cdot min^{-1}$) during transitional activities across 10 official matches. Data are shown as team mean ± SD and 95% confidence intervals.

Note: Significant difference (p < 0.05).

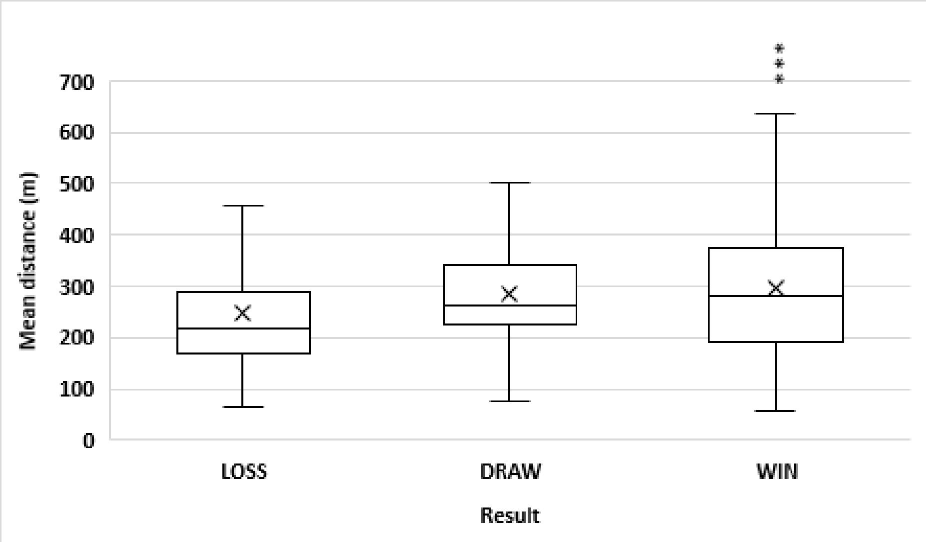
	0-45'		45-90'			
	Mean ± SD	95%CI	Mean ± SD	95%CI	p - Value	Effect size η^2
TD ($m \cdot min^{-1}$)	208.2±11.2	200.0-216.2	199.4±17.4	187.0-211.8	0.174	0.004
HSRD ($m \cdot min^{-1}$)	52.6±9.5	45.8-59.4	50.5±12.0	41.9-59.1	0.394	0.002
SD ($m \cdot min^{-1}$)	14.8±3.6	12.2-17.4	15.9±5.5	11.9-19.9	0.495	0.001
A+D ($n \cdot min^{-1}$)	1.2±0.3	1.0-1.4	1.2±0.2	1.0-1.4	0.627	0.001

Table 3: Mean ± SD, 95% confidence intervals and minimum/maximum frequency of transitional activities (TA's) in clusters across 10 official matches.

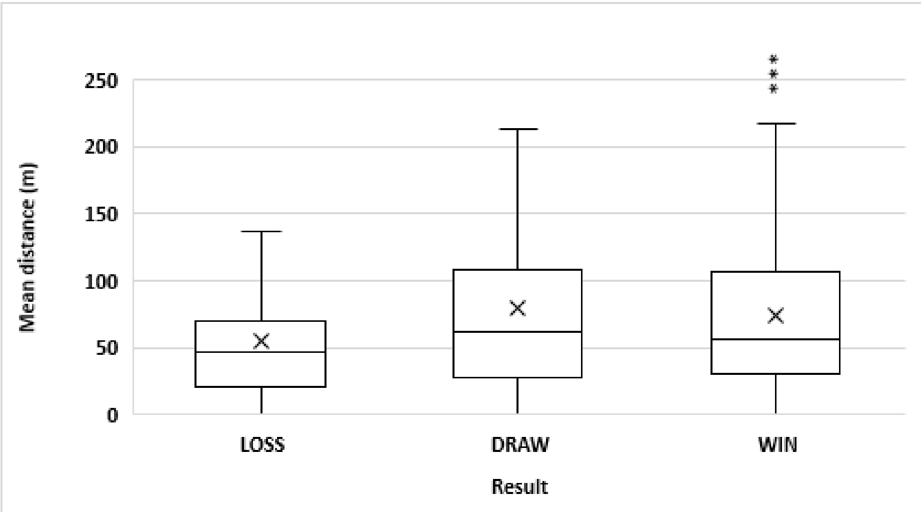
Frequency	Mean±SD	95%CI	Minimum	Maximum
Total clusters (n)	12.2±3.2	9.9-14.5	8	18
Mean TA's in cluster (n)	2.6±0.4	2.3-2.9	2	3.3
Peak TA's in cluster (n)	4.5±1.4	3.5-5.5	2	7
Total TA's as clusters (n)	32.7±11.5	24.5-40.9	16	52
Total TA's (all games)	50.0±11.1	41.6-57.6	32	68

Match performance outcomes (loss, draw, win)

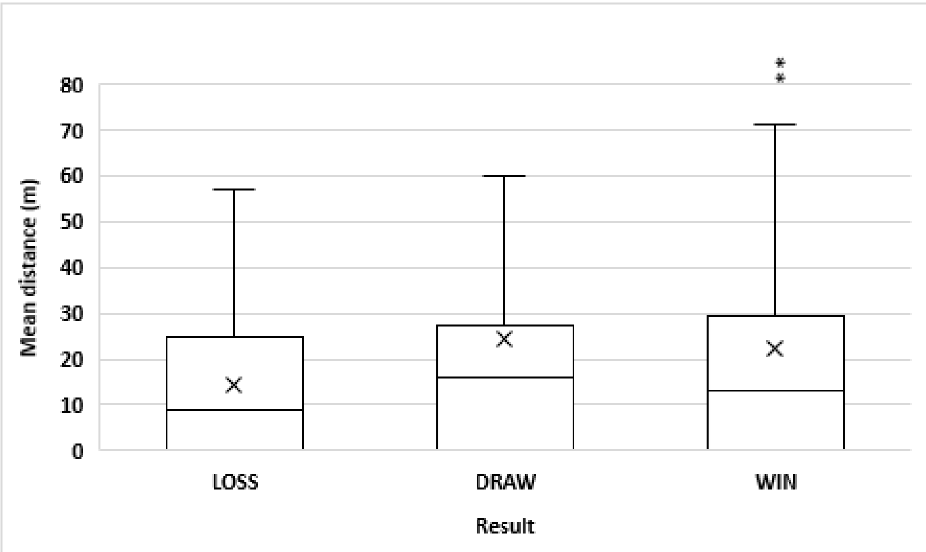
Significant difference was found during TA'a for absolute metrics such as TD (m) and HSRD (m) (p< .001), SD (m) and VelB4 (m) (p=.011) as well as VelB5 (m) and HI Acc distance (m) (p=.002 and p=.020, respectively) between matches with a win and loss performance outcomes. Number of HI accelerations and decelerations (n) revealed no significant impact on the match outcome (result) (p> .05). No significant difference during TA'a was found for TD ($m \cdot min^{-1}$), HSRD ($m \cdot min^{-1}$), SD ($m \cdot min^{-1}$), A+D ($n \cdot min^{-1}$) between different match performance outcomes (win vs draw vs lost) (p> .05). Comparisons between matches with a loss, draw and win performance outcomes in absolute and per minute physical metrics during all transitions and high-pressure activities can be seen in Figure 1 & 2, respectively. Pairwise comparisons showed that TA's volume in absolute metrics such as TD (p=.023), HSRD (p=.017), VelB4 (p=.006), VelB5 (p=.028) in lost matches (Loss) was lower in the 2nd half compared to the first half. Other absolute metrics did not reveal any significant differences (p>.05). In addition, 2nd half performance significantly decreased for TD ($m \cdot min^{-1}$) (p=.003). Match result revealed no difference between both halves in other metrics per minute (p>.05). Figure 3 depicts differences between matches with a loss, draw and win match results in half 1 vs. half 2 in absolute metrics. Figure 4 represents the same differences for metrics for minute such as total distance -TD ($m \cdot min^{-1}$), high-speed running distance -HSRD ($m \cdot min^{-1}$), sprint distance - SD ($m \cdot min^{-1}$) and number of accelerations/decelerations -A+D ($n \cdot min^{-1}$).



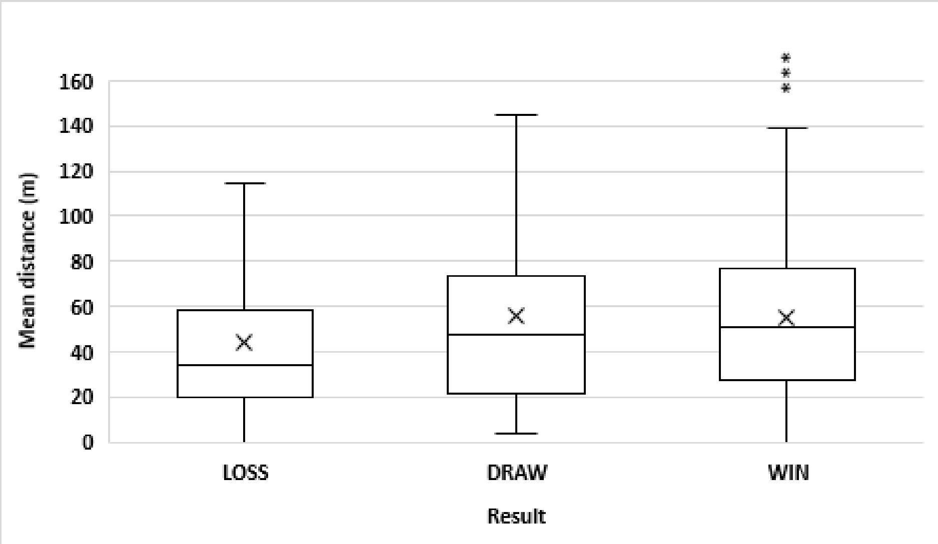
A. Displays TD (m) by match outcome.



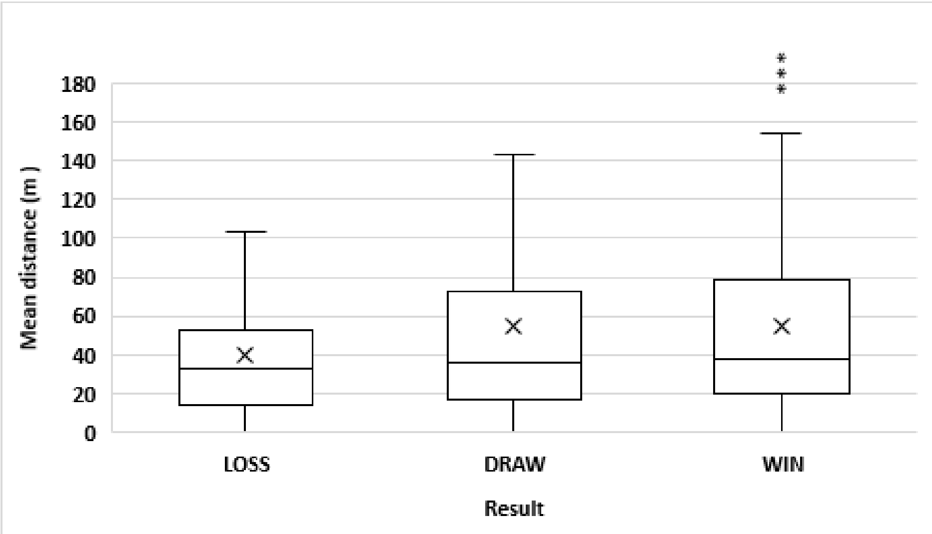
B. Displays HSRD (m) by match outcome.



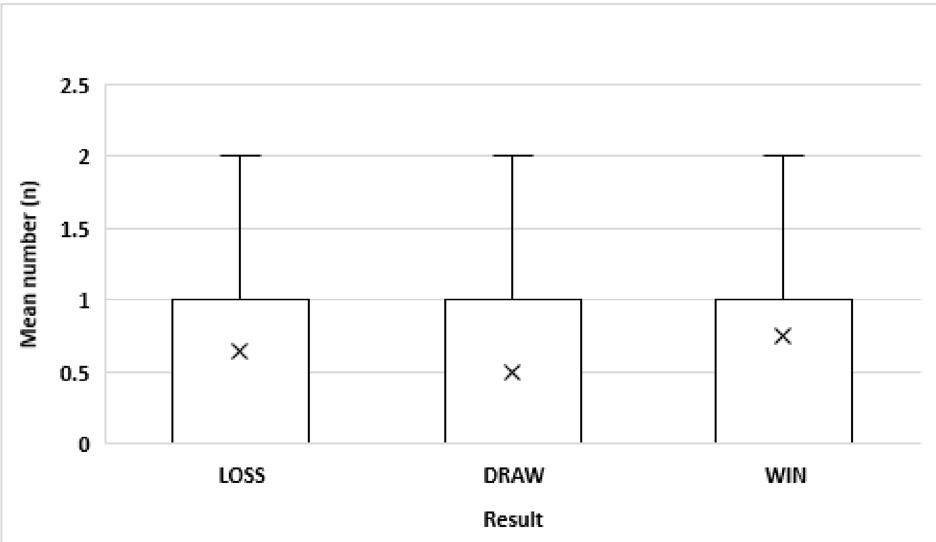
C. Displays SD (m) by match outcome.



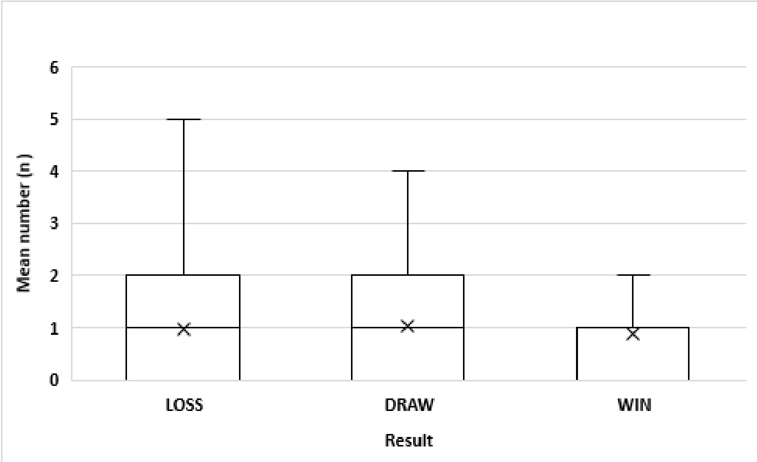
D. Displays VelB4 (m) by match outcome.



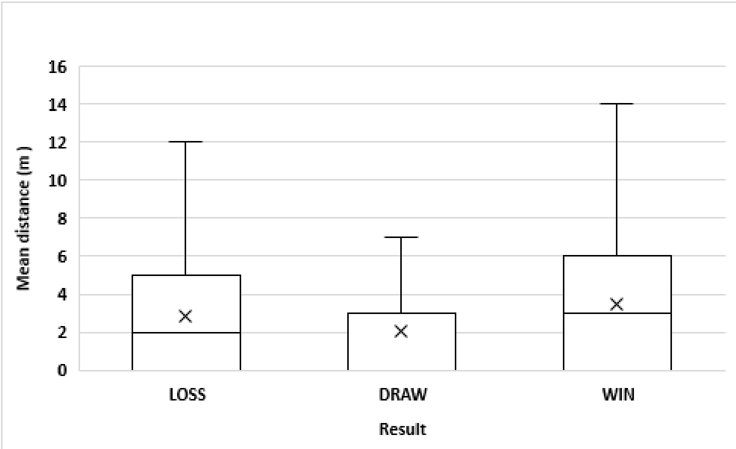
E. Displays VelB5 (m) by match outcome.



F. Displays HI Acc (n) by match outcome.

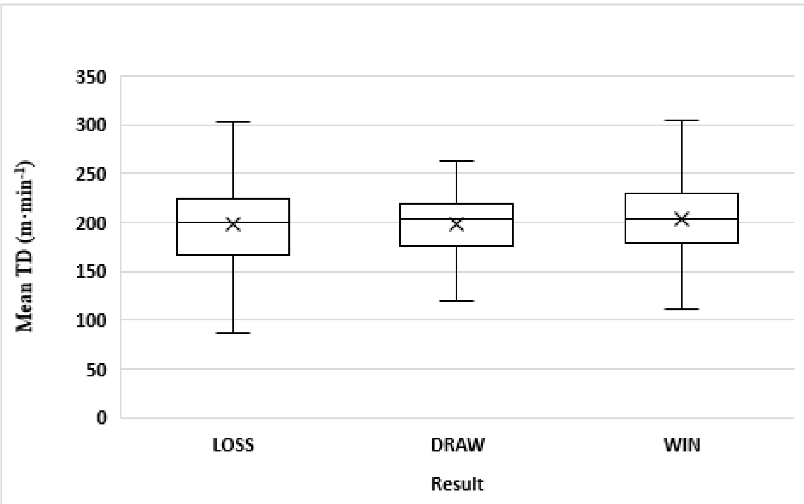


G. Displays HI Dec (n) by match outcome.

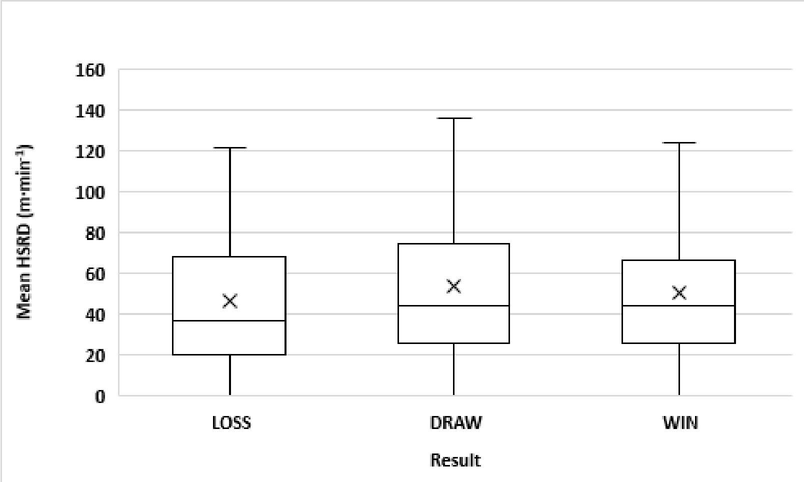


H. Displays AccelB3 (m) by match outcome.

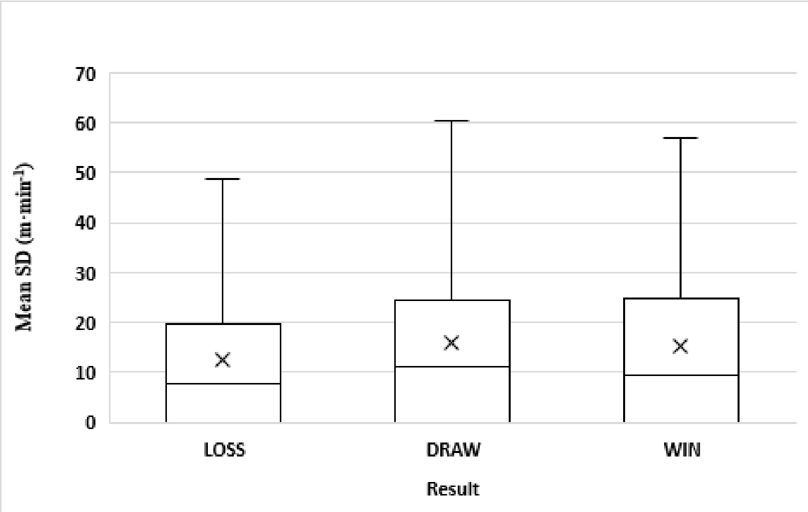
Figure 1: Comparisons between matches with loss, draw and win performance outcomes during transitions and high pressure activities in a) mean Total Distance (TD), b) mean High-Speed Running Distance (HSRD), c) mean Sprint Distance (SD), d) mean Relative High-Speed Running Distance (RelV4), e) mean Relative Sprint Distance (RelV5), f) mean number of High-Intensity Accelerations (HI Acc), g) mean number of High-Intensity Decelerations (HI Dec), and h) mean high-intensity acceleration distance (AccB3).
Note: Different from WIN *p < 0.05; **p < 0.01; ***p < 0.001



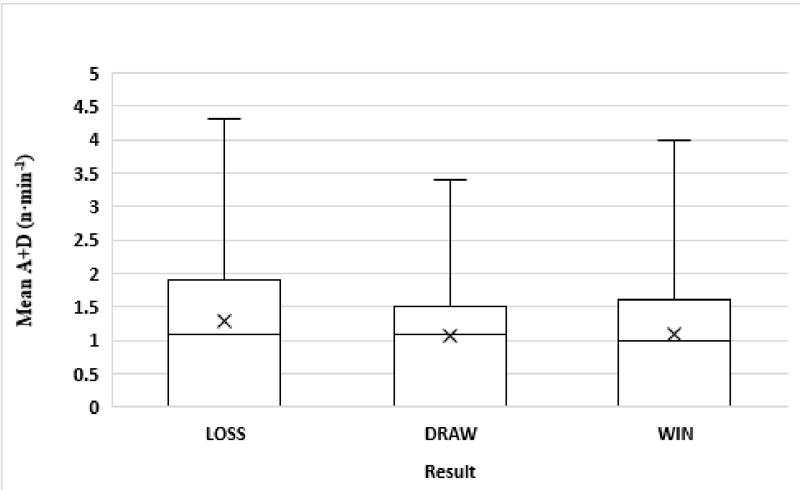
A. Displays TD ($m \cdot min^{-1}$) by match outcome.



B. Displays HSRD (m·min^{-1}) by match outcome.

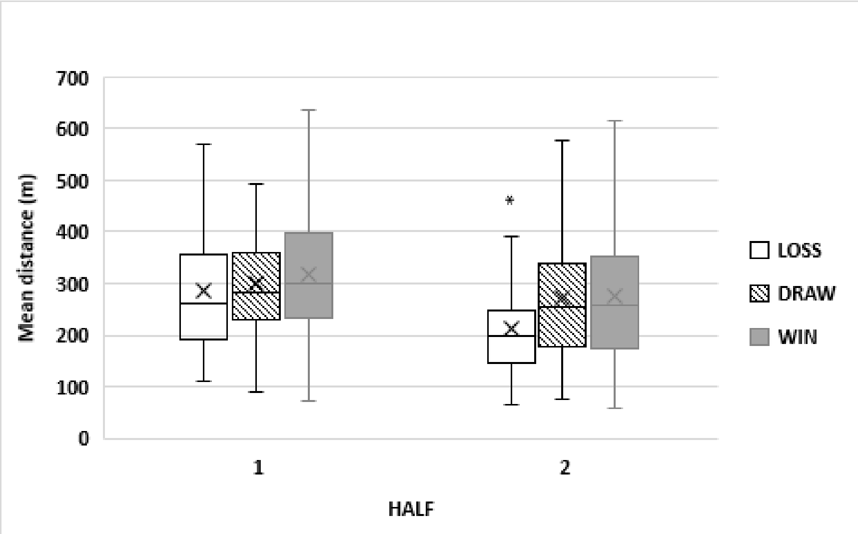


C. Displays SD (m·min^{-1}) by match outcome.

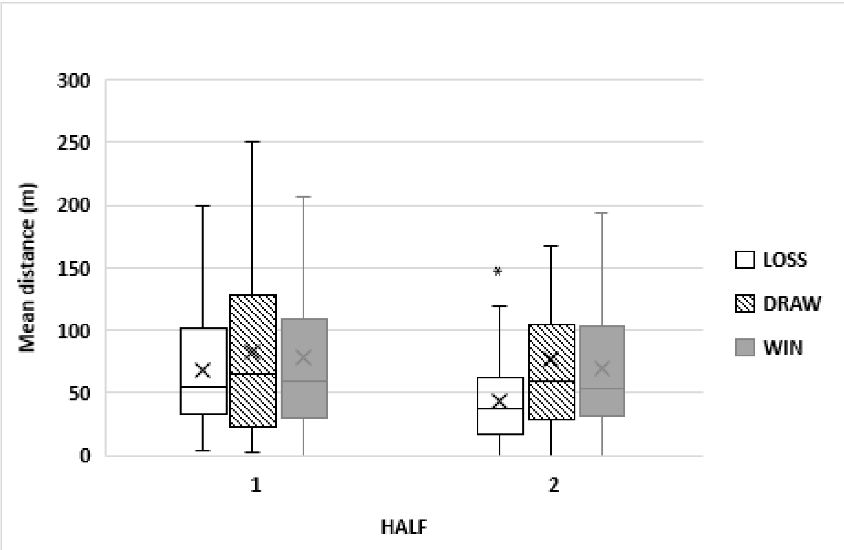


D. Displays A+D (n·min^{-1}) by match outcome.

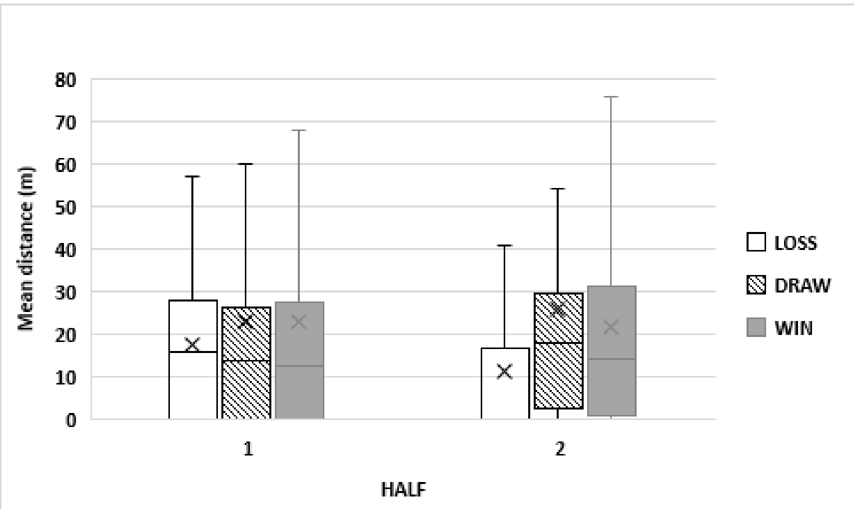
Figure 2: Comparisons between matches with loss, draw and win performance outcomes during transitions and high-pressure activities across 10 matches in a) mean TD (m·min^{-1}), b) mean HSRD (m·min^{-1}), c) mean SD (m·min^{-1}), and d) mean A+D (n·min^{-1}).
Note: Different from WIN *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$



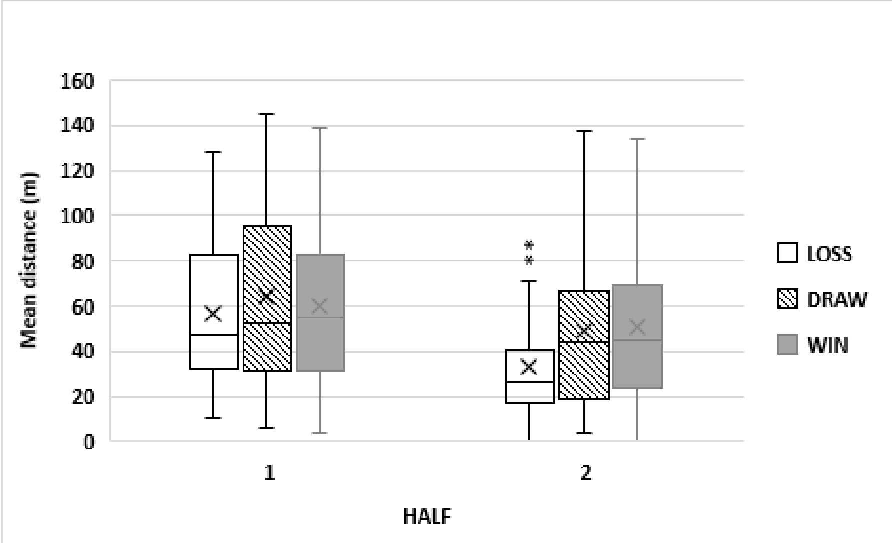
A. Displays TD (m) by match outcome per half.



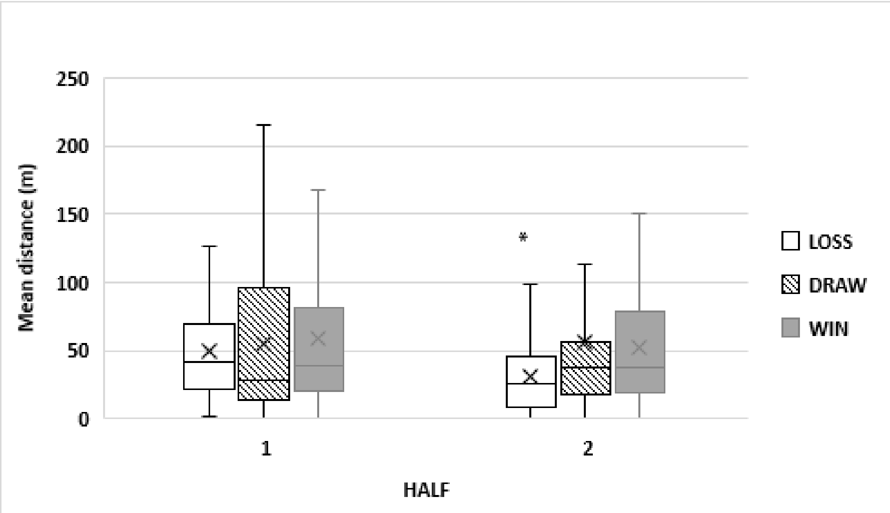
B. Displays HSRD (m) by match outcome per half.



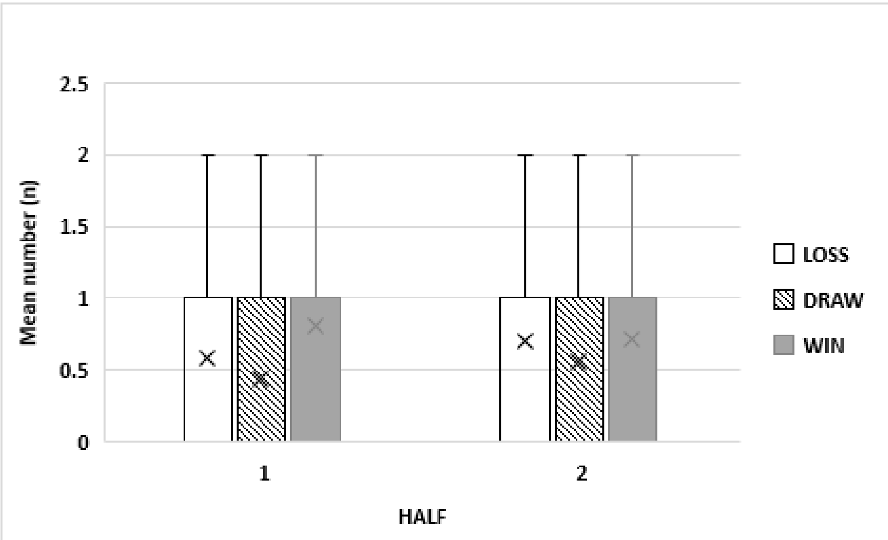
C. Displays SD (m) by match outcome per half.



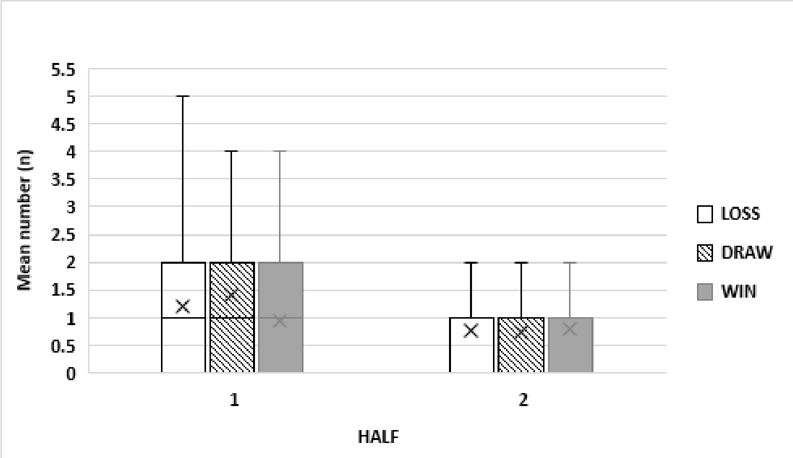
D. Displays VelB4 (m) by match outcome per half.



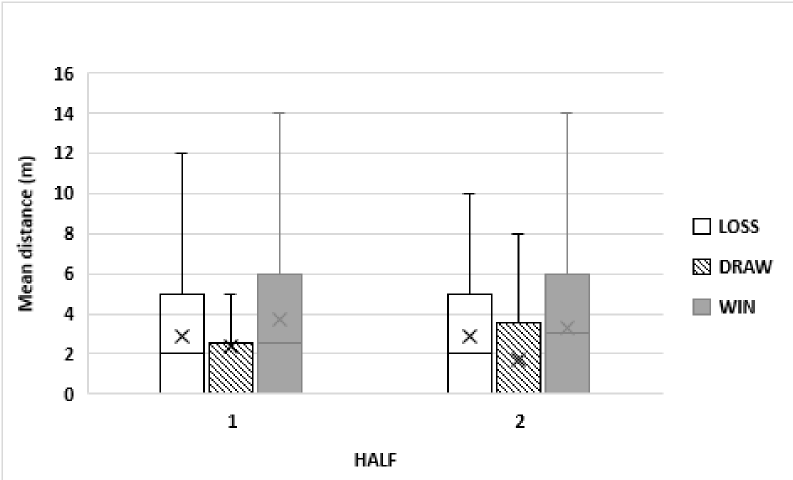
E. Displays VelB5 (m) by match outcome per half.



F. Displays HI Acc (n) by match outcome per half.

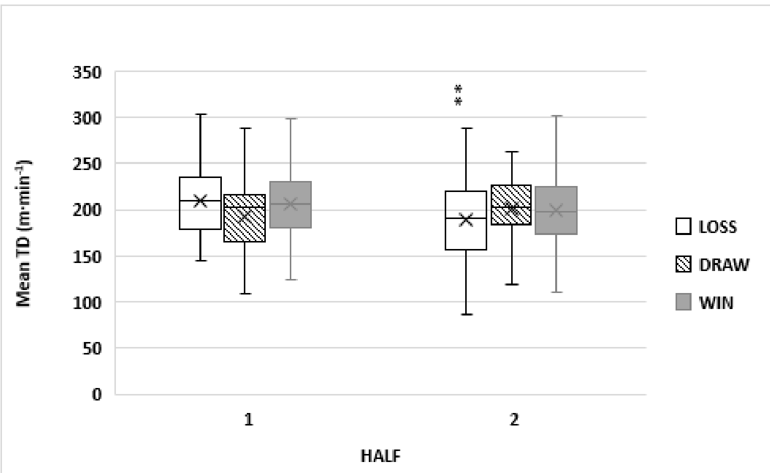


G. Displays HI Dec (n) by match outcome per half.

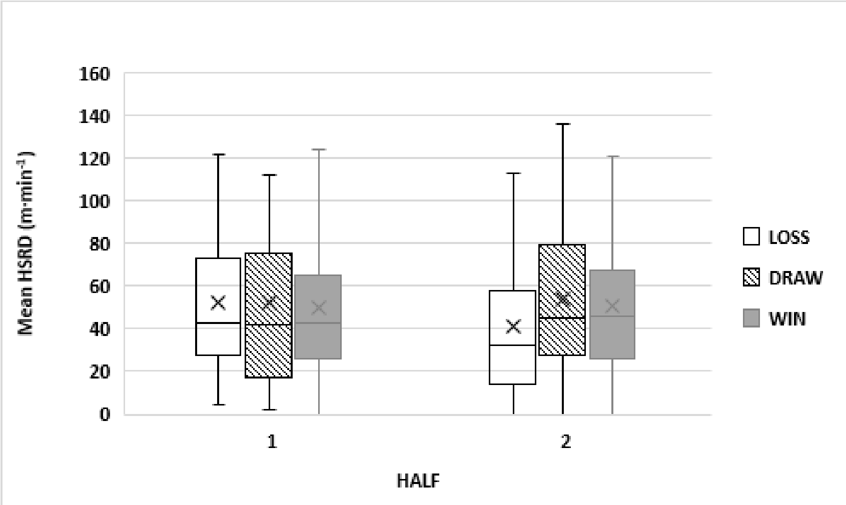


H. Displays AccelB3 (m) by match outcome per half.

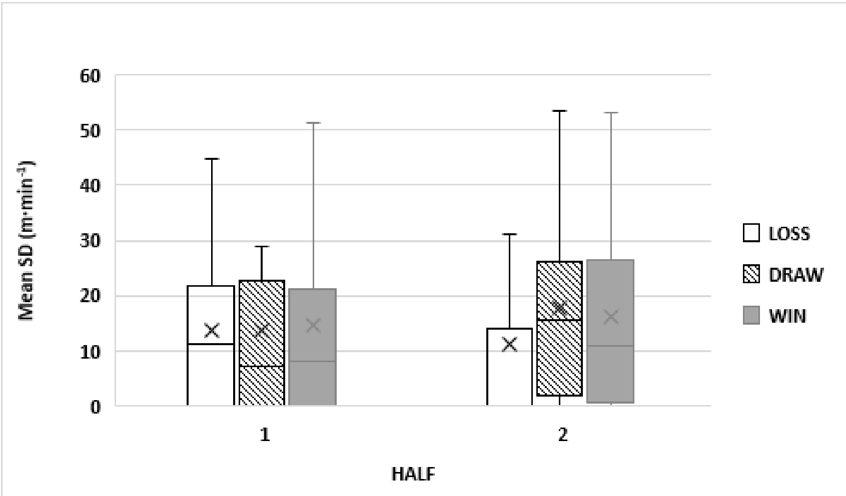
Figure 3: Comparisons between matches with loss, draw and win performance outcomes per match half (1&2) during transitions and high-pressure activities in a) mean Total Distance (TD), b) mean High-Speed Running Distance (HSRD), c) mean Sprint Distance (SD), d) mean Relative High-Speed Running Distance (RelV4), e) mean Relative Sprint Distance (RelV5), f) mean number of High-Intensity Accelerations (HI Acc), g) mean number of High-Intensity Decelerations (HI Dec), and h) mean high-intensity Acceleration Distance (AccB3).
Note: Different from WIN *p < 0.05; **p < 0.01; ***p < 0.001



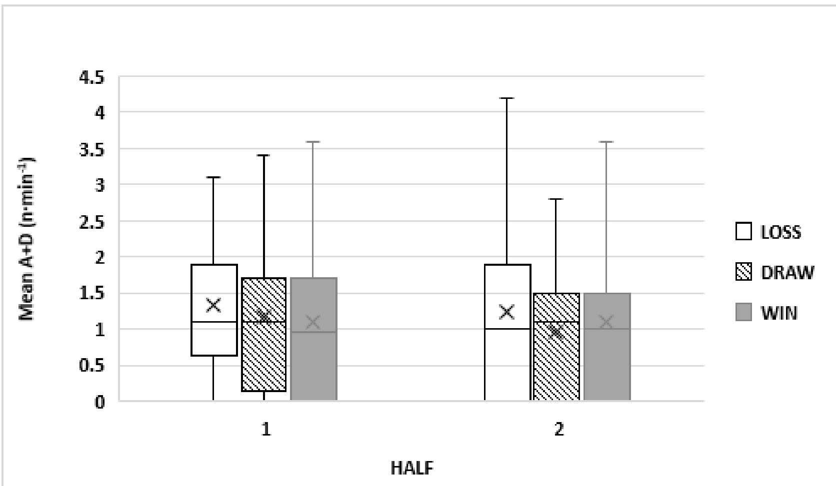
A. Displays TD (m·min^{-1}) by match outcome per half.



B. Displays HSRD (m·min^{-1}) by match outcome per half.



C. Displays SD (m·min^{-1}) by match outcome per half.



D. Displays A+D (n·min^{-1}) by match outcome per half.

Figure 4: Comparisons between matches with loss, draw and win performance outcomes per match half (1&2) during transitions and high-pressure activities across 10 matches in a) mean TD (m·min^{-1}), b) mean HSRD (m·min^{-1}), c) mean SD (m·min^{-1}), and d) mean A+D (n·min^{-1}).
Note: Different from WIN *p < 0.05; **p < 0.01; ***p < 0.001.

Discussion

The aims of the present study were to analyze the impact that different contextual variables (match half and match outcome) had on absolute and relative physical performance metrics during transitions and high-pressure activities in elite football. This is the first study introducing a novel concept of repeated TA's defined as clusters. Our findings show that during a modern football game players are exposed to repeated short, intermittent high velocity actions together. Thus, emphasizing the need to move away from training design guided by 90-minute averages [8]. The main findings indicate significant effects of contextual factors on transitions. All volume-related (totals) physical metrics were lower in the second half, but differences between both halves were significant in TD (m), HSRD (m), VelB4 (m) and HI Dec (n). Interestingly, high-intensity decelerations noted a significant decrease in the second 45mins, emphasizing the importance of these eccentric actions in the modern football match play, which not only demands high velocity activities, but also imposes many sharp and explosive actions in smaller spaces [19]. Accelerations and deceleration have been found to be more energetically stressful than velocity-based movements [30] and associated with success in modern football. Hence, training design, considering transitional game demand, should focus on exposing players to these important metrics. This will better prepare players for match demands, conditioning specifically for performance with the aim of reducing the effect of game specific fatigue [19]. The present work also revealed higher outputs in all physical variables, except high-intensity accelerations and decelerations, were displayed in games won.

Importantly, volume-related locomotor variables were decreased during TA's in the second half in lost games reaching significance for TD, HSRD, VelB4, and VelB5. Moreover, TD ($m \cdot min^{-1}$), HSRD ($m \cdot min^{-1}$) and SD ($m \cdot min^{-1}$) were also lower in the second 45min in lost matches but only TD ($m \cdot min^{-1}$) revealed a significant drop. However, no effect of match outcome and match half on all metrics per minute was found. A possible explanation could be that these differences might not be detected in short-duration high-intensity activities (transitions) [8]. These findings are consistent with previous work in elite football showing a decline in physical performance in the second 45min [16] as well as exploring the impact of peak intensity periods on match result [17]. Fatigue and/or inadequate recovery could explain the phenomenon of declined physical outputs and an increased risk of injury [19]. Also, the ability to run at high velocity as an important indicator of physical performance in contemporary football [31] might not be optimally stressed in training [32], which could potentially lead to decreased outputs in the final moments of the game.

To our knowledge, this is the first study in elite soccer investigating the impact of match outcome on the second half physical performance during transitions. Changing physical output, work-rate and tactical strategy has been linked to motivational aspects and to the score-line [33]. Our study failed to analyze the effect of score-line on transitions and future studies should address these concerns. Nevertheless, our findings show that both absolute/relative volume-and intensity-related metrics were lower in the second half in lost matches. Thus, posing a question if practitioners/coaches adequately perform transitional activities during a weekly macrocycle to best prepare and condition the players for these maximum intensity periods. Each TA's should be performed at high intensity to surprise the opponent with speed and create goal scoring opportunities in the offensive part and react quickly to squeeze space and/or make an effective recovery run defensively [8,27]. Coaches could overload different locomotor and mechanical demands using various tactical drills with/without the ball possession (defense-to-offense transitions, offense-to-defense transitions, and fast attacks) and/or transitional games (large-, medium-, and small-sided) during midweek sessions (MD-4 and/or MD-3) [7,12,32]. It would be crucial to add/create more space to reach near-maximum speed, and quickly arrive at the penalty area [8,34].

Small-sided games impose high-pressure demands on players and have been shown to over-stimulate (150%) high-intensity accelerations/decelerations, while large-sided games have been reported to overload sprinting demands by 125% [35]. Also, it has been suggested to supplement SSG's that include keepers played in a smaller area with additional positional drills and running-based exercises to replicate the match peak intensity periods for high-velocity activities [36]. It is noteworthy that counterattacks and fast attacks (offensive transitions) expose players to maximum velocity activities and generate nearly half of the game sprint distance [8]. Players have been shown to achieve higher running speed in transitional games versus SSG's and LSG's [37]. Also, transitional games show lower variability for different physical metrics, which could indicate a better suitability if a similar external load and sprinting actions were the main session objectives [37]. Another alternative approach to lower external load variability and expose all players to a greater physical output in a similar manner during different small-sided games, would be to play without goalkeepers [36]. Being consistent with the current definition of repeated high-velocity efforts and accelerations in football [28], this work introduces a novel concept of clusters defined as more than two transitional activities within a period of 1min. Findings indicate that the mean total number of clusters present across ten games was 12.2, which was higher than the ones previously reported in professional football [21]. Also, results show that the mean number of activities in clusters was equal to 2.6, peak number was 4.5 and mean total number of all TA's as clusters reached nearly 33 efforts. Decisive and contextualized high-intensity offensive/defensive phases [21] happen within a short period of time (>1min) over 90min [8]. Short rest periods between successive high-intensity bouts could deteriorate physical performance [38]. Modern physical conditioning programs (team, individual, and/or end-stage rehabilitation sessions) should emphasize TA's to improve players' ability to repeat high-intensity efforts over 90min [21] to better prepare for competition demands [5,8,32,35], reduce injuries and prevent declines in physical performance in the last stages of match play [23]. It is imperative to acknowledge that individual physical profile, willingness to run, style of play, level of opponent, and other situational and contextual factors would impact these physical demands [39].

The evolving nature of football and its unpredictability provides insight to the need to no longer look at the averages or totals over 90min periods, but to observe transitional play physical output to understand better how often these things occur, what is their context, duration, and recovery period [40]. To ensure that it guides how we design training and fulfill position-specific requirements for each individual player. Understanding transitional demands and veering from 90min averages provides greater insight into condensed game demand. This insight provides coaches with greater information to ensure training exposure is optimal, decreasing the chance of under/over exposure. Fatigue rather than pacing strategies has been linked to decreased physical performance over a longer period of activity and/or associated to a lower number of players involved during blocks of collective high-intensity actions in the final phases of match play [31]. Many goals are scored in the second half, it is crucial that all players including substitutions are well prepared and conditioned for the whole match [41]. Although only ten games and one team analyzed, these results provide insights and ammunition for further research. Also emphasizing the importance of relative data to further tailor training to individual physical capabilities, especially high-speed running, and sprinting. Future studies should investigate transitional play across a greater period, higher number of matches, and across many elite soccer teams. Moreover, future research should analyze transitions using individual acceleration and deceleration thresholds, determine duration and rest periods between clusters, identify positional differences, explore other contextual variables (match location, formation, score-line, style of play, etc.) and analyze replication of transitional exposure in training in relation to game [21].

Conclusion

In conclusion, the present study examined the effect of different contextual variables on transitional activities and identified repeated TA's (clusters) in elite football. Understanding the meaning of contextualized blocks of maximum output activities occurring in modern match play is of high importance to practitioners and coaches. Players should be trained accordingly to be able to withstand the most demanding passages of contemporary game, effectively fulfill their tactical/positional requirements and repeatedly perform high-intensity offensive and defensive activities. Absolute and relative locomotor metrics should be closely monitored, and high-intensity accelerations and decelerations regularly imposed on players. This might potentially reduce the negative effects of fatigue on match performance. Nevertheless, these findings should be applied with caution, since only one team was analyzed across ten games and more research is required in the future.

Key Points Summary

A. Transitional activities expose players to maximum physical demands much greater than the 90min averages.

B. To counteract declines in physical performance in the second half, coaches could prescribe appropriate conditioning and tactical drills, introduce offensive (in possession) and defensive (out of possession) exercises and transitional games manipulating the pitch size, number of players, and play with/without goalkeepers to best prepare athletes for the competition demands.

C. Repeated transitional activities integrating offensive and defensive actions with a rest period shorter than 1 min could be utilized in team, individual and return to play sessions; for instance, counterattacks might be followed by a negative transition and then by a fast attack once the ball has been recuperated.

D. High-velocity (high-speed running) and high-intensity (decelerations) activities should be closely monitored during a weekly macrocycle in relation to different positional groups to best condition players for the modern demands of competition and reduce the risk of injury (under preparedness).

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