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The Effect of Fixture Congestion on High-Intensity Acceleration and Deceleration Profiles in Professional Soccer Players

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ABSTRACT

This study aimed to analyse the effects of fixture congestion on high-intensity acceleration, deceleration and high metabolic load distance (HMLD) profiles in male professional soccer players. Eighteen English Football League Two outfield players participated in the study across a full season. Periods assessed included congestion (< 96 hours recovery between matches) and non-congestion (> 96 hours recovery between matches). Physical performance during matches was recorded using 10 Hz GPS units assessing total distance and frequency of high-intensity accelerations and decelerations, and HMLD. A repeated measures two-way ANOVA was used to test the effect of congestion, player position, and the interaction between congestion and position. There was no effect of congestion for all GPS metrics (p > .05). Whilst there were no differences within position, differences were found between position for congestion (p < .05). Significant differences were found for position within all GPS metrics, mainly that forwards had significantly higher loads than centre backs (p < .05). Fixture congestion did not cause changes in high-intensity acceleration, deceleration, and HMLD profiles; however, the positional differences identified suggest it is important to build resilience to these demands and ensure that monitoring and testing considers the player's position to optimise high-intensity physical performance.

Keywords: High metabolic load distance, Position, GPS, Physical performance, Soccer, Team sports.

INTRODUCTION

Soccer is an intermittent sport that is characterised at the highest level by a player's ability to repeatedly perform high-intensity work (Mohr et al., 2003). The physical demands have been studied extensively and require players to perform frequent, explosive changes of direction alongside repeated high-intensity actions (Varley & Aughey, 2013). Previous research has primarily focused on total distance, high-speed running, and sprint distance (Bradley et al., 2010; Mallo et al., 2015). However, the energy cost of high-speed running and sprint distance may be underestimated as this does not assess specific actions such as accelerations and decelerations (Gaudino et al., 2013). Despite this, whilst research has been published on accelerations and decelerations for the past decade (Akenhead et al., 2013), it has taken longer for accelerations, and especially decelerations, to become commonly used metrics to assess physical performance in professional soccer players (Oliva-Lozano et al., 2020; Rhodes et al., 2021).

Accelerations and decelerations are important external load metrics that are used to monitor physical performance and injury risk in professional soccer; they are also directly associated with match success (Rhodes et al., 2021; Guitart et al.,

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2022). Acceleration and deceleration output during matches is impacted by several factors including league position; formation; match location; and player position, with wide players and central midfielders covering the greatest total distance of both accelerations and decelerations (Oliva-Lozano et al., 2020; Aquino et al., 2021; Arjol-Serrano et al., 2021; Barrera et al., 2021). There are clear discrepancies between studies when reporting acceleration and deceleration output even with methodological similarities, as total distance of acceleration ranges from 334 m to 1022 m and total distance of deceleration between 265 m and 899 m during matches (Akenhead et al., 2013; Oliva-Lozano et al., 2020). However, whilst inter-unit reliability is high in 10 Hz global positioning system (GPS) units for linear actions (Beato & Keijzer, 2019), caution must be taken when analysing data as validity and inter-unit reliability decrease with greater acceleration and rapid directional change specifically above 3-4 $m \cdot s^{-2}$ (Akenhead et al., 2014; Rawstorn et al., 2014). Furthermore, it is advised that practitioners should apply care when comparing data from different models or units, even with data collected at the same frequency, due to this variability (Buchheit et al., 2014). Even with these limitations, 10 Hz GPS units are still currently the most practical devices used to measure acceleration and deceleration within professional soccer (Hoppe et al., 2018).

The number of accelerations and decelerations involved during a match induce a high number of eccentric muscle contractions which results in an increased potential of micro-muscle damage occurring, and therefore post-match fatigue (Nédélec et al., 2012). This can be linked to a reduction in acceleration and deceleration distance during the second half and especially within the final 15 min of matches (Akenhead et al., 2013; Russell et al., 2016). In addition, correlations show that increased acceleration and deceleration output during matches elicit significantly higher creatine kinase levels immediately following a match, but also up to 60 hours post-match (de Hoyo et al., 2016; Varley et al., 2017). This emphasises the greater physiological impact that high acceleration and deceleration output can have on players. Therefore, the relationship between accelerations and decelerations and fatigue status shows that these metrics provide a useful non-invasive predictor of fatigue for players and should be monitored both short and long term (Marqués-Jiménez et al., 2022). Acceleration profiles have been studied for longer and more extensively than deceleration profiles within soccer. Players with higher maximum acceleration rates are able to sprint faster over shorter distances and achieve greater change of direction velocities (Loturco et al., 2019). In addition, players perform eight times more accelerations than sprints per mat, emphasising the requirement for players to have a high acceleration ability (Varley & Aughey, 2013). However, decelerations may be of greater importance than accelerations within soccer as previous evidence has shown that professional players perform 80-104% more high-intensity decelerations than accelerations during matches (Oliva-Lozano et al., 2020). High-intensity decelerations also have a 2.7 times greater peak ground reaction force than high-intensity accelerations (Harper et al., 2022).In addition, decelerations have been found to be one of the most common actions to precede goals in soccer (Martínez-Hernández et al., 2023). Therefore, whilst accelerations and decelerations have different properties, both are important to successful performance in matches. Advancing the knowledge of acceleration and deceleration profiles in soccer will become increasingly important in the future due to further tactical evolutions, based on models of high pressing and counter-attacking, which will result in greater exposure to short intense accelerations and decelerations interspersed with more high-speed running (Harper et al., 2021).

It is important to analyse metrics that combine and integrate all high-intensity work, including high-intensity accelerations and decelerations, when monitoring physical performance in soccer. Therefore, high metabolic load distance (HMLD) is of interest as it represents the total distance of high-speed running, accelerations and decelerations a player performs and equates to the distance covered by a player when their metabolic power is over 25.5 $W \cdot kg^{-1}$ (Tierney et al., 2016). This value of 25.5 $W \cdot kg^{-1}$ is relevant as it corresponds to a player running at a constant speed of 5.5 $m \cdot s^{-1}$ or when they are significantly accelerating or decelerating above 2 $m \cdot s^{-2}$ (Tierney et al., 2016; Martín-García et al., 2018). Monitoring HMLD should be prioritised because high-intensity work during a match is the biggest risk factor for fatigue and injury, specifically muscle injuries in the quadriceps and hamstrings (Nédélec et al., 2012; Martins et al., 2023). Within the limited research surrounding HMLD in professional soccer, multiple factors have impacted output including competition level, formation, and playing position (Tierney et al., 2016; Martín-García et al., 2018; García-Calvo et al., 2022). Whilst it is important to understand how accelerations, decelerations, and

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HMLD impact physical performance during a single match, knowing how these metrics are affected by fixture congestion is crucial for monitoring physical load, fatigue, and injury risk.

The majority of professional teams in the United Kingdom compete in 50+ matches in an approximate 40-week season, which means that two matches per week occur frequently throughout the fixture calendar (Carling et al., 2015a). There has been extensive research analysing the impact of fixture congestion on physical performance during matches; however, this has primarily focused on total distance, high-speed running, and sprint metrics. Most studies found that fixture congestion does not affect these metrics in professional male players (Carling et al., 2012; Djaoui et al., 2014). Only limited evidence has suggested otherwise, stating that these metrics did decrease within microcycles of < 4 days (Penedo-Jamardo et al., 2017). It is important to monitor variables such as HMLD during fixture congestion, as high-intensity actions of high-speed running, accelerations, and decelerations can cause fatigue accumulation and delayed recovery; therefore, players may not be able to perform high-intensity actions as frequently during these periods (Martín-García et al., 2018; Djaoui et al., 2022). Fixture congestion research analysing accelerations, decelerations, and HMLD has been very limited, with most studies finding contrasting results primarily in elite youth players (Jiménez et al., 2022; Muñoz-Castellanos et al., 2022). Muñoz-Castellanos et al. (2022) found that in elite youth players high-intensity decelerations significantly reduced during a period of fixture congestion; however, high-intensity accelerations were not affected. Whilst Clemente et al. (2021) found that in professional players the weekly acute load, which included both training and matches, for accelerations and HMLD was significantly increased during fixture congestion. To the authors' knowledge, no study has investigated HMLD, with only one directly comparing acceleration and deceleration metrics, during match-by-match fixture congestion (Djaoui et al., 2022). Djaoui et al. (2022) found that both acceleration and deceleration were significantly impaired by fixture congestion. The distance covered at high (244 m vs 267 m) and maximal (73.2 m vs 84.9 m) acceleration, maximal deceleration distance (139 m vs 152 m), and the total decelerating distance (5132 m vs 5245 m) were all lower during congestion compared to non-congestion. This highlights a potential fatigue accumulation being responsible for the decrement in maximal acceleration and deceleration metrics, which are affected the most. However, this data was collected from one squad and more research is required to build on this study and provide further evidence (Djaoui et al., 2022).

This study aims to expand and build on the limited previous research by analysing the effects of fixture congestion on high-intensity acceleration, deceleration, and HMLD profiles in male professional soccer players. It should also be considered whether players have different profiles depending on their position, and these differences should be analysed accordingly. There is also limited evidence investigating any effect of position during fixture congestion (Djaoui et al., 2022). Therefore, this study will also investigate the effects of player position on GPS metrics and fixture congestion.

MATERIALS AND METHODS

Participants

Eighteen first-team professional male soccer players excluding goalkeepers, competing in the English Football League (EFL) Two were involved in the study during the 2022-23 season (mean age: 26.8 ± 5.2 years, height: 182.5 ± 5.3 cm, body mass: 80.6 ± 5.9 kg). Seventeen matches were included in this study. All matches utilised within the study were competitive fixtures from competitions including the EFL League Two, FA Cup, and League Cup. Informed and voluntary consent was gained from the club and the players involved. Ethical approval was granted by the University of Lincoln Ethics Committee (ethics reference number: 2023_14338).

Study Design

A within-group repeated measures design was used to compare changes in high-intensity accelerations and decelerations, and HMLD between congestion and non-congestion throughout the season. In addition, the effect of position on GPS metrics and fixture congestion was also analysed.

Within this study, congestion and non-congestion were represented by two- and one-match weeks, respectively (Djaoui et al., 2014). Congestion was defined as having < 96 hours of recovery time between matches and non-congestion was defined as having > 96 hours of recovery time preceding a match (Lago-Peñas et al., 2011). Inclusion criteria required players to play in ≥ 75 minutes of a match

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for them to be included in that match sample (Dellal et al., 2015). Therefore, for a non-congested period, players must have completed ≥ 75 minutes of a single match and for a congested period players must have completed ≥ 75 minutes of both matches (Howle et al., 2019). Only congested periods that involved a Saturday-Tuesday schedule, or the equivalent of, were included to ensure the same recovery time was maintained between matches (Hattersley et al., 2018). Congested and non-congested data points for each player were paired together for analysis, ensuring that these data points were within four weeks of each other to reduce any long-term training or injury effects on player output. There were 44 sets of player data points used in this study from 10 paired congested and non-congested matches.

Microcycle training structure for matches in congested and non-congested periods were kept consistent throughout the season. All matches were played on outdoor grass pitches in accordance with the English Football Association rules.

Procedure

Throughout all matches, players' physical performance was assessed using 10 Hz GPS (Apex, STATSports, Ireland), which has been found to be reliable and valid when assessing team sport movements including accelerations and decelerations (Varley et al., 2012; Crang et al., 2022). Each player used the same unit during the period of data collection to reduce inter-unit variability (Jennings et al., 2010). Players used a manufacturer provided vest in which the GPS unit was placed tightly between the scapulae to ensure it did not restrict upper body range of movement. Manufacturer's guidelines were followed during the use of the GPS units. Only match-play data was analysed within this study, and data was cropped so that any other periods, such as a warmup or cool down, were removed. Following each match, data was downloaded from the STATSports system into Microsoft Excel and checked for irregularities ensuring data quality and validity remained high. Acceleration zones, deceleration zones, and HMLD were determined through the STATSports software.

The metrics that were assessed in this study included total distance of high-intensity accelerations (TD_{Acc}) (> 3 $m \cdot s^{-2}$) and decelerations (TD_{Dec}) (< -3 $m \cdot s^{-2}$), total number of high-intensity accelerations (Num_{Acc}) (> 3 $m \cdot s^{-2}$) and decelerations (Num_{Dec}) (< -3 $m \cdot s^{-2}$), and HMLD, which was defined as the total distance of high-speed running (> 5.5 $m \cdot s^{-1}$), accelerations (> 2 $m \cdot s^{-2}$), and decelerations (< -2 $m \cdot s^{-2}$). The thresholds used within this study were determined to be the most valuable during match play following a review of the research (Akenhead et al., 2013; Tierney et al., 2016). As positional differences were assessed, players were grouped by playing position according to the tactical disposition of the team (3-5-2/5-3-2). These positions were: centre backs (CB), wide defenders (WD), central midfielders (CM), and forwards (FW).

Statistical Analysis

GPS data was imported from the STATSports software into Microsoft Excel. All statistical analyses were completed using Jamovi version 2.5.5 with all data output presented as mean ± standard deviation and statistical significance set at $p < .05$. Normality checks of the data were undertaken using the Shapiro-Wilk test. As all GPS metrics were normally distributed, a repeated measures two-way ANOVA was used to test the effect of condition (congestion vs non-congestion), player position, and the interaction of these two factors on the GPS metric. Equal variances were violated as per Mauchly's Test of sphericity; therefore the Greenhouse-Geisser correction was used. Post-hoc comparisons were used via the Bonferroni correction for the analysis of position and the interaction between congestion and position. Eta squared effect sizes were used to determine the magnitude of these differences and were reported as generalised eta squared (η^2_G), eta squared (η^2), and partial eta squared (η^2_P). These were classified as small (0.01), medium (0.06), or large (0.14) (Cohen, 1988).

RESULTS

No significant main effects of congestion were observed for either Num_{Dec} ($p = .478$, $\eta^2_G = .011$) or HMLD ($p = .348$, $\eta^2_G = .019$). However, position significantly influenced both Num_{Dec} ($p = .006$, $\eta^2_G = .459$) and HMLD ($p < .001$, $\eta^2_G = .508$), with large effect sizes indicating substantial positional differences. No significant congestion × position interactions were identified for either variable ($p \geq .515$, $\eta^2_G \leq .021$), suggesting that the effect of congestion was consistent across positions (refer to Table 1 for further details).

The interaction between congestion and position (Figure 1) showed that for TD_{Acc}, significant differences were found between non-congested

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Table 1. Comparison of congestion, position, and the interactions of congestion and position.

GPS metric	Effect	F(df1, df2)	*p*	η^2_G
TD_{Acc}	Congestion	0.04 (1, 7)	.840	<.001
	Position	8.85 (2.15, 15.02)	.003	.461
	Congestion × Position	0.37 (2.41, 16.88)	.731	.010
TD_{Dec}	Congestion	1.33(1, 7)	.287	.021
	Position	13.64 (2.01, 14.04)	< .010	.502
	Congestion × Position	0.73 (2.29, 16.03)	.514	.026
Num_{Acc}	Congestion	0.47 (1, 7)	.515	.006
	Position	5.52 (2.82, 19.77)	.007	.297
	Congestion × Position	0.22 (1.93, 13.52)	.797	.009
Num_{Dec}	Congestion	0.59 (1, 5)	.478	.011
	Position	8.75 (2.03, 10.13)	.006	.459
	Congestion × Position	0.19 (1.43, 7.14)	.763	.014
HMLD	Congestion	1.01 (1, 7)	.348	.019
	Position	14.44 (2.36, 16.49)	< .001	.508
	Congestion × Position	0.75 (2.47, 17.28)	.515	.021

Table 2. Comparison of high-intensity GPS metrics between non-congestion and congestion.

GPS metric	Non-congestion	Congestion	*p* value	η^2_G	η^2_P
TD_{Acc} (m)	528.3 ± 155.8	541.3 ± 164.0	.84	< .001	.006
TD_{Dec} (m)	207.7 ± 57.0	207.4 ± 57.9	.29	.021	.160
Num_{Acc}	70.3 ± 22.0	72.1 ± 18.9	.52	.006	.063
Num_{Dec}	75.8 ± 18.5	76.4 ± 18.0	.48	.011	.105
HMLD (m)	2573.4 ± 596.0	2543.4 ± 652.1	.35	.019	.126

TD_{Acc} = total distance of high-intensity accelerations, TD_{Dec} = total distance of high-intensity decelerations, Num_{Acc} = number of high-intensity accelerations, $NumD_{ec}$ = number of high-intensity decelerations, HMLD = high metabolic load distance.

Table 3. Differences in playing position in relation to high-intensity GPS metric output.

GPS metric	Positional differences	η^2_G	η^2_P
TD_{Acc} (m)	FW > CB, WD, CM	< .001	.006
TD_{Dec} (m)	FW > CB, WD	.021	.160
Num_{Acc}	FW > CB	.006	.063
Num_{Dec}	FW > CB	.011	.105
HMLD (m)	FW > CB, CM	.019	.126

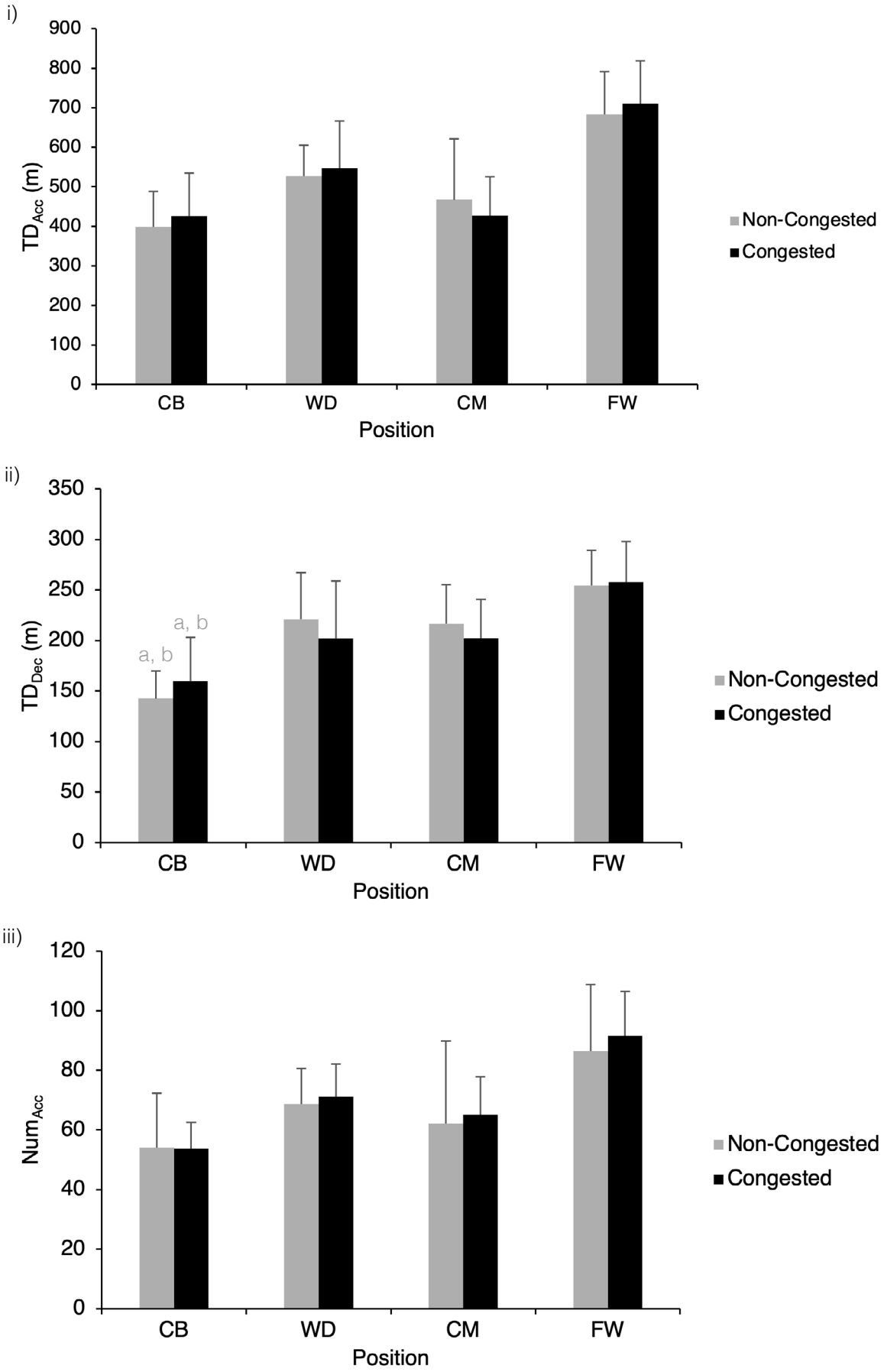
TD_{Acc} = total distance of high-intensity accelerations, TD_{Dec} = total distance of high-intensity decelerations, Num_{Acc} = number of high-intensity accelerations, Num_{Dec} = number of high-intensity decelerations, HMLD = high metabolic load distance, CB = centre backs, WD = wide defenders, CM = centre midfielders, FW = forwards

CB and congested FW (p = .013), congested CB and congested FW (p = .048), congested CM and non-congested FW (p = .024), and congested CM and congested FW (p = .023). For TD_{Dec}, significant differences were found between non-congested CB and non-congested FW (p = .012), non-congested CB and congested FW (p < .001), congested CB and non-congested FW (p = .010), and congested CB and congested FW (p = .005). For Num_{Dec}, the only significant difference was between non-congested CB and congested FW (p = .002). For HMLD, significant differences were found between non-congested CB and non-congested FW (p = .015), non-congested CB and congested FW (p = .002), congested CB and non-congested FW (p = .014), congested CB and congested FW (p = .005), and non-congested FW and congested CM (p = .029). No other significant differences were found between congestion and position.

Positional analysis (Table 3) showed that when comparing FW and CB, there were significant differences in TD_{Acc} (p = .009), TD_{Dec} (p < .001), Num_{Acc} (p = .017), Num_{Dec} (p = .003), and HMLD (p

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< .001). When comparing FW and WD, there were significant differences in TD_{Acc} (p = .029) and TD_{Dec} (p = .041). When comparing FW and CM, there were significant differences in TD_{Acc} (p = .025) and HMLD (p = .020). There were no other positional differences in any GPS metric.



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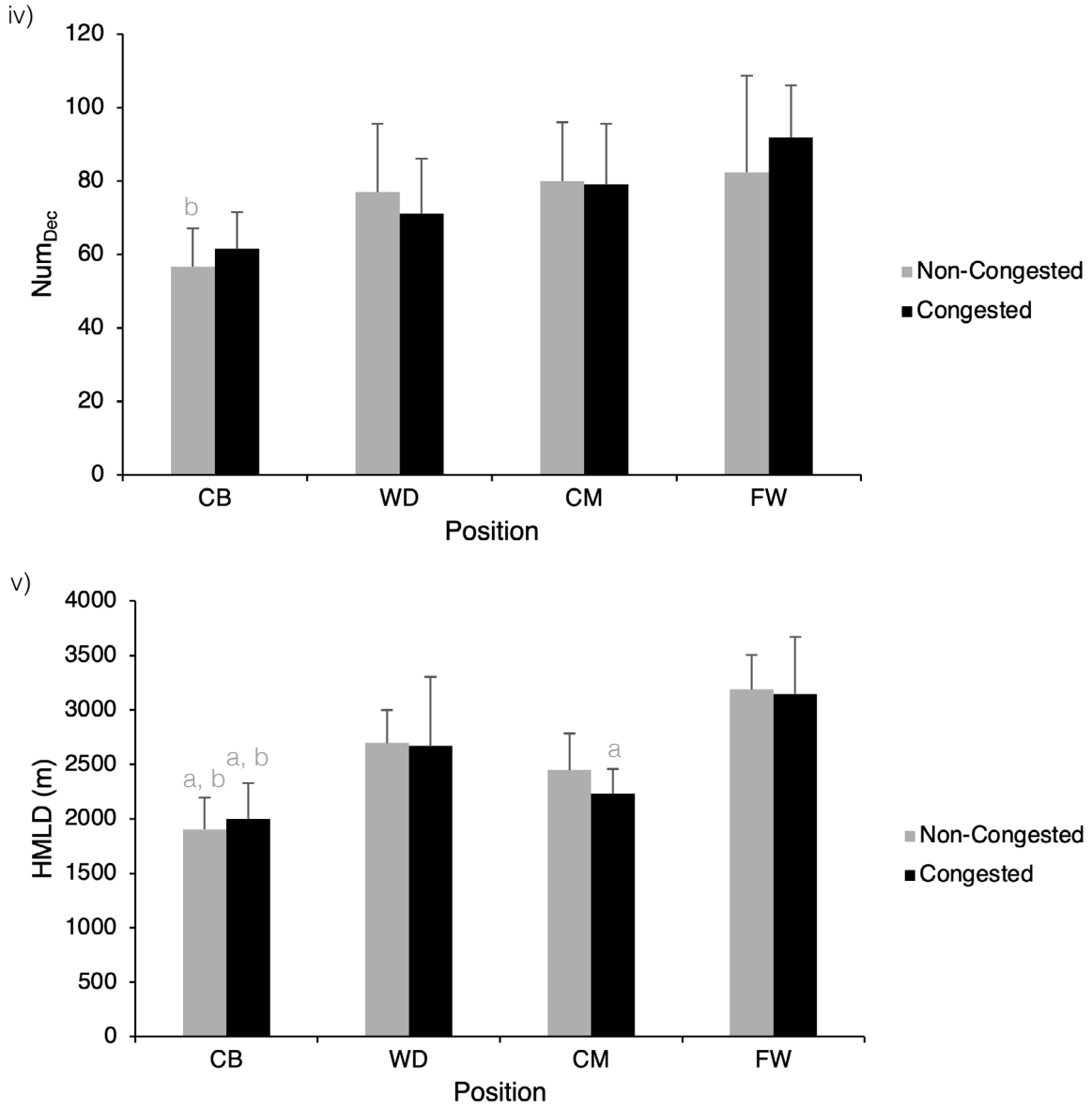


Figure 1. Positional differences between non-congestion and congestion for each high-intensity GPS metric including: i) TD_{Acc}, ii) TD_{Dec}, iii) Num_{Acc}, iv) Num_{Dec}, v) HMLD.
a = Significantly different to non-congested FW, b = significantly different to congested FW
TD_{Acc} = total distance of high-intensity accelerations, TD_{Dec} = total distance of high-intensity decelerations, Num_{Acc} = number of high-intensity accelerations, Num_{Dec} = number of high-intensity decelerations, HMLD = high metabolic load distance, CB = centre backs, WD = wide defenders, CM = centre midfielders, FW = forwards.

DISCUSSION

The aims of this study were to analyse the effects of fixture congestion on high-intensity acceleration, deceleration, and HMLD profiles; whilst also investigating the effects of position on GPS metrics and congestion. At the time of writing, this study was the first to analyse the effects of fixture congestion on HMLD and the associated positional differences; and the first to analyse the effects of fixture congestion on acceleration and deceleration profiles in the English football leagues, therefore providing novel findings for this population.

The findings of this study show that in EFL League Two players there is no significant differences in high-intensity acceleration and deceleration, and HMLD profiles between congestion and non-congestion during a full season (Table 2). Some differences were found between congestion and position for nearly all high-intensity GPS metrics, primarily between FWs and CBs (Figure 1). Finally, when analysing position, it was found that FWs had a significantly higher output compared to other positions across all high-intensity GPS metrics (Table 3).

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This study found no difference in high-intensity acceleration and deceleration profiles between congestion and non-congestion. This contrasts to previous research in professional male players which found that both TD_{Acc} and TD_{Dec} were impaired during fixture congestion (Djaoui et al., 2022). The values of TD_{Acc} and TD_{Dec} found in this study were significantly higher to those described by Djaoui et al. (2022) during both non-congestion (TD_{Acc}: 528.3 m vs 84.9 m, TD_{Dec}: 207.7 m vs 152.0 m) and congestion (TD_{Acc}: 541.3 m vs 73.2 m, TD_{Dec}: 207.4 m vs 139.0 m) even though a similar type of GPS unit was used, and the GPS thresholds were the same.

One explanation for this could be due to the differences in physical demands and characteristics of the league and country. Whilst this study uses EFL League Two players, Djaoui et al. (2022) utilises players from the top division of Swiss soccer including many who play for their respective international teams. Therefore, there may potentially be differences between the pace of the match between English teams and those from other countries. Furthermore, whilst GPS inter-unit reliability is high for lower-intensity movements (Beato et al., 2018), the difference between the studies could be explained by the potential issues with the sensitivity of GPS units when analysing accelerations and decelerations (Buchheit et al., 2014). These movements show the most variability, and it has been suggested that accuracy may be compromised when accelerating above 3-4 $m \cdot s^{-2}$, possibly impacting the results of these studies (Akenhead et al., 2014). Whilst potential explanations can be suggested for the large differences that have been shown, due to the fact there is limited evidence available comparisons cannot reliably be made to other studies. Therefore, future research should focus on presenting data from more teams in different leagues to allow for better comparability.

To the authors' knowledge, only one previous study has analysed high-intensity accelerations and decelerations in professional male players and whilst it did measure TD_{Acc} and TD_{Dec}, it did not account for Num_{Acc} and Num_{Dec}. Most other studies have used professional male youth players and have found contrasting results relating to Num_{Acc} and Num_{Dec} (Arruda et al., 2015; Jiménez et al., 2022; Muñoz-Castellanos et al., 2022). As GPS metric thresholds may vary between clubs and GPS providers, differences can arise when comparing research due to the classification of these thresholds. Data must be compared carefully between studies due to the methodological differences in identifying fixture congestion. Therefore, future research would be beneficial to further define how fixture congestion is assessed as there is currently limited rigour within this area. This would aid in the clarification and comparability of research by providing a structured and clear definition which many studies lack.

Whilst multiple studies have analysed high-intensity accelerations and decelerations, there has been limited research investigating the impact of fixture congestion on HMLD. Clemente et al. (2021) found that the acute load of HMLD was significantly greater during congestion compared to non-congestion. However, this data consisted of total physical load and not just matches, so whilst it can provide some context, the outcomes are not directly comparable to the results of this study. Therefore, this emphasises the need for future research on the impact of fixture congestion on HMLD.

This study found no difference when analysing the effect of fixture congestion within position for high-intensity acceleration and deceleration, and HMLD metrics. Whilst Djaoui et al. (2022) found that TD_{Acc} was significantly impaired during congestion in CMs, no other high-intensity GPS metric that the study analysed showed any effect. The only other evidence showing significant changes within position utilised lower thresholds. Impairments were found during congestion in TD_{Acc} per minute for CMs at an intensity of 2-3 $m \cdot s^{2}$ and Num_{Acc} per minute for CBs using a threshold of > 2.5 $m \cdot s^{2}$ (Djaoui et al., 2022; Muñoz-Castellanos et al., 2022). Overall, the majority of evidence shows that there are not significant differences within position due to congestion. However, this study found differences between positions for all GPS metrics apart from Num_{Acc}. Significantly greater outputs were shown in both congested and non-congested FWs compared to both congested and non-congested CBs in all GPS metrics apart from Num_{Acc}. Furthermore, there were some differences shown between congested CMs and congested and non-congested FWs in TD_{Acc} and HMLD, respectively. To the author's knowledge, no previous study has compared differences between position when analysing fixture congestion.

As most of the current evidence suggests that fixture congestion has limited effects on positional differences, it may be inferred that squad rotation strategies were used to minimise the impact of high-intensity demands on specific playing positions

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(Carling et al., 2015b). Such strategies could reduce the negative effects of fixture congestion, particularly for positions that typically experience greater high-intensity workloads within a team's tactical system. In the present dataset, forwards and centre-backs recorded the highest number of paired data points, indicating that they were rotated less frequently than other positions. This may help explain why these positions demonstrated the highest outputs across all the GPS metrics. Conversely, positions that were rotated more regularly may have benefited from reduced fatigue, allowing players to maintain the high-intensity physical demands required during congested fixture periods.

This study showed significant positional differences, primarily that FWs produced the highest output for all high-intensity GPS metrics. In all GPS metrics, FWs were significantly greater than CBs and that CBs had the lowest positional physical demands; which is in line with previous literature (Di Salvo et al., 2009; Djaoui et al., 2022). In addition, FWs also had significantly greater outputs than WDs in TD_{Acc} and TD_{Dec}, and also greater outputs than CMs in TD_{Acc} and HMLD. However, other research analysing professional male players show that midfielders, both central and wide, performed the greatest TD_{Acc}, TD_{Dec}, and HMLD which significantly contrasts to this study (de Hoyo et al., 2018; Oliva-Lozano et al., 2020; García-Calvo et al., 2022). This difference could be linked to squad rotation as CM's had the lowest number of 'paired' data points suggesting that they may have not been exposed as much as other positions to fixture congestion.

These differences in positional outputs between high-intensity GPS metrics may also be linked to formational differences and the impact of the coach's playing style. Different formations can elicit different demands for each position therefore altering the high-intensity output during matches (Arjol-Serrano et al., 2021). More specifically, the 3-5-2/5-3-2 formation employed by the team in this study produces higher HMLD than all other formations and a higher-than-average acceleration and deceleration output (Tierney et al., 2016). Furthermore, the coach's style of play such as high pressing or counter attacking can generate significantly different demands which need to be accounted for when comparing positional outputs (Arjol-Serrano et al., 2021). In this study, FWs produce the highest high-intensity output of all the positions suggesting the coach may require the forwards to press and run in behind the defence often.

This may be exacerbated by fixture congestion as the positions with the highest demands, in this case FW's, will be at greater risk of fatigue and therefore may have a reduction in the capacity to perform these high-intensity actions and increase the risk of injury (Nédélec et al., 2012). There is limited research focusing on the impact of specific formations, a player's role, and coaching style on fixture congestion so future research is required surrounding this.

It is also important to note that this study is limited due to the fact that it only involves match play data. To understand more holistically some of the reasons behind the data within this study, it would be beneficial to monitor and analyse the load across training and matches to see if any trends are found which can explain the results further.

PRACTICAL APPLICATIONS

Whilst this study found no effect of congestion on high-intensity GPS metrics, it is still important to consider that players are competing at high-intensity levels and may therefore remain at an increased risk of fatigue and injury. Consequently, the effective management of training loads and the development of players' tolerance to these demands are important to ensure that high-intensity physical performance is maintained and injury risk is minimised. However, the study found a number of positional differences highlighted in nearly all GPS metrics. Therefore, the individual monitoring of players, with particular reference to their playing position during congested periods, may lead to strategies such as squad rotation and fatigue monitoring which should be determined by position to optimise high-intensity physical performance during congestion.

CONCLUSION

This study set out to analyse the effects of fixture congestion on high-intensity acceleration, deceleration, and HMLD profiles; whilst also investigating the effects of position on GPS metrics and congestion. This study found that there was no impact of fixture congestion on any high-intensity GPS metric. Whilst there was not an effect within position, there were differences between position for congestion in that significantly greater outputs were

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shown in both congested and non-congested FWs compared to both congested and non-congested CBs in all GPS metrics apart from Num_{Acc}. In addition, there was a significant effect found for position within all GPS metrics, mainly that FWs had significantly higher loads than CBs. Coaches and sport scientists should utilise GPS metrics in training and matches to monitor high-intensity activities and help inform the decision-making regarding player selection and squad load management.

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CONFLICTS OF INTEREST

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