

THE INFLUENCE OF PLAYER POSITION DURING  
MATCH PLAY ON LOADING IN ELITE FEMALE  
SOCCER PLAYERS

By

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Bachelor of Science in Sports Science and Health

Dublin City University

Dublin, Ireland

2017

Submitted to the Faculty of the  
Graduate College of the  
Oklahoma State University  
in partial fulfillment of  
the requirements for  
the Degree of  
MASTER OF SCIENCE  
December, 2018

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## ACKNOWLEDGEMENTS

I would firstly like to say a huge thanks to my thesis advisor, Dr. Nathaniel Jenkins, who has guided me through every step of this thesis and who has always made time for helping me out over Skype, phone calls or emails despite his busy schedule and our 6-hour time difference. I would also like to thank my other thesis committee members, Dr. Douglas Smith and Dr. Bert Jacobsen for their help.

I want to thank the OSU track and field team for everything they have done for me, for making this masters possible through their funding and support, their contribution to my academics has been invaluable. I'd like to especially thank my event coach Zivile Zebarauskaite-Pukstiene and head coach Dave Smith for looking after me so well during my time at OSU.

Thank you to all of the staff in STATSports, Newry for providing me with equipment and subjects to carry out this study, without them, this study would not have been possible. I would especially like to thank Kate Keaney for her data collection and both Kate and Maeve Nethercott for their help in introducing me to the Linfield Ladies team, who served as the subjects for this study. A special thank you also to Barry Watters, Jason Black, Dave O'Donovan, Emmanuel Fajemilua and Mark Conrad Connor in STATSports for all of their sound advice on how to carry out this study and for helping me in several other aspects of this thesis, including sharing their existing knowledge of using the software and the current literature.

I'd like to express my thanks to all of the girls from Linfield Ladies Football team for agreeing to participate in this study and for all of the coaches' cooperation, especially Neil

Morrow, who has helped me massively through informing me on positional arrangements, to making sure I had a parking space and seat. He went above and beyond to make this data collection as simple as possible for me. Finally, I would like to express my profound gratitude to my parents for their continuous support and encouragement throughout my studies and always, none of this would have been possible without them, thank you.

Name: EMILY ROGERS

Date of Degree: DECEMBER, 2018

Title of Study: THE INFLUENCE OF PLAYER POSITION ON MATCH PLAY  
LOADING IN ELITE FEMALE SOCCER PLAYERS

Major Field: APPLIED EXERCISE SCIENCE

**Abstract:** This study aimed to examine the influence of player position on match play loading, determined by GPS and accelerometer data, in a team of elite female soccer players in Northern Ireland. Players (n=16) were divided into 3 positional groups: defenders (n=6, obs=12), midfielders (n=8, obs=18) and forwards (n=3, obs=6) and data was gathered over 5 matches. Total distance (TD), average and max speeds (AS and MS), accelerations and decelerations (ACC and DEC), high-speed running distance (HSRD), sprint distance and count (SD and SC), dynamic stress load (DSL), total load (TL), explosive distance (ED), high metabolic load distance (HMLD) and equivalent metabolic distance (EMD) data were collected for analysis. Midfielders and forwards covered a significantly further TD than defenders on average (14%,  $p < 0.001$ , and 13%,  $p = 0.006$ , respectively), they also recorded more SC (41%,  $p = 0.036$  and 76%,  $p = 0.003$ , respectively) and covered significantly further SD (57%,  $p = 0.020$  and 102%,  $p = 0.002$  respectively) than defenders did. Midfielders and forwards covered significantly more HSRD than defenders (31%,  $p = 0.025$  and 39%,  $p = 0.0125$ , respectively). Midfielders and forwards also had significantly faster average speeds than defenders (14%,  $p = 0.020$  and 15%,  $p = 0.002$ , respectively) and forwards had significantly faster max speeds than defenders (56%,  $p = 0.014$ ). Midfielders and forwards performed significantly more ACC than defenders (38%,  $p = 0.005$  and 48%,  $p = 0.009$ , respectively) and forwards performed significantly more DEC than defenders (48%,  $p = 0.028$ ). Midfielders and forwards covered greater HMLDs than defenders (34%,  $p < 0.016$ , and 61%,  $p = 0.001$ , respectively), and they also presented with significantly higher EMD values than defenders (15%,  $p < 0.001$  and 17%,  $p < 0.001$ , respectively). In contrast, there were no significant differences observed between any positional groups for DSL, TL, or ED. It is clear that elite soccer forwards and midfielders have similar workloads, which are greater than for defenders during match-play. The results of this study may be useful to coaches by giving them more information on positional differences in physiological demand during match play, which should be taken into consideration when designing and implementing training plans.

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## CHAPTER I

### INTRODUCTION

It is essential to understand the physical loading demands of match play in soccer in order for coaches to effectively design training programs specific to player position. It is well known that differences in activity profile in elite soccer are position dependent (Dalen, Jørgen, Gertjan, Geir Havard & Ulrik, 2016). The differences can be represented as estimates of external load metrics, calculated by different methods of player tracking such as GPS and accelerometer data collection, hand notations, video analyses and time motion analyses. It is important to note how different player positions influence the types of activities carried out, this is done by looking at a variety of match play loading metrics (acceleration, deceleration, sprints etc.). GPS units that are directly worn by players have been reported to have most reliability and validity of all player tracking methods (Tierney, Young, Clarke & Duncan, 2016). Their use has become increasingly popular since FIFA amended their rules to allow the use of wearable technology during match play in March, 2015 (Tierney et al., 2016).

Based on findings in the literature, mid fielders appear to cover the furthest distances overall during match play (~11.5 km). Forwards and wide midfielders cover the furthest distances during high speed running and sprinting activities and central backs appear to cover the least total distance and distance during high intensity activities (Baptista, Johansen, Seabra

& Pettersen, 2018). These studies investigated male soccer players. To date, there have been very few studies carried out to examine the differences in female soccer players' match play loading metrics per position.

Therefore, the aim of this study was to establish and compare the match play demands in three different player positions (forwards, defenders and midfielders) in a Northern Irish elite female soccer team using GPS and triaxial accelerometer data (Apex, STATSports, Newry, Northern Ireland).

## CHAPTER II

### REVIEW OF LITERATURE

#### **2.1. Global Positioning Systems (GPS)**

The use of GPS for training and match play in elite sports has become increasingly popular since March 2015, when FIFA amended their rules to allow the use of wearable technology (Tierney, Young, Clarke & Duncan, 2016). This allows for a more informed understanding of the physiological demands of elite level soccer players during match play (Akenhead, Hayes, Thompson & French, 2013). GPS is commonly used to quantify the total distance, accelerations, decelerations and speeds, among other metrics during match play and training (Dellaserra, Gao & Ransdell, 2014).

GPS units that are directly worn by players have been reported to have more reliability and validity than other methods of player tracking such as hand notations, video analyses, and time motion analyses (Tierney, Young, Clarke & Duncan, 2016).

#### **2.2. Determining Speed Zones**

##### **2.2.1 Dwyer & Gabbett, 2012**

The purpose of this study was to propose standard definitions for velocity ranges that were determined by an objective analysis of time-motion data. The researchers analyzed 25 GPS data files from 5 different sports: men's and women's field hockey, men's and women's soccer,

and Australian Football Rules. However, I have only summarized the findings for women's soccer, as these are most germane to my study. To determine the velocity ranges, the authors used a curve fitting process to determine the optimal placement of 4 Gaussian curves representing four different speed categories: walking, jogging, running, and sprinting.

The authors determined that a sprint should be classified as running over a speed of  $5.4 \text{ m}\cdot\text{s}^{-1}$  for at least 1 second, whereas a high-speed run should be classified as any running performed between speeds of  $3.4 - 5.3 \text{ m}\cdot\text{s}^{-1}$ . The authors also determined that an acceleration should be classified as an increase in speed  $> 2 \text{ m}\cdot\text{s}^{-2}$  and that a deceleration should be classified as a decrease in speed  $< 2 \text{ m}\cdot\text{s}^{-2}$ .

When performing at an elite level of soccer, it has been found that the ability to perform repeated bouts of high-speed running (HSR) is a key characteristic required of players (Drust, Atkinson & Reilly, 2007). HSR has been identified as an important contributor to the overall physical demands during a bout of exercise and it contributes heavily to fatigue (Gabbett & Ullah, 2012). Insufficient recovery from fatigue has been linked to increased risk of injury (Folgado, Duarte, Marques & Sampaio, 2015). It has also been found that rates of non-contact injury increase with busier match schedules (Arruda et al., 2015). Fatigue also effects the ability to perform repeated bouts of accelerations and decelerations during the latter stages of match play (Akenhead et al., 2013).

### **2.3. Loading Metrics**

PlayerLoad represents total body load, is expressed in arbitrary units (Scott, Lockie, Knight, Clark & Janse de Jonge, 2013), and is an accumulation of all data from all axes of a tri-axial accelerometer. This metric was created by Catapult Innovations, Melbourne, Australia. Specifically, PlayerLoad is “a modified vector magnitude expressed as the square root of the sum



of the squared instantaneous rates of change in acceleration in each of the three planes and divided by 100" (Barrett, 2017) and is strongly related ( $r=0.93$ ) to the total distance covered during soccer activities.

Similar to PlayerLoad, Total Load represents the accumulation of g forces a player encounters during an exercise bout, which includes running and any static activities that involve short distance accelerations and decelerations, such as rucking in rugby. The magnitude of the accelerometer values from a tri-axial accelerometer in the GPS unit are totalled, before being scaled by 1,000 to provide more manageable values. This metric is used by STATSports, Newry, Northern Ireland.

Dynamic Stress Load (DSL) measures impacts above 2 g based on convex curved g force ratings using an accelerometer (STATSports, Ireland). The key concept here is that an impact of 4 g is more than twice as hard on the body as an impact of 2 g (Gaudino et al., 2015).

Accelerations (Acc), Decelerations (Dec) and high speed running all combine to contribute to High Metabolic Load Distance (HMLD). These movements have been found to pose a higher physical stress on the players than high-speed running (HSR) alone. In turn, these movements are associated with a higher risk of injury (Chamari, 2004). Further evidence exists to show that when players become fatigued, especially from movements included in HMLD, the injury rate may be increased further (Kellmann, 2010). Accelerations and decelerations are also more energetically demanding than running at constant velocities. Even if an athlete is running at a low speed, if their acceleration is elevated, then there is a higher metabolic load imposed on that player (Rampinini, Coutts, Castagna, Sassi & Impellizzeri, 2007). Overall, there has been an increased focus on HMLD in soccer in recent years and it has become a widely used metric for position specific conditioning (Nevill, Holder & Watts, 2009).

## 2.4. Energy Cost and Metabolic Power

### 2.4.1. di Prampero, 2005

#### *Energy Cost of Accelerating and Decelerating*

Di Prampero discovered that accelerated running on flat ground is energetically equivalent to running up a hill at a constant speed. This is because when a person is accelerating, their body is at a similar angle to the ground as if the person was running upright, up a slope (terrain tilted upwards) at a constant speed. This means that accelerated running can be considered equivalent to running up an “equivalent slope” (ES) at a constant speed where  $ES = \tan(90 - \alpha)$ , where “ $\alpha$ ” represents the angle of the body to the terrain.

The average muscular force exertion during sprinting is greater than the simple body weight of the subject. This is represented by a ratio  $g'/g$ , called “equivalent mass” (EM). This represents an overload imposed on the athlete by the acceleration itself.

If the forward acceleration is known, then ES and EM can be determined. According to Minetti, Moia, Roi, Susta & Ferretti, 2002, “the energy cost (EC,  $J \cdot kg^{-1} \cdot m^{-1}$ ) of running uphill at constant speed is described by:  $EC = 155.4i^5 - 30.4i^4 - 43.3i^3 + 46.3i^2 + 19.5i + 3.6$  where “ $i$ ” is the incline of the terrain, and “ $3.6 (J \cdot kg^{-1} \cdot m^{-1})$ ” is the EC of running at constant speed on flat compact terrain”. The “ $i$ ” in this equation can be replaced by “ES” and this will give us the energy cost (EC) of accelerated running. The overall cost is then multiplied by EM, so the equation for obtaining the EC of accelerated running is as follows “ $EC = (155.4ES^5 - 30.4ES^4 - 43.3ES^3 + 46.3ES^2 + 19.5ES + 3.6)EM$ ”. The Metabolic power (P) can then be determined by multiplying the EC by running speed (v) as follows  $P = EC(v)$ .

#### **2.4.2. Osgnach, Poser, Bernardini, Rinaldo & Di Prampero, 2010**

The aim of this study was to propose a new approach for the assessment of the metabolic demands of male soccer players by using the algorithms described by di Prampero (2005) and to compare the results with those of traditional video match analysis.

Data was collected from 56 matches in the 2007-2008 soccer season, from the Italian “Serie A” (first division). Data was collected at 25 Hz using a multiple camera match analysis system, SICS (Bassano del Grappa, Italy). All of these matches were played in either the Mezza Stadium in Milan or the Franchi Stadium in Florence. A total of 399 players from 20 different teams were evaluated (mean  $\pm$  SD; age = 27  $\pm$  4 yrs., mass = 75.8  $\pm$  5.0 kg, stature = 1.80  $\pm$  0.06 m). The performance of each athlete was assessed by looking at three parameters: speed, acceleration, and power. The following parameters were also calculated (using the equations to estimate energy cost and metabolic power by di Prampero) to reach a better understanding of the performance of soccer players: Equivalent Distance, Equivalent Distance Index. and Anaerobic Index.

##### *Speed*

Six speed categories were used in this study: walking (W; 0 – 8 km·h<sup>-1</sup>), jogging (J; 8 – 13 km·h<sup>-1</sup>), low-speed running (LSR; 13 – 16 km·h<sup>-1</sup>), intermediate-speed running (ISR; 16 – 19 km·h<sup>-1</sup>), high-speed running (HSR; 19 – 22 km·h<sup>-1</sup>) and max-speed running (MSR; > 22 km·h<sup>-1</sup>). Overall, the players covered 40.9% of their total distance in the W speed category, 28.3% in J, 12.8% in LSR, 8.3% in ISR, 4.9% in HSR and 4.8% in MSR.

##### *Accelerations and Decelerations*

Eight acceleration categories were used: max deceleration (MD; < - 3 m·s<sup>-2</sup>), high deceleration (HD; -3 – -2 m·s<sup>-2</sup>), intermediate deceleration (ID; -2 – -1 m·s<sup>-2</sup>), low deceleration

(LD;  $-1 - 0 \text{ m}\cdot\text{s}^{-2}$ ), low acceleration (LA;  $0 - 1 \text{ m}\cdot\text{s}^{-2}$ ), intermediate acceleration (IA;  $1 - 2 \text{ m}\cdot\text{s}^{-2}$ ), high acceleration (HA;  $2 - 3 \text{ m}\cdot\text{s}^{-2}$ ) and max acceleration (MA;  $> 3 \text{ m}\cdot\text{s}^{-2}$ ). Overall, the players covered 1.7% of their total distance in the MD, 3.7% in HD, 10.7% in ID, 35% in LD, 32.8% in LA, 10.7% in IA, 3.7% in HA, and 1.6% in MA categories.

### *Power*

Five categories were used for power: low power (LP;  $0 - 10 \text{ W}\cdot\text{kg}^{-1}$ ), intermediate power (IP;  $10 - 20 \text{ W}\cdot\text{kg}^{-1}$ ), high power (HP;  $20 - 35 \text{ W}\cdot\text{kg}^{-1}$ ), elevated power (EP;  $35 - 55 \text{ W}\cdot\text{kg}^{-1}$ ) and max power (MP;  $> 55 \text{ W}\cdot\text{kg}^{-1}$ ). Time, distance, and estimated net (above resting) energy expenditure were then quantified in each category. Overall, the players estimated energy expenditure (EEE) for the LP category during the match was  $4.54 \pm 0.29 \text{ kcal}\cdot\text{kg}^{-1}$ , in IP their EEE was  $3.92 \pm 0.56 \text{ kcal}\cdot\text{kg}^{-1}$ , in HP their EEE was  $2.84 \pm 0.57 \text{ kcal}\cdot\text{kg}^{-1}$ , in EP their EEE  $1.67 \pm 0.39 \text{ kcal}\cdot\text{kg}^{-1}$ , and in MP their EEE was  $1.63 \pm 0.53 \text{ kcal}\cdot\text{kg}^{-1}$ .

### *Equivalent Distance*

Equivalent distance (ED) represents the distance that an athlete would run at a steady pace, based off how much energy they expend over an exercise period. The equation takes into account that an acceleration, deceleration, and any high speed running uses a significant amount more energy than steady state running (Edwards & Clark, 2006). In this study, the mean ED (of all players) was  $13,166 \pm 1415 \text{ m}$ .

### *Equivalent Distance Index (EDI)*

This is the ratio between Equivalent Distance and actual Total Distance Covered in a match. The mean EDI of all players was  $1.20 \pm 0.03$ .

### *Anaerobic Index (AI)*

This is the ratio between energy expenditure above a certain metabolic threshold (TP) and energy expenditure over the whole match. The certain metabolic threshold is decided by the investigator, for example they might choose a power output corresponding to a  $VO_2^{\max}$  or to an anaerobic threshold. The mean AI of all players was  $0.18 \pm 0.03$ .

### *Conclusion on the New Approach to Using Energy Cost and Metabolic Power in Analysis of Player Performance*

The researchers concluded that the present approach obtains results of higher intensities in soccer than the traditional video match analysis. They explained this through an example: consider a speed threshold of  $16 \text{ km}\cdot\text{h}^{-1}$ , the distances covered over this threshold in most studies, including this one, are found to amount to about 18% of the player's TD. If they use their equation to estimate the metabolic power of running at  $16 \text{ km}\cdot\text{h}^{-1}$ , it is found that:

$$P = ECvKT = 3.6 \times 4.44 \times 1.29 = 20 \text{ W}\cdot\text{kg}^{-1}$$

“where P is expressed in watts per kilogram ( $\text{W}\cdot\text{kg}^{-1}$ ), v is expressed in meters per squared second ( $\text{m}\cdot\text{s}^{-2}$ ), EC is expressed in joules per kilogram per meter ( $\text{J}\cdot\text{kg}^{-1}\cdot\text{m}^{-1}$ ), and the factor 1.29 is introduced to take into account the terrain characteristics (soccer field vs. compact terrain)”.

They suggested that, if instead of considering the speed threshold ( $16 \text{ km}\cdot\text{h}^{-1}$ ) as such, the corresponding metabolic power ( $20 \text{ W}\cdot\text{kg}^{-1}$ ) is considered, then the TD covered at a power exceeding this threshold amounts to 26% instead of 18%, and the corresponding EEE would amount to about 42% of the total.

From this, the authors also suggested that the profile of a soccer player can be analyzed using the additional parameters identified above rather than the traditional ones. The total energy expenditure can be expressed as ED rather than TD, where ED takes into account both TD and *how* that TD was covered, taking into account that changing speed and/or running faster requires more energy than steady state running. The authors found that ED is linearly related to TD, but that ED is approximately 20% greater and that the relationship does vary dependent on the individual player. Specifically, the authors stated that 'lazy players' EDI is approximately 1.15 and that more dynamic players have an EDI of roughly 1.30.

## **2.5. GPS Load Monitoring in Elite Male Soccer Players**

### **2.5.1. Baptista, Johansen, Seabra & Pettersen, 2018**

A study carried out by Baptista et al. in 2018 examined the differences in physical profiles of elite soccer players across playing-positions. There were 18 players ( $25.2 \pm 4.4$  years;  $76.2 \pm 6.4$  kg;  $181.6 \pm 5.6$  cm; in age, body mass and height, respectively) involved in this study, categorized as 3 central backs, 5 full-backs, 6 central midfielders, 3 wide midfielders, and 4 central forwards. The data was collected over 23 official home matches, over 2 seasons, from a professional soccer club. This gave a total of 138 observations. The team used a mixture of 4-5-1 or 4-3-3 (defenders/ backs, midfielders, forwards/ strikers) tactic formations. A ZXY Sport Tracking System was used to collect the data.

#### *Accelerations and Decelerations*

They defined an acceleration (acc) by having met 4 criteria: 1) the start of the acc is marked by that acc reaching the minimum limit of  $1 \text{ m}\cdot\text{s}^{-2}$ , the acc must reach the acc limit of  $2 \text{ m}\cdot\text{s}^{-2}$ , 3) the acc must remain above the  $2 \text{ m}\cdot\text{s}^{-2}$  for a minimum of 0.5 seconds and 4) the acc ends when the speed drops below the min acc limit, defined earlier as  $1 \text{ m}\cdot\text{s}^{-2}$ . The researchers

in this study looked at both acc count and work rate and dec count and work rate, where work rate was defined as the acc or dec in  $\text{m} \cdot \text{min}^{-1}$  and a count was simply any acc or dec that met the minimum criteria.

All positions performed more acc counts than dec counts, except for CB. The patterns were similar between acc and dec work rate, where full backs (FB), wide midfielders (WM), and centre forwards (CF) performed more than centre backs (CB) and centre midfielders (CM). The most significant difference for dec was between CB ( $3.5 \pm 0.7$ ) and CF ( $5.3 \pm 1.0$ ), ( $p < 0.001$ ). WM had significantly higher values ( $76.7 \pm 12.1$ ;  $86.1 \pm 14.7$ ) for acc and dec counts than CB ( $64.9 \pm 9.7$ ;  $61.5 \pm 10.8$ ) and CM ( $65.8 \pm 15.6$ ;  $71.5 \pm 20.6$ ). CB and CF also presented lower counts than WM.

#### *Sprints and High Intensity Running (HIR)*

HIR was defined as any running at a speed of  $19.8 \text{ km} \cdot \text{h}^{-1}$  or faster. A sprint was defined as any distance covered running at a speed of  $25.2 \text{ km} \cdot \text{h}^{-1}$  or faster. These metrics were looked at in terms of work rate and in terms of counts. Work rate was measured in meters per minute and counts were measured as the amount of times HIR or a sprint was performed. HIR counts were divided into different categories by distance i.e. 1-5m, 6-10m, etc. to 46-50m.

CB had the lowest values of all positions in both HIR work rate and sprint work rate. The most pronounced difference from these variables was that between CB ( $0.9 \pm 0.5 \text{ m/min}$ ) and CF ( $2.5 \pm 1.0 \text{ m/min}$ ) for sprint work rate.

Looking at HIR, CF presented the highest values of all positions in the 26-30m category. Distances of 36-40m and 46-50m were covered most times by FB ( $1.7 \pm 1.4$ ;  $0.9 \pm 1.0$ ). CB had the lowest counts for the longer distances (36-40m and 46-50m) ( $0.8 \pm 0.9$ ;  $0.2 \pm 0.6$ ). The

distance of 1-5m was the most frequently covered distance by CB, CM, WM and CF. FB's most frequently covered distance was 6-10m. This shows that player position did have a significant influence on different distances covered in HIR.

Regarding sprint distance, CB, FB, CM and WM presented higher counts of 1-5m sprints and CF performed more 6-10m sprints.

### *Conclusion*

This study found that there was a significantly higher work rate for wide positions in HIR, acc and dec, but not in sprints, than central players. The counts for wide positions were also higher, but not significantly higher than that for the central position players (excluding CF). The researchers speculated that this may be due to the differences in wide versus central playing positions, where there may be a lack of space for the central positions to reach sprinting velocity. Also, the fact that the wider players participate in both defensive and offensive match play could be a potential reason for presenting higher numbers of sprints. This study concluded that CF is the most physically demanding position as they covered the furthest distance of all positions in HIR, sprints, acc, and dec.

### **2.5.2. Dalen, Jørgen, Gertjan, Geir Havard & Ulrik, 2016**

The aim of this study was to gather information on players' match load using triaxial accelerometer data and time-motion analysis. They looked specifically at acc and dec and their contribution to the players' total match load. The data was gathered from 45 domestic home games (Rosenborg FC) over the course of 3 seasons (2009-2011). The sample comprised 8 CD, 9 FB, 9 CM, 7 WM and 5 attackers (age range:  $25.38 \pm 4.73$  years)



The players' movements were recorded by small body worn sensors. The data was transferred to 10 RadioEye sensors (ZXY SportTracking AS, Radionor Communications AS), which were mounted on the team's home arena. The player's movements were registered at 20 Hz.

#### *Total Player Load*

The highest player load per positions' means over a full match were as follows in descending order: WM (15,113), CM (14,128), CD (13,423) attackers (12,957) and FB (11,955). CD, CM, WM, and attackers had higher player loads by 12, 18, 26 and 8% respectively than FB. WM had 13% higher player loads than CD and 17% higher player loads than attackers. CM had 9% higher player loads than attackers. When first and second halves were looked at individually, they demonstrated similar patterns as over a full match between player's positions'. There was approximately a 5% decrease in player load across all positions from the first to the second half.

#### *Accelerations and Decelerations*

The mean accelerations per player position in descending order of counts for the full match are as follows: WM (87), FB (85), CM (74), attackers (74) and CD (61). Looking at the full match data, WM and FB accelerated more often than CD (by 43 and 39%), CM (by 18 and 15%) and attackers (by 18 and 15%). Accelerations contributed to total player load for CD, FB, CM, WM and attackers by 8, 8, 7, 10 and 9% respectively.

The mean decelerations per player position in descending order of counts for the full match are as follows: FB (62), WM (60), attackers (59), CM (49) and CD (40). Looking at the full match data, CD and CM had lower counts of decelerations than FB (by 55 and 27%, respectively), WM (by 50 and 22%, respectively), and attackers (by 48 and 20%, respectively). Decelerations contributed to total player load for CD, FB, CM, WM, and attackers by 5, 7, 5, 6, and 7% respectively.

### *Total Distance*

During a full match, on average, players covered a total distance of  $10,200 \pm 785\text{m}$ . When looking at high-intensity activities (locomotion  $\geq 19.8 \text{ km}\cdot\text{h}^{-1}$  or sprinting and high-speed running) there was a noticeable difference covered between player positions. FB's and WM's had further high-intensity running distances than CD, CM and attackers by  $>230$ ,  $>48$  and  $>40\%$  respectively. The distance covered in high-intensity running by CD was shorter than any of the other playing positions.

### *Conclusions*

The researchers in this study found limitations in using only speed and distance variables to accurately show the physical demands of soccer players. They went on to explain that this is because high-intensity bouts “such as jumping, tackling, collisions, accelerations and decelerations (duration  $<0.5$  seconds), passing, shooting, and unorthodox movements (sideways and backward running)” can be classified as low-speed activities, even though they pose a high physical strain on the player.

### **2.5.3. Tierney, Young, Clarke & Duncan, 2016**

The primary purpose of this study was to look at the variations in movement patterns during match play, gathered by GPS (STATSports, Newry, Ireland), across the 5 most common soccer playing formations (4-4-2; 4-3-3; 5-5-2; 3-4-3; 4-2-3-1). Another aim of this study was to examine the match play demands for the different playing positions employed in the various formations. 46 elite level, full-time professional soccer players from a professional soccer club participated in this study (mean age  $20 \pm 3$  years, height of  $179 \pm 5$  cm, body mass of  $79.5 \pm 6.3$  kg and estimated body fat percentage of  $6.9 \pm 1.5\%$ ). This sample was broken down into 5 player position groups: 10 WD, 9 CD, 9 WM, 10 CM, and 8 forwards (FW). The GPS units gathered data

at 10 Hz. 10 Hz has been previously identified as a better method of data collection than 15 Hz (Johnston, Watsford, Kelly, Pine & Spurrs, 2014) or 1-5 Hz devices (Portas, Harley, Barnes & Rush, 2010). This GPS unit has also been found to be superior in comparison to other available brands as it has a reduced error of measurement (Marathon Performance, 2014). The metrics used in the comparison of player positions' load were total distance (TD), high-speed running (HSR), high metabolic load distance (HMLD), accelerations (acc) and decelerations (dec). The thresholds employed for each of these metrics were chosen by adopting what the previous research found to be of the most value during match play (Akenhead et al., 2013; Barnes, Archer, Hogg, Bush & Bradley, 2014).

#### *Total Distance*

In terms of means, WM covered the furthest TD (10,523m) followed by FW (10,502m), CM (10,395m), WD (10,152m) and CD (9,669m). The researchers found that there were significant differences between playing position and TD. They carried out Bonferroni post hoc analysis to see where these differences lay, and their findings were as follows: "CD had lower TD values compared to WD ( $p = 0.038$ ;  $d = 0.91$ ), WM ( $p = 0.002$ ;  $d = 0.74$ ), CM ( $p = 0.001$ ;  $d = 0.59$ ) and FW ( $p = 0.042$ ;  $d = 0.79$ )."

#### *Accelerations and Decelerations*

For an acc or dec to be recorded, the players had to accelerate or decelerate at a rate of  $\geq 3 \text{ m/s}^2$ . There were no significant differences found between playing positions and acc and dec. WM covered the highest number of dec and FW covered the highest number of acc.

#### *High Speed Running*

In this study, HSR was defined as any running equal to or above 19.8 km/h (m). In terms of means of means, FW covered the furthest HSR distance (690m), followed by WD (660m), WM

(636m), CM (429m), and CD (396m). Bonferroni post hoc analysis showed where significant differences in playing positions lay here as follows: “CD had lower values compared to WD ( $p = 0.001$ ;  $d = 2.07$ ), WM ( $p = 0.001$ ;  $d = 0.49$ ) and FW ( $p = 0.001$ ;  $d = 1.48$ ) (CM had lower values compared to WD ( $p = 0.001$ ;  $d = 1.34$ ), WM ( $p = 0.001$ ;  $d = 0.19$ ) and FW ( $p = 0.001$ ;  $d = 1.00$ ).”

#### *High Metabolic Load Distance*

HMLD is defined as all HSR plus any acc or dec above  $2 \text{ m.s}^2$ . In terms of means, FW had furthest HMLD (2476m), followed by WM (1912m), WD (1850m), CM (1781m), and CD (1527m). Bonferroni post hoc analysis showed where significant differences in playing positions lay, as follows: “CD had significantly lower values compared to WD ( $p = 0.001$ ;  $d = 1.35$ ), WM ( $p = 0.001$ ;  $d = 1.10$ ), FW ( $p = 0.001$ ;  $d = 1.21$ )) and CM ( $p = 0.002$ ;  $d = 0.66$ ). CM also had significantly lower values compared to WM ( $p = 0.037$ ;  $d = 0.23$ ) but higher values compared to FW ( $p = 0.05$ ;  $d = 0.43$ ).”

#### *Conclusion*

WM and FW showed the highest work rates over all. WM had the greatest number of dec and covered the furthest HMLD and TD. FW had the greatest number of acc and covered the furthest HSR distance.

#### **2.5.4. Brito, Roriz, Silva, Duarte & Garganta, 2017**

The purpose of this study was to investigate the effect of pitch surface on the types of technical actions performed and on the running activity profiles of young soccer players. Another aim of this study was to find whether playing position had an influence on the technical actions and running activities performed.

There was a total of 66 U14 males involved in this study (age:  $13.4 \pm .5$  years; height:  $161.82 \pm 7.52$  cm; body mass;  $50.79 \pm 7.22$  kg). Participants were selected if they and their teams were registered at the Porto Football Association championship. All participants in this study were at the same competitive level (regional-level and  $3.5 \pm 1.4$  years training experience). This group of 66 was divided into 3 teams of 22. Data was collected over 3 weeks, where each team played one game every Sunday, giving a total of 9 matches performed. The formation used was a 1-4-3-3, there were 12 CD, 6 CF, 18 CM, 12 WM and 12 FB.

Each player wore a GPS tracking device (Qstarz, Model: BT-Q1000eX) on their upper back (positioned using a harness) which recorded their 2D positional co-ordinates (sampling frequency rate 10Hz). Metrics investigated included Low Intensity Running (LIR), High Intensity Running (HIR), Very High Intensity Running (VHIR), Sprinting and Very High Intensity Activities (VHIA). The thresholds and ranges for these metrics were adapted from previous studies by Buchheit et al., 2010.

#### *Total Distance*

CM displayed the highest TD of all of the positions (3,234.08m), followed by WM (3,022.91m), FB (2,912.26m), CF (2,843.20m) and CD (2,718.86m). The CM's highest TD was associated with the highest amount of LIR also. CD covered the lowest TD. The difference in TD across playing positions was significant. The highest level of significance was found when players were on the dirt field surface.

#### *Low Intensity Running*

LIR was classified as any running performed at a speed below  $13.0 \text{ km.h}^{-1}$ . CM covered the highest amount of LIR (2,599.86m), followed by WM (2,316.61m), CD (2269.03m), CF

(2234.93m) while FB covered the least amount (2,226.53m). The difference in LIR across playing positions was significant.

#### *High Intensity Running*

HIR was defined as any running performed between the speeds of 13.1 – 16 km.h<sup>-1</sup>. CM covered the highest amount of HIR (367.89m), followed by WM (362.18m), FB (348.05m), CF (293.24m), while CD covered the least (233.93m). The difference in HIR across playing positions was significant.

#### *Very High Intensity Running*

VHIR was classified as any running performed at a speed over 19.1 km.h<sup>-1</sup>. FB presented the furthest distance for VHIR (182.41m) and CD had the shortest VHIR distance (121.31m). The difference in VHIR across playing positions was not significant.

#### *Sprinting*

Sprinting was defined as any running above the speed of 19.1 km.h<sup>-1</sup>. CF presented with the highest Sprinting distance (95.63m) and CD presented with the lowest (49.18m). The difference in Sprinting across playing positions was not significant.

#### *Very High Intensity Activities*

This metric is calculated by combining VHIR plus Sprinting. WM presented the highest value for VHIA (318.68m), whereas CD presented the lowest value (200.44m). The difference in VHIA across playing positions was not significant.

### **2.5.5. Gomez-Piriz, Jiménez-Reyes & Ruiz-Ruiz, 2011**

The aims of this study were 1) to assess the validity of total body load (TBL), collected by GPS units (SPI Elite; GPSports Systems), in quantifying soccer training load assessing its

relationship with session rates of perceived exertion (session-RPE) and 2) to examine the differences in session-RPE and TBL between player positions in soccer, where 22 professional soccer players “(Spanish first division, Real Club Recreativo de Huelva, season 2007–2008; 26.74 ± 4.2 years; height 179.74 ± 4.04 cm; weight 73.7 ± 3.35 kg)” were divided into defenders, midfielders and forwards for analysis.

Data was collected from 13 training sessions, which comprised mainly small-sided games (5, 6, 7 or 8 players on each side) on various sized pitches (“rectangular pitches had playing areas ranging from 1,785 m<sup>2</sup> (52.5 ± 34 m) to 5,440 m<sup>2</sup> (80 ± 68 m)”). Each game lasted about 20 minutes.

Session-RPE was determined using the 21-point scale and multiplying the player’s session-RPE by the number of minutes spent in the session. GPS data was recorded at 1 Hz and a calculation was made in the GPSports software to give TBL. There were transmission issues from six of the GPS data, so a total of 124 data were used for analysis.

The accelerometer in the GPS unit gathered the following data in “g-forces”, which is what was used in the calculation of TBL: “5–6g: light impact, hard acceleration, deceleration, or change of direction; 6–6.5 g: light to moderate impact (player collision, contact with the ground); 6.5–7g: moderate to heavy impact (tackle); 7–8 g: heavy impact (tackle); 8–10g: very heavy impact (scrum engagement, tackle); and 10+g: severe impact, tackle, or collision”.

During each training session, TBL and session-RPE data were collected from 10 players who were randomly selected (made up of defenders, midfielders and forwards).

A one-way ANOVA was used to examine any differences in session-RPE or TBL between player positions.

### *Total Body Load*

In terms of means, the midfielders had the highest value for TBL (153,998.5 au), followed by defenders (124,100.5 au), with forwards having the lowest value (107,554.3 au). The researchers found that there was no significant difference between playing positions in terms of session-RPE ( $F(2,19) = 0.15$ ,  $p = 0.86$ ,  $\eta^2 = 0.03$ ) or TBL ( $F(2,19) = 0.28$ ;  $p = 0.76$ ,  $\eta^2 = 0.03$ ).

### *Session-RPE*

They also found that session-RPE only accounted for 5% of the variance in TBL, despite the linear regression analysis revealing that session-RPE was a significant predictor of TBL ( $\beta = 0.23$ ,  $p = 0.05$ ). This finding suggested that a TBL is not a valid metric in quantifying training load in soccer.

### **2.5.6. Martín-García, Gómez Díaz, Bradley, Morera & Casamichana, 2018**

The two aims of this study were to a) measure the external load of a soccer team across playing positions and relative to competition for a structured microcycle and b) examine the variation in loading between players with game time versus those without game time, the day after a competition. Both training data (42 weeks) and match data (37 matches) were collected, using GPS (10 Hz Viper Pod, 50 gr, 88 x 33 mm; STATSports Viper; Northern Ireland), from 24 professional soccer players (age;  $20 \pm 2$  years, body mass;  $70.2 \pm 6.1$  kg, and stature;  $1.78 \pm 0.64$  cm; all measurements mean  $\pm$  SD) belonging to the reserve squad of a Spanish La Liga club during the 2015/2016 season. The team played in a 4-3-3 formation and players were split in groups by position, where there were 3 central defenders (CD), 6 fullbacks (FB), 3 midfielders (MF), 5 offensive midfielders (OMF), and 7 forwards (FW).



Training weeks were only included where players had 6 days between matches and where the training week was composed of 5 training sessions which were clearly focussed on an upcoming match. Training load data was analysed in respect to the amount of days pre- or post-match (MD + or -).

### *Overall Results*

Training load metrics were found to decline as match day approached. On MD + 1, players who had not played in the match showed greater training load metrics than those who did play. Accelerations and decelerations during training exceeded 50% of those performed during competition. Full backs performed the highest HSR and Sprint distances out of all players. “The data demonstrate that the external load of a structured microcycle varied substantially based on the players training day and position”

## **2.6. Time-motion Analysis Load Monitoring in Elite Male Soccer Players**

### **2.6.1. Lago-Peñas, Rey, Lago-Ballesteros, Casais & Domínguez, 2009**

This study aimed to examine the differences in work rate profiles and exercise patterns between different playing positions in elite male soccer players. Data was collected over 18 Spanish Premier League matches during the 2005/2006 season, using Amisco Pro®, version 1.0.2, Nice, France. 20 players were observed during each match (all players from each team, excluding the 2 goalkeepers). Movements of each player were observed using 8 synchronized cameras mounted around each stadium (the sampling frequency was at 25 measures a second). Players were only included in the analysis if they played the full 90 minutes of the match. A total of 127 players total were profiled in this study one time each. The metrics that were used in the analysis were as follows: distance covered, time spent in 5 different intensity categories (0–11 km.h<sup>-1</sup> (standing, walking, jogging); 11.1–14 km.h<sup>-1</sup> (low speed running); 14.1–19 km.h<sup>-1</sup>

(moderate-speed running); 19.1–23 km.h<sup>-1</sup> (highspeed running); > 23 km.h<sup>-1</sup> (sprinting)), and the frequency of occurrence for each activity for the players in different positions. These metrics were analysed using the following software: Athletic Mode Amisco Pro®, Nice, France. The players were divided into 5 different playing positions, where there were 31 central defenders (CD), 38 external defenders (ED), 27 central midfield players (CM), 16 external midfield players (EM) and 15 forwards (F).

An ANOVA was used to examine any differences between playing positions and the different metrics and a Bonferroni post hoc test was used to identify exactly where those differences lay. A Student's paired t-test was used to examine any difference between halves.

#### *Distance*

The average distance covered regardless of playing position was 10,943m. EM covered the furthest distance in terms of means (11,659m), followed by CM (11,541m), ED (11,056m), F (10,626m), with CD covering the least distance (10,070m). CM and EM covered significantly greater distances than CD and F. CD covered a significantly shorter distance than ED, EM, and CM. F did cover a further distance than CD but that difference was not significant.

#### *Distance Covered in Different Work Intensities*

All players covered most of their distance in the 0-11km/h category and there was no significant difference found between playing positions. There were no statistical differences found when comparing the mean of all players' distances between first half and second half in this intensity category.

In the 11.1-14km/h (low-speed running) category, in terms of means, CM covered the furthest distance (1,809m), followed by EM (1,702m), ED (1,568m), F (1,462m), with CD covering

the least distance (1,336m). When the average of all players' distance covered in this intensity category was compared between halves, it was found that there were significant differences in distance covered from the first half (812m) to the second half (754m).

In the 14.1-19km/h (moderate-speed running) category, in terms of means, EM covered the furthest distance (1,999m), followed by CM (1,975m), ED (1,654m), F (1,629m), with CD covering the least distance (1,238m). When the average of all players' distance covered in this intensity category was compared between halves, it was found that there were significant differences in distance covered from the first half (860m) to the second half (801m).

In the 19.1-23km/h (high-speed running) category, in terms of means, EM covered the furthest distance (682m), followed by ED (579m), F (566m), CM (540m), with CD covering the least distance (333m). When the average of all players' distance covered in this intensity category was compared between halves, it was found that there were no significant differences in distance covered from the first half (269m) to the second half (253m).

In the > 23km/h (sprinting) category, in terms of means, EM covered the furthest distance (490m), followed by F (340m), ED (304m), CM (219m), with CD covering the least distance (184m). When the average of all players' distance covered in this intensity category was compared between halves, it was found that there were no significant differences in distance covered from the first half (137m) to the second half (147m).

At all work intensities higher than 11km/h, CD covered significantly shorter distances than all other playing positions, with exception of the > 23km/h category, where CD did not cover significantly less distance than CM players. At the 11.1-14km/h intensity category, different subgroups showed significant differences, with the exception of that between ED and

F. There were also no significant differences found between ED and F in all other intensity categories.

### **2.6.2. Bloomfield, Polman & O'Donoghue, 2007**

The aim of this study was to compare physical demands during match play between three different positions during English Football Premier League soccer. There were 55 players involved in this study (18 defenders, 18 midfielders, 19 strikers), from 12 different English FA Premier League clubs during the 2003-2004 season. The players involved were experienced professional soccer players and had a mean number of  $36.35 \pm 25.21$  international appearances for their own nations prior to this study.

'PlayerCam' Service was used to record players' movements from a clear elevated position. This service used a camera to focus on a single player for 15-minute periods, 6 times during a 90-minute match i.e. one player was observed for 0-15min, another player was observed for 15-30min etc., giving observations for 6 different players for each match, for 15 minutes each. Sky Sports chose which players were observed for each match. Players were only included in the analysis if they completed the entire 15 minutes of the PlayerCam period and if they played the match from start to finish. The computerised time-motion analysis was carried out by the "Observer system Version 5.1 (Noldus Information Technology, The Netherlands)", to analyse purposeful movement (PM) of the players, defined by the 'Bloomfield Movement Classification' (BMC). The BMC included behaviours and modifiers of the behaviours. Behaviours were timed (and included Sprint, Run, Shuffle, Skip, Jog, Walk, Stand Still, Slow Down, Jump, Land, Dive, Slide, Fall and Get Up) or instantaneous (which included activities where the player Stopped, Swerved or engaged in an Impact, and also any on the ball activity including Receiving, Passing, Shooting, Dribbling, Tackling, Tricking and Other). The modifiers broke these different

activities down into more specific categories such as intensity, direction, turn (left or right), among other categories.

### *Findings*

Defenders carried out the most jogging, skipping and shuffling of all positions. They also spent significantly less time during sprinting and running activities than the other playing positions. They spent a significantly greater proportion of their PM time moving backwards than the other positions did. Midfielders spent most of their time running and sprinting and spent significantly less time standing still and shuffling than the other positions. They performed significantly less turns than the other positions. Both strikers and midfielders had a high level of possession action and similar amounts of sprinting, however the strikers performed a significantly higher amount of shuffling activities than midfielders.

Strikers and midfielders performed significantly more 'other' type activities, which included "jumping, landing, diving, sliding, slowing down, falling and getting up". Strikers performed the most of these movement out of all positions.

## **2.7. Time-motion Analysis Load Monitoring in Elite Female Soccer Players**

### **2.7.1. Mara, Thompson, Pumpa & Morgan, 2017**

This study aimed to determine profiles of high-speed running and sprinting for elite female soccer players during match play. Another aim of this study was to explore the positional differences present during high-intensity activities.

There were 12 elite female soccer players involved in this study "(age,  $24.3 \pm 4.2$  years; height,  $171.9 \pm 5.1$  cm; body mass,  $65.3 \pm 5.1$  kg)". Players were divided into positional groups for analysis "(central defenders (CD) = 3, wide defenders (WD) = 2, midfielders = 3, central attackers (CA) = 1, and wide attackers (WA) = 3)". Data was collected over 7 competitive

matches during a Women's National League competition (Australian national league). Only players who played the full match were included in the analysis. The formation used for all matches was 4-3-3.

The Optical Player Tracking system was used to collect data on each player. This system used eight cameras (Legria HF R38; Canon, Tokyo, Japan) that were fixed around the soccer field, each camera giving a different vantage point. When all camera views were combined, the whole field could be viewed simultaneously. The Optical Player Tracking system detected the position of each player at every video frame (25 frames per second) in the match using x and y coordinates. Post-match analysis was carried out using this systems software (Optical Player Tracking; Australian Institute of Sport, Canberra, Australia). The system used algorithms to detect player movement using video footage. Different work-rate variables were presented in this way (using algorithms applied to time and field coordinates), including total distance covered and distances covered at different speeds. An ANOVA was carried out to determine if there were any differences between positional groups and a Bonferroni post hoc analysis was performed to identify where the differences lay.

#### *Total Distance (TD)*

All players covered a further TD in the first half compared to the second half. There were significant differences observed in TD between playing positions. CD covered the least TD of all positions ( $9,220 \pm 590$  m), this difference was significant when compared to midfielders ( $10,581 \pm 22$  m), WA ( $10,472 \pm 878$ m) and WD ( $10,203 \pm 568$  m). CA covered  $9,661 \pm 602$ m, which was the second shortest TD of all playing positions but was not significantly less than CD.

### *High Speed Running (HSR)*

HSR was defined as any running between speeds of 3.4–5.3 m.s<sup>-1</sup>. All players covered a further HSRD in the first half (202 ± 49) compared to the second half (174 ± 45).

CD covered the least HSRD (1,772 ± 439m). This difference was significant when compared to midfielders (2,761 ± 417 m), WA (2,917 ± 545 m), and WD (2,569 ± 612 m). CA covered 2,420 ± 405m, which was the second shortest HSR of all playing positions but was not significantly less than CD.

There was a significant variation in time spent between repeat high-speed runs between different playing positions. CD spent the longest amount of time on average between high-speed runs (18.6 ± 5.0 seconds), compared to WD (13.2 ± 3.3 seconds), midfielders (11.9 ± 2.2 seconds), and WA (11.1 ± 2.4 seconds).

The number of repeat high-speed runs did differ significantly between playing positions. CD performed the least amount of high-speed efforts (209 ± 71) compared to midfielders (334 ± 75) and WA, who completed the highest number of high speed efforts (360 ± 75).

### *Sprint Distance (SPRD)*

A sprint was defined as any running performed above a speed of 5.4 m.s<sup>-1</sup>. All players covered a further SPRD in the first half (38 ± 16) compared to the second half (32 ± 14).

CD covered the least SPRD (417 ± 116m) compared to CA (841 ± 238 m), WA (850 ± 178 m), and WD (680 ± 278 m).

The average time between repeat sprints varied significantly between playing positions. CD spent more time between sprints on average (121.5 ± 43.9 seconds;  $p = 0.002$ ; partial  $\eta^2 =$

0.340) compared to CA ( $68.9 \pm 25.9$  seconds), WA ( $59.1 \pm 13.8$  seconds), and CD ( $77.5 \pm 27.6$  seconds) but not midfielders ( $85.9 \pm 33.7$  seconds;  $p = 0.162$ ).

## **2.8. GPS Load Monitoring in Elite Youth Male Soccer Players**

### **2.8.1. Gonçalves, Figueira, Maças & Sampaio, 2013**

The aim of this study was to examine the differences in time-motion, modified training impulse, body load and movement behaviour between player positions. 22 elite male soccer players (age:  $18.1 \pm 0.7$  years old, body mass:  $70.5 \pm 4.3$  kg, height:  $1.8 \pm 0.3$  m and playing experience:  $9.4 \pm 1.3$  years) were involved in this study. They played at elite youth level in Portugal. This sample were divided into three positional groups for comparison: defenders, midfielders and forwards (formation 4-3-3). The goal keeper was not included in the analysis.

The players all participated in a standard warm up which lasted 20 minutes. After this, they simulated a match which consisted of two 25-minute halves with a 10-minute active recovery period between halves. The reason they only played for 25 minutes each half was to prevent the effects of fatigue (Mohr, Krustup, & Bangsbo, 2003). The 22 players were split into two 11-a-side teams. The games were played on an unofficial size natural astro turf pitch (105 x 70m).

Data was collected using GPS units (Spi-Pro, GPSports, Canberra, Australia). The units collected data at 5 Hz and were placed on the backs of each player with the help of a harness. The distance covered was measured both overall and broken down into six speed zones (which are shown below in the graph), where speed zone 1 was defined as speed between 0.0-6.9 km/h<sup>-1</sup> etc., speed zone 2 was any distance recorded between the speeds of 7.0-9.9 km/h<sup>-1</sup> and so on.



The differences in player distances were analysed using a one-way ANOVA and then the pairwise differences were tested using a Bonferroni post-hoc test.

### *Distance*

The total distance covered was similar across all playing positions: defenders =  $2925 \pm 261$  m, midfielders =  $3061 \pm 377$  m, forwards  $2750 \pm 350$  m;  $F(2,37) = 2.7$ ,  $P = .077$ ,  $\eta^2 = .13$ . However, there was a significant difference between player position and distances covered at speeds below  $13.0 \text{ km/h}^{-1}$  ( $F(10,185) = 8.9$ ,  $P < .001$ ,  $\eta^2 = .33$ ). Differences between player positions were not described specifically, although the researchers presented the graph below to show the distances that each player position covered in each zone. From this graph I can see a significant difference between midfielders and forwards in speed zone 1, where forwards covered a further distance than midfielders. In zone 2, statistically significant differences were found between defenders and forwards, where defenders covered more distance than forwards, and midfielders and forwards, where midfielders covered more distance than forwards. Finally, in zone 3, midfielders' distance was significantly further than defenders, defenders' distance was significantly further than forwards' and midfielders' distance was significantly further than forward's. There were no significant differences found between player position distances above zone 3.

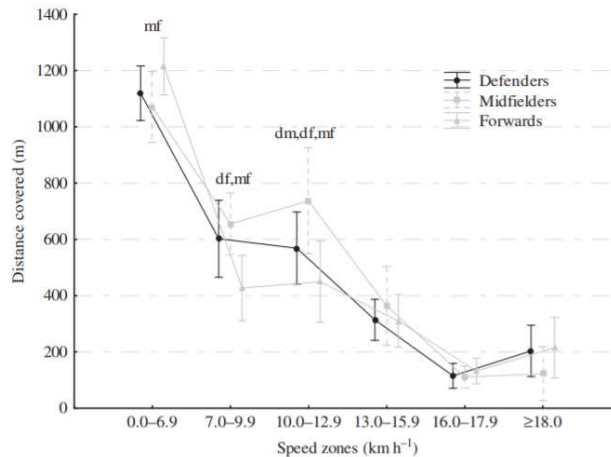


Figure 1. The variation of distance covered at the considered speed zones. Statistically significant differences are between (dm) defenders and midfielders; (df) defenders and forwards; and (mf) midfielders and forwards.

## Conclusion

There was no significant difference in the total distance covered between the different player positions. However, significant differences were found when distance per speed zones were examined between players. These significant differences were only present when looking at speed zones 1-3, and not 4-6. It would have been useful to see the results of a Bonferroni post-hoc test in a table as well as the graph that is presented in this study. It also would be useful if the study looked at more than one soccer match in their analysis.

### 2.8.2. Barron, Atkins, Edmundson & Fewtrell, 2014

The aim of this study was to examine accelerations, decelerations and triaxial player load in competitive youth soccer and to compare each of these metrics using player positions. There were 38 sub-elite soccer players involved in this study ( $17.3 \pm 0.9$  years,  $71.3 \pm 8.1$  kg,  $177 \pm 6$  cm). Players were divided into player position groups. There were 8 WD, 6 CD, 6 WM, 11 CM and 7 FW. A formation of 4-3-2-1 was used and data was collected from 8 home English College fixtures (competitive phase of the 2012-2013 season). The players wore GPS units (Catapult Sports, Minimax, 5 Hz), on their backs in a harness. The units contained an accelerometer which

gathered data at 100 Hz. The players included in the data analysis were those who played the full 90 minutes of the game (2 x 45 minute halves).

#### *Accelerations and Decelerations*

Accelerations were broken down into different zones for analysis as follows:

acceleration zone 5: 0.0 to 2.0 m.s<sup>-2</sup> ; zone 6: 2.0 to 4.0m.s<sup>-2</sup> ; zone 7: 4.0 - 5.0 m.s<sup>-2</sup> ; zone 8: 5.0 - 20.0m.s<sup>-2</sup>. CM covered the furthest distance during acceleration activities (5923m), followed by FW (5621m), WD (5567m), WM (5366m) and CD (4909m).

Decelerations were broken down into different zones for analysis as follows:

deceleration zone 1: -20.0 to -5.0m.s<sup>-2</sup>, zone 2: -5.0 to -4.0m.s<sup>-2</sup>, zone 3: -4.0 to -2.0m.s<sup>-2</sup>, zone 4: - 2.0 to 0.0m.s<sup>-2</sup>. CM completed the greatest total distance during deceleration activities (3165m) followed by WD (3121m), WM (2963m), FW (2947m), and CD (2710m).

#### *Player Load*

PlayerLoad did vary between playing positions but the only significant difference found was that between CM and CD (991.49AU vs. 745.84,  $p \leq 0.04$ ,  $d=0.19$ ). FW had the 2<sup>nd</sup> highest PlayerLoad (892.33 AU), followed by WM (866.12 AU), WD (782 AU) and CD (745.84 AU). When looking at PlayerLoad in the three different axes individually, there was only a significant difference found between CM and CD in the Y-axis. The greatest PlayerLoad and greatest Y-axis load by CM can be explained by the fact that they also covered the greatest total distance.

#### *Conclusion*

This study found that CM covered the furthest distances in acceleration activities, deceleration activities, and presented the highest value for PlayerLoad. The accelerations and decelerations were broken into a lot of zones (4 zones each), which meant that almost every

movement was recognised as an acceleration or deceleration. Because of this, acceleration distance and deceleration distance combined may add to give roughly the same figure as total distance. However, total distances covered was not presented in this study's findings to compare against. It may have been better if fewer acceleration and deceleration zones were used in the analysis.

## CHAPTER III

### METHODOLOGY

#### **3.1. Participants and Match Analysis**

A total of 16 elite female soccer players participated in this study. Players were divided into 3 positional groups: Forwards, Defenders and Midfielders. The goal keeper was excluded from the analysis. A mixture of 2-3-5, 3-5-2, and 4-3-2-1 formations were used during match play. Players were only included in the analysis if they played a full match. Therefore, only 13 players' data were analysed. Data was gathered over 5 matches in the 2018 soccer season. There were a total of 36 observations (Forwards:  $n = 3$ ,  $obs = 6$ , defenders:  $n = 6$ ,  $obs = 12$ , midfielders:  $n = 8$ ,  $obs = 18$ ). All participants played for the same elite level women's soccer team, Linfield Ladies F.C. (Belfast, Northern Ireland). Three of the matches were played in the UEFA Women's Champions League and two were played in the Women's Premiership League. The UEFA Women's Champions League is an international women's association soccer competition, which involves the top club teams from countries affiliated with the European governing body, UEFA. The Women's Premiership is the top level women's soccer league of Northern Ireland. All matches were played on outdoor grass soccer pitches. A waiver will be sought from the Oklahoma State University Institutional Review Board indicating that IRB approval is not necessary for the analyses or publication of these data because they will be transferred to Oklahoma State University as de-identified data from STATSports and therefore

does not qualify as human subjects research as defined in 45 CFR 46.102 (d) and (f).will be transferred to Oklahoma State University as de-identified data from STAT Sports and therefore does not qualify as human subjects research as defined in 45 CFR 46.102 (d) and (f).

### **3.2. Experimental Procedure**

Individual GPS units (Apex, STATSports, Newry, Ireland; dimensions 80mm (height) x 30mm (width), mass 50g) were worn in a tight-fitting vest by each of the players during match play. The GPS units captured data at 18Hz and had a built in 600Hz tri-axial accelerometer. Players wore the GPS units for approximately 40 minutes prior to kick-off while warming up until approximately 5 – 10 minutes after the completion of the match. However, the data was filtered to exclude any activity prior to kick-off, during half time, and immediately after the match so that only match play data was analysed.

### **3.3. Physical Loading Metrics**

The physical loading variables analysed included: TD,  $\text{m}\cdot\text{min}^{-1}$ , sprints (count and distance), HSR, max speed, HMLD, ED, accelerations and decelerations (counts), TL, DSL, and EMD.

A sprint was defined as any running recorded over the speed  $5.4 \text{ m}\cdot\text{s}^{-1}$  and held for at least 1 s, the sprint ended when the speed dropped below 80% of the sprint entry zone. Accelerations and decelerations were classified as changes in speed  $>2 \text{ m}\cdot\text{s}^{-2}$  and  $<2 \text{ m}\cdot\text{s}^{-2}$  respectively. The acceleration or deceleration must have been held for a minimum of 0.5 s. These thresholds were chosen based on recommendations for determining speed thresholds in female soccer players (Dwyer & Gabbett, 2012). These thresholds have also been used in previous research (McCormack et al., 2015) (Mara, Thompson, Pumpa & Ball, 2015). High speed running (HSR) was

classified as any running performed between speeds of 3.4-5.3 m.s<sup>-1</sup> based on recommendations by Dwyer & Gabbett, 2012.

High metabolic load distance (HMLD) measured the distance covered during the following activities combined (or any activities over 25.5W/kg): accelerations, decelerations and HSR. Total loading measured all forces experienced by the accelerometer over the course of a match. Dynamic stress load (DSL) measured any forces above 2G's experienced by the accelerometer. Explosive distance measured distance covered by accelerations and decelerations above the 25.5W/Kg threshold. Equivalent metabolic distance represented the distance that an athlete would have run at a steady pace, based off how much energy they expended over the entire match.

### **3.4. Statistical Analysis**

All data are presented as means  $\pm$  standard deviations unless otherwise indicated. 13 separate, one-way analyses of variance (ANOVAs) were performed to examine differences in the loading metrics among player positions (forwards vs. defenders vs. midfielders). Follow-up comparisons included Bonferroni-corrected t-tests. All statistical analyses were conducted using SPSS and the alpha level was set a priori at 0.05.

## CHAPTER IV

### RESULTS

#### 4.1. Total Distance

There was a significant influence of player position on TD [ $F_{(2,33)} = 11.78$ ,  $p < 0.001$ ]. On average, the midfielders and forwards covered similar TDs ( $9243 \pm 550\text{m}$  and  $9209 \pm 755\text{m}$ , respectively;  $p \geq 0.999$ ). However, defenders covered lower TDs ( $8129 \pm 720\text{m}$ ) than midfielders ( $p < 0.001$ ) and forwards ( $p = 0.006$ ).

#### 4.2. High Speed Running Distance & Sprints

There was a significant influence of player position on sprint count and sprint distance [ $F_{(2,33)} = 7.26$ ,  $p = 0.002$ ] and [ $F_{(2,33)} = 8.23$ ,  $p = 0.001$ ], respectively. On average, the forwards and midfielders performed a similar number of sprints ( $30 \pm 7$  and  $24 \pm 8$ , respectively;  $p = 0.271$ ) and covered similar sprint distances ( $547 \pm 163\text{m}$  and  $426 \pm 145\text{m}$ , respectively;  $p = 0.249$ ), whereas the defenders performed fewer sprints ( $17 \pm 6$ ) than forwards ( $p = 0.003$ ) and midfielders ( $p = 0.036$ ). The defenders also covered shorter sprint distances ( $271 \pm 133\text{m}$ ) than the forwards ( $p = 0.002$ ) and midfielders ( $p = 0.020$ ).

HSRD was significantly different among playing positions [ $F_{(2,33)} = 5.85$ ,  $p = 0.007$ ]. On average, forwards ( $1924 \pm 337\text{m}$ ) and midfielders ( $1812 \pm 395\text{m}$ ), covered greater further



distances than the defenders ( $1382 \pm 388\text{m}$ ;  $p = 0.015$  and  $0.025$ , respectively), but similar distances to each other ( $p \geq 0.999$ ).

### **4.3. Average & Max Speeds**

There was a significant influence of player position on average speed and max speed [ $F_{(2,33)} = 12.92$ ,  $p < 0.001$ ] and [ $F_{(2,33)} = 4.86$ ,  $p = 0.014$ ] respectively. On average, forwards and midfielders presented similar average speeds ( $95.28 \pm 8.35 \text{ m}\cdot\text{m}^{-1}$ , and  $94.49 \pm 6.26 \text{ m}\cdot\text{m}^{-1}$  respectively;  $p \geq 0.999$ ). However, defenders presented slower average speeds ( $82.65 \pm 6.53 \text{ m}\cdot\text{m}^{-1}$ ) than forwards ( $p = 0.002$ ) and midfielders ( $p = 0.020$ ).

On average, forwards and midfielders had similar max speeds ( $7.39 \pm 0.30 \text{ m}\cdot\text{s}^{-1}$  and  $7.47 \pm 0.54 \text{ m}\cdot\text{s}^{-1}$ , respectively;  $p \geq 0.999$ ). Defenders had significantly slower max speeds ( $6.91 \pm 0.48 \text{ m}\cdot\text{s}^{-1}$ ) compared to midfielders ( $p = 0.014$ ) but not compared to forwards ( $p = 0.171$ ).

### **4.4. Accelerations & Decelerations**

There was a significant influence of player position on accelerations and decelerations [ $F_{(2,33)} = 7.62$ ,  $p = 0.002$ ] and [ $F_{(2,33)} = 4.17$ ,  $p = 0.024$ ] respectively. On average, forwards ( $147 \pm 41$ ;  $172 \pm 45$  respectively), and midfielders ( $137 \pm 27$ ;  $146 \pm 43$  respectively) performed a similar number of accelerations and decelerations ( $p \geq 0.999$  and  $p = 0.545$ , respectively). The deceleration counts by midfielders and defenders ( $116 \pm 32$ ) were also similar ( $p = 0.166$ ). However, defenders' acceleration counts ( $99 \pm 28$ ) were lower than midfielders ( $p = 0.005$ ), and defenders' acceleration and deceleration counts were lower than forwards ( $p = 0.009$  and  $p = 0.028$  respectively).

### **4.5. Total Loading**

The influence of player position on total loading was significant [ $F_{(2,33)} = 4.11$ ,  $p = 0.026$ ]. However, Bonferroni's Post Hoc test results showed that there were no significant differences

found between any pairs within this population. Forwards presented the highest total loading values ( $139.90 \pm 19.52$  au), followed by midfielders ( $136.12 \pm 16.28$  au) and defenders ( $121.09 \pm 13.67$  au).

#### **4.6. Dynamic Stress Load**

There was no significant influence of player position on DSL [ $F_{(2,33)} = 0.962$ ,  $p = 0.393$ ].

Forwards presented the highest DSL values ( $510.61 \pm 345.02$  au), followed by midfielders ( $427.48 \pm 213.44$  au) and defenders ( $348.32 \pm 220.49$  au).

#### **4.7. High Metabolic Load Distance**

There was a significant influence of player position on HMLD [ $F_{(2,33)} = 8.57$ ,  $p = 0.001$ ].

Forwards and midfielders covered similar HMLDs ( $1398 \pm 225$ m and  $1171 \pm 287$ m, respectively;  $p = 0.253$ ). However, defenders ( $871 \pm 248$ m) covered shorter HMLDs than forwards ( $p = 0.001$ ) and midfielders ( $p = 0.016$ ).

#### **4.8. Explosive Distance**

There was a significant influence of player position on ED [ $F_{(2,33)} = 3.70$ ,  $p = 0.036$ ].

However, Bonferroni's Post Hoc test results showed that there were no significant differences found between any pairs within this population. Forwards covered the furthest ED ( $979 \pm 225$ m) followed by midfielders ( $861 \pm 250$ m) and defenders ( $686 \pm 205$ m).

#### **4.9. Equivalent Metabolic Distance**

There was a significant influence of player position on EMD [ $F_{(2,33)} = 15.647$ ,  $p < 0.001$ ].

Forwards and midfielders presented similar EMD values ( $10709 \pm 890$ m and  $10534 \pm 653$ m respectively;  $p \geq 0.999$ ). However, defenders ( $9192 \pm 683$ m) presented with the shorter EMD values than forwards ( $p < 0.001$ ) and midfielders ( $p < 0.001$ ).

**Table 1.**

Means  $\pm$  SD of TD, Average Speed ( $\text{m}\cdot\text{min}^{-1}$ ), Max Speed ( $\text{m}\cdot\text{s}^{-1}$ ), Accelerations, Decelerations, Sprints, Sprint Distance, HSRD, TL, DSL, HMLD, ED and EMD

	Positional Group			ANOVA p-value
	Defenders	Midfielders	Forwards	
TD (m)	8129 $\pm$ 720	9243 $\pm$ 550	9209 $\pm$ 755	p < 0.001
Max Speed ( $\text{m}\cdot\text{s}^{-1}$ )	6.91 $\pm$ 0.48	7.47 $\pm$ 0.54	7.39 $\pm$ 0.30	p=0.014
Average Speed ( $\text{m}\cdot\text{min}^{-1}$ )	82.65 $\pm$ 6.53	94.49 $\pm$ 6.26	95.28 $\pm$ 8.35	p < 0.001
Accelerations (count)	99 $\pm$ 28	137 $\pm$ 27	147 $\pm$ 41	p=0.002
Deceleration (count)	116 $\pm$ 32	146 $\pm$ 43	172 $\pm$ 45	p = 0.024
Sprints (count)	17 $\pm$ 6	24 $\pm$ 8	30 $\pm$ 7	p = 0.002
Sprint Distance (m)	271 $\pm$ 133	426 $\pm$ 145	547 $\pm$ 163	p = 0.001
HSRD (m)	1383 $\pm$ 388	1812 $\pm$ 395	1924 $\pm$ 337	p = 0.007
TL (au)	121.09 $\pm$ 13.67	136.12 $\pm$ 16.28	139.90 $\pm$ 19.52	p = 0.026
DSL (au)	348.32 $\pm$ 220.49	427.48 $\pm$ 213.44	510.61 $\pm$ 345.02	p = 0.393
HMLD (m)	871 $\pm$ 248	1171 $\pm$ 287	1398 $\pm$ 225	p = 0.001
ED (m)	686 $\pm$ 205	861 $\pm$ 250	979 $\pm$ 225	p = 0.036
EMD (m)	9192 $\pm$ 683	10534 $\pm$ 653	10709 $\pm$ 890	p < 0.001

## CHAPTER V

### DISCUSSION

The aim of this study was to identify differences in loading metrics among defenders, midfielders, and forwards in elite female soccer players. To the authors knowledge, this is the first study of its kind to use GPS technology to answer this research question. The results of this study indicated that player position had a significant influence on most of the loading metrics examined, with midfielders and forwards generally experiencing greater loads than defenders. These data have important implications for coaches, trainers, and strength and conditioning specialists, and should be considered when designing training programs or monitoring athlete playing and/or training loads.

The findings of this study are similar to those reported previously (Gomez-Piriz et al., 2011; Barron et al., 2014; Baptista et al., 2018; Tierney et al., 2016; Brito et al., 2017) and suggested that midfielders to cover the furthest total distance of all positions while defenders covered the least, particularly central defenders. Moreover, we observed no difference in TD covered by midfielders versus forwards. Previously, Lago-Peñas et al. (2009) observed that wide defenders cover the second furthest distance after midfielders. However, in the present study, we did not categorize central versus wide positions and were not able to determine how this may influence TD.

The existing literature for men's soccer suggests that midfielders and forwards perform the highest amount of accelerations and decelerations, while central defenders generally perform the least (Dalen, et al., 2016, Tierney et al., 2016). Our current study in elite women's soccer largely agreed with these previous studies in men. Specifically, the forwards and midfielders performed significantly more accelerations and decelerations than defenders and the difference in acceleration and deceleration counts between midfielders and forwards was not significant. In addition to differences in acceleration and deceleration counts, we observed greater total sprint distances and sprint counts in forwards and midfielders, whereas defenders covered the shortest sprint distances and the fewest sprints. Although our findings largely support those of previous studies, we observed that forwards and midfielders covered similar HSR distances (with forwards covering slightly greater HSR distances), whereas previous studies have shown that wide midfielders cover the most distance during HSR, closely followed by forwards, with central defenders covering the least distance (Mara et al., 2017, Lago-Peñas et al., 2009, Brito et al., 2017, Tierney et al., 2016, Baptista et al., 2018).

Previous studies have reported that midfielders experience the highest total loads during match-play (Dalen et al., 2016, Gomez-Piriz et al., 2011 Barron et al., 2014), whereas it has been reported that either forwards (Gomez-Piriz et al., 2011) or central defenders (Barron et al., 2014) experience the lowest total loads. Our data also suggest that midfielders experienced relatively high total loads. However, our data also suggested that forwards experience similar total loads to midfielders, whereas defenders experienced the lowest total loads among the positional groups examined in this study. However, surprisingly, our data suggested that there was no difference among the three positional groups for dynamic stress load values. Due to the

differences in several other player load metrics, where midfielders and forwards work rates appear to be significantly higher than defenders', we expected the DSL values to also reflect these differences. However, we believe that we lacked the power to observe differences among positional groups for DSL due to the variability present in the DSL metric. Specifically, DSL was measured using forces experienced by the accelerometer, and it appears that this metric is more highly variable than the other metrics examined in this study. This could also be due to the fact that DSL presents an absolute value, meaning a heavier person will almost always present with a higher DSL value than a lighter person who has performed the exact same exercise bout. Future studies examining the reliability and sensitivity of this DSL metric are warranted before recommending it for use in athlete monitoring.

Forwards presented with the highest HMLD, ED and EMD values. This was not surprising as they also covered the furthest sprint distances, HSR distances and presented with the fastest average speed and highest acceleration, deceleration and sprint counts, which all heavily influence HMLD, ED, and EMD. Midfielders presented with the second highest values in these three metrics, although, again there was no significant difference observed between the forwards and midfielders. However, both the forwards and midfielders experienced greater HMLD, ED, and EMD values than defenders.

## **5.1. Conclusion**

This study shows, through GPS and accelerometer-based data, that there are significant influences of player position on loading in elite female soccer players. Forwards presented the highest values for HSR distance, sprint distance and count, accelerations and decelerations, average speed, total loading, DSL, HMLD, ED and EMD. Midfielders presented the highest values for TD and max speed. There were, however, no significant differences found between these

two positions in any of these metrics. Thus, these data suggest that, in elite women's soccer, forwards and midfielders had similar workloads overall. It was also clear that defenders had significantly lower workloads than the other two player positions, presenting with the lowest values for every metric examined in this study. This was the first study of its kind to utilize GPS technology, and further research is needed in this evolving area of study. This study improves our understanding of position specific demands in elite women's soccer, thus equipping coaches to better predict their athletes' needs and to plan and periodize training programs to meet the specific match play demands for each individual position. Ultimately, studies such as this may be used to help athletes to achieve optimal performance in match play.

## **5.2. Limitations**

One limitation of this study was the small number of observations across all player positions, due to collection during only five matches for analysis. The initial plan was to have seven matches worth of data for analyses, but two matches were called off due to weather conditions and were not rescheduled. Another limitation of this study was the fact that participants were only broken into three positional groups. The existing literature suggests positional differences in loading metrics for wide versus central players. The reason players were not broken down into more specific positions was due to the small number of participants involved in the study. It could be seen as a limitation that formation was not considered when investigating positional workload, as existing literature has also suggested formation-influenced differences in positional workload in elite men's soccer (Tierney et al., 2016). A final limitation of this study was the uneven distribution of players, as there were only 6 observations for forwards and 18 and 12 for midfielders and defenders, respectively.

### **5.3. Future Recommendations**

Future studies should replicate this one using a larger number of participants, and a more evenly distributed population. Formation has been found to have an impact on physical demands across all player positions (Tierney et al., 2016), so future studies may also consider investigating the effect of playing formation on player position.



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## APPENDICES

**Figure 2 Relationship Between Total Distance (m) Covered and Player Position**

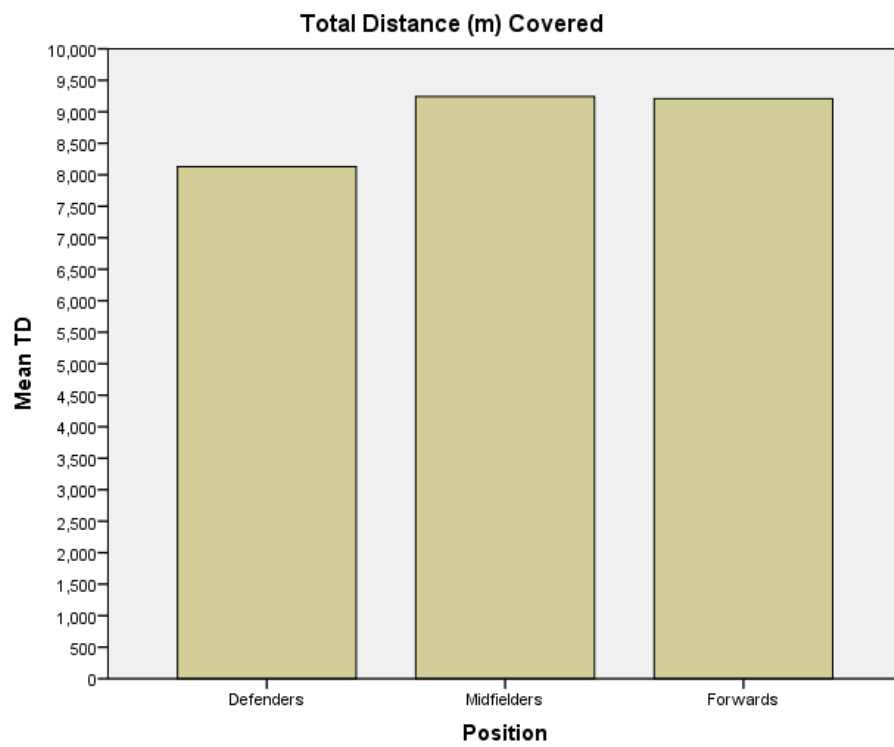


Figure 3 Relationship Between Average Speed (m/min) and Player Position

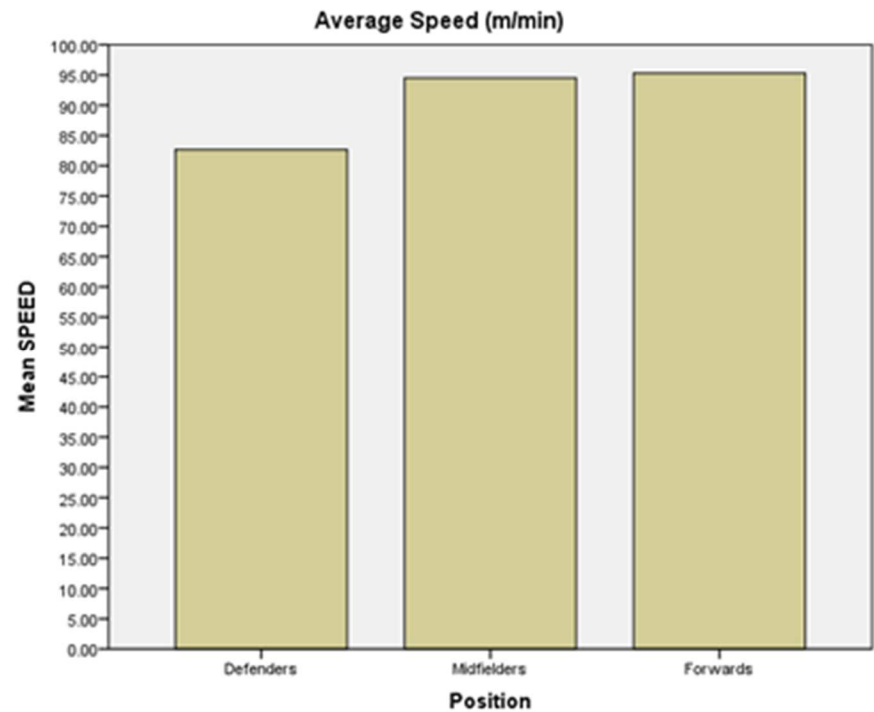
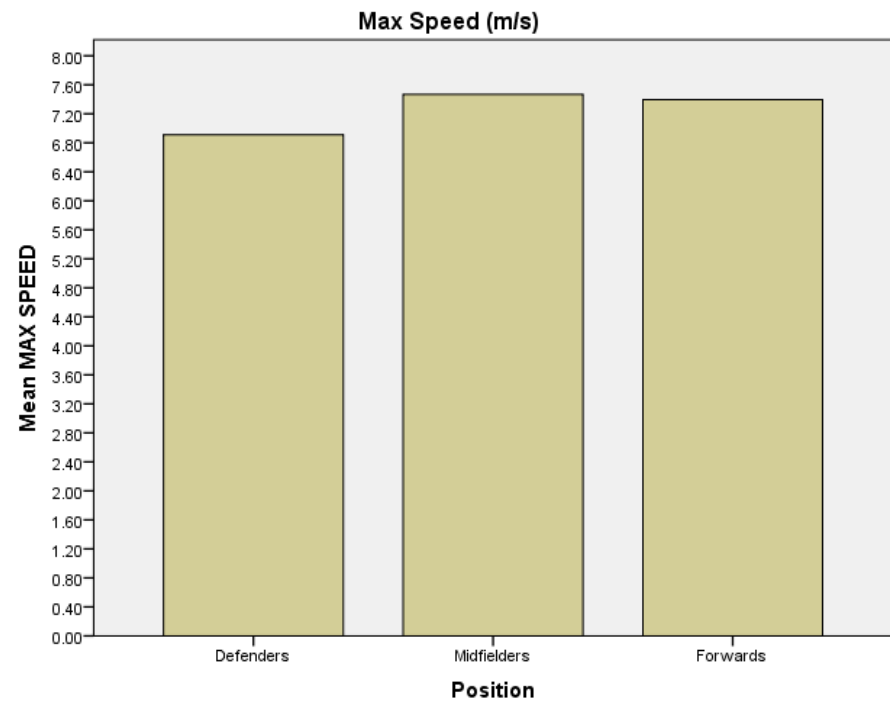
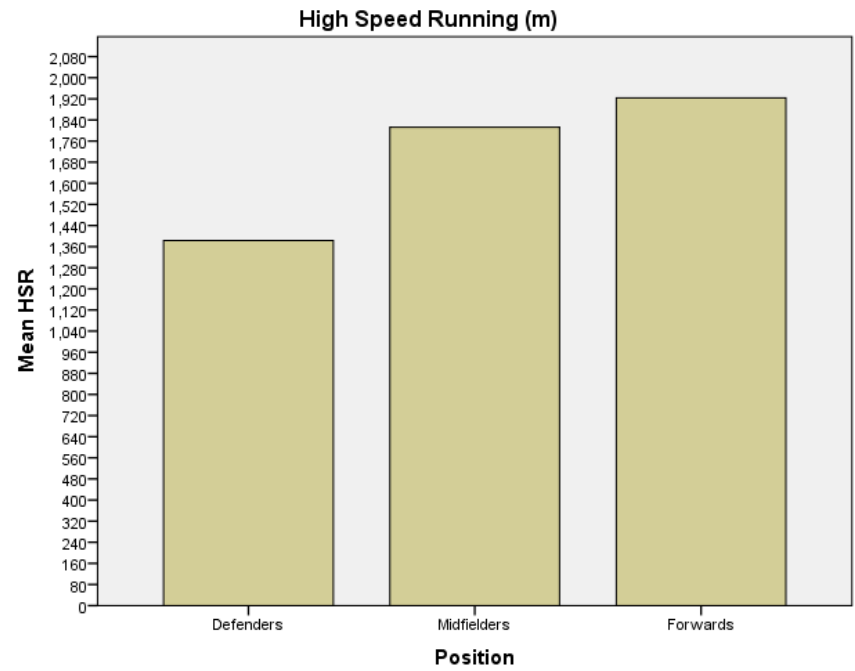


Figure 4 Relationship Between Max Speed (m/s) and Player Position

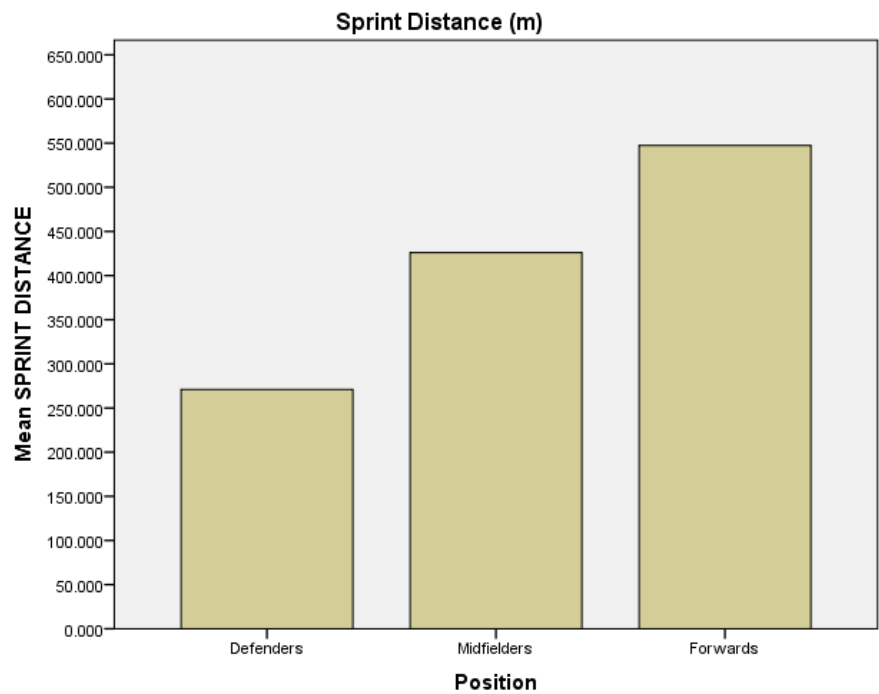




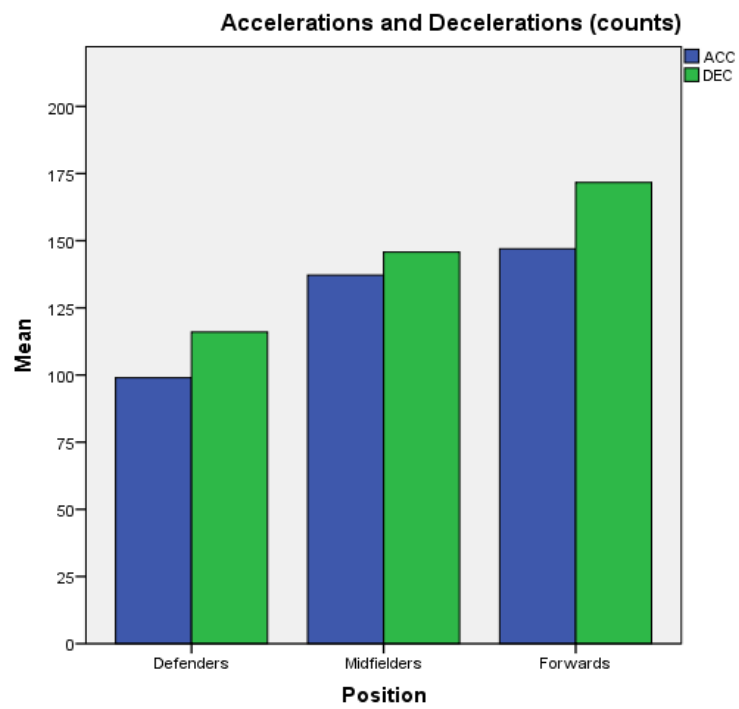
**Figure 5 Relationship Between High Speed Running Distance (m) and Player Position**



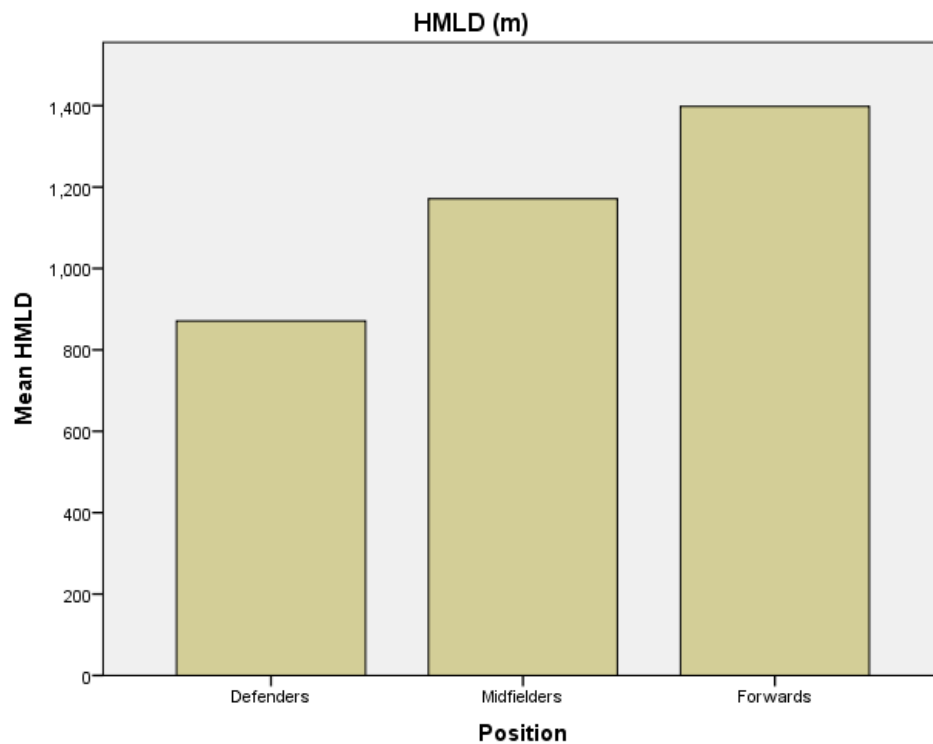
**Figure 6 Relationship Between Sprint Distance (m) and Player Position**



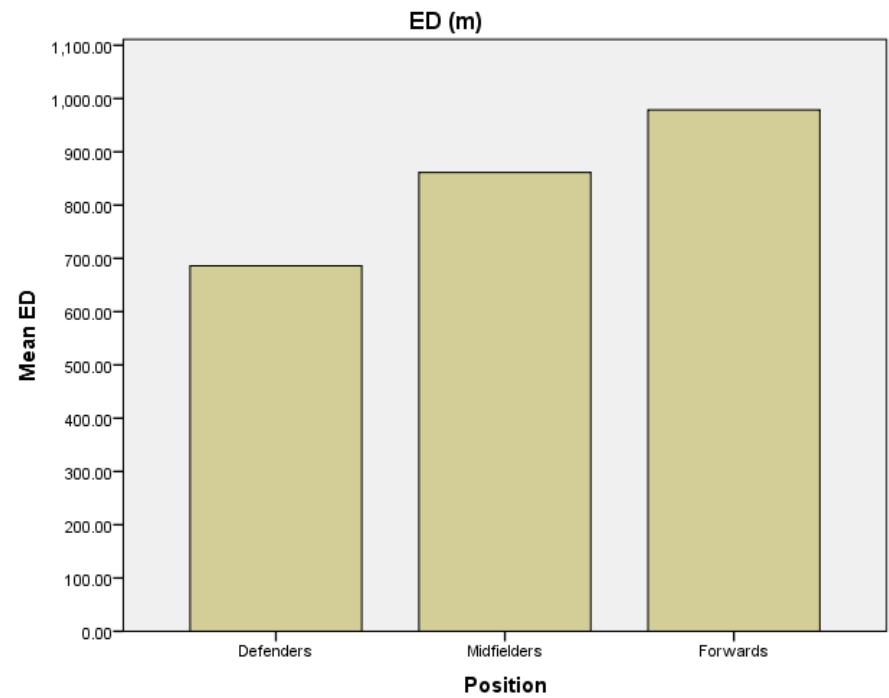
**Figure 7 Relationship Between Acc and Dec Counts and Player Position**



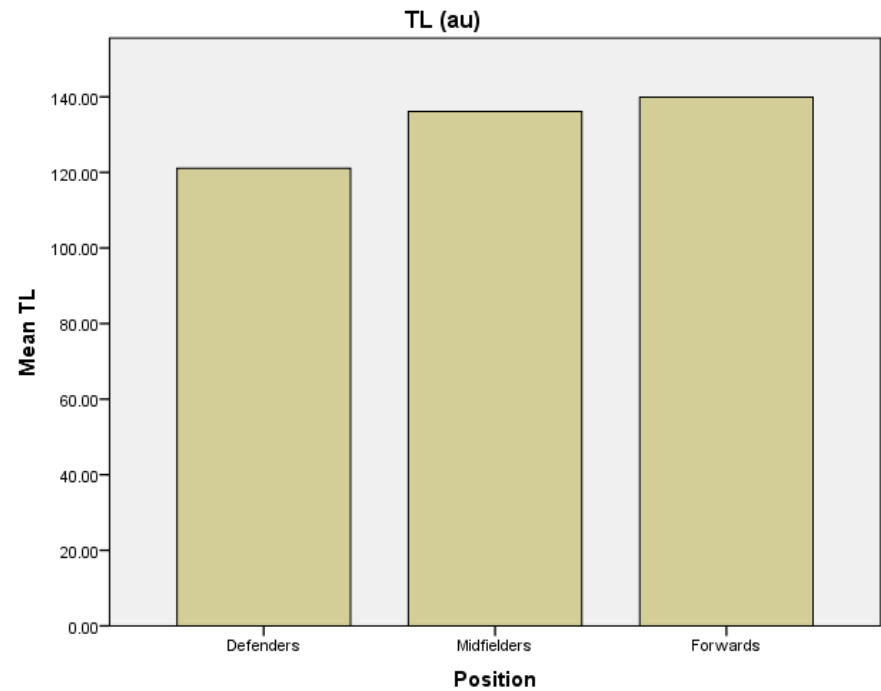
**Figure 8 Relationship Between HMLD (m) and Player Position**



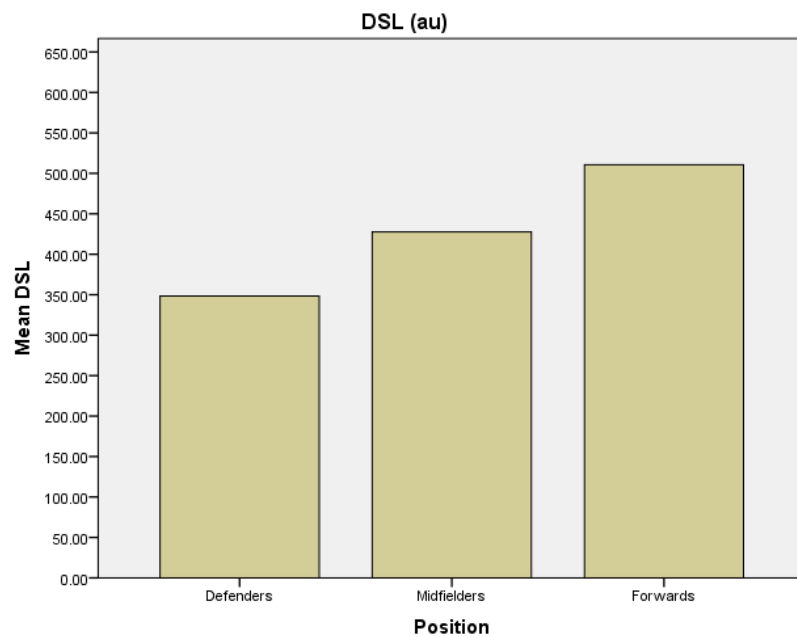
**Figure 9 Relationship Between ED (m) and Player Position**



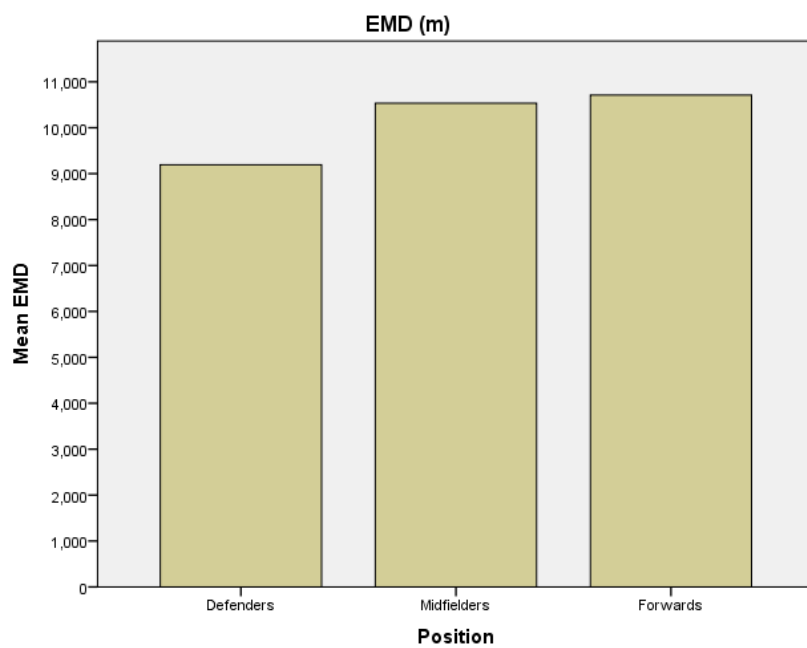
**Figure 10 Relationship Between TL (au) and Player Position**



**Figure 11 Relationship Between DSL (au) and Player Position**



**Figure 12 Relationship Between EMD (m) and Player Position**



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