Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Medicine and Health Sciences
Department of Neuromedicine and Movement Science

Oda Margrethe Skaug

Position specific quantification of training load in-season using microcycles: Norwegian elite female soccer

Master's thesis in Master of science in physical activity and health
Supervisor: Ulrik Wisløff
Co-supervisor: Martijn Ravenhorst
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In-season monitoring of external training load

Elite female soccer

Aims: 1) To quantify position specific external load over a week with one game. 2) Quantify load in different types of training sessions.

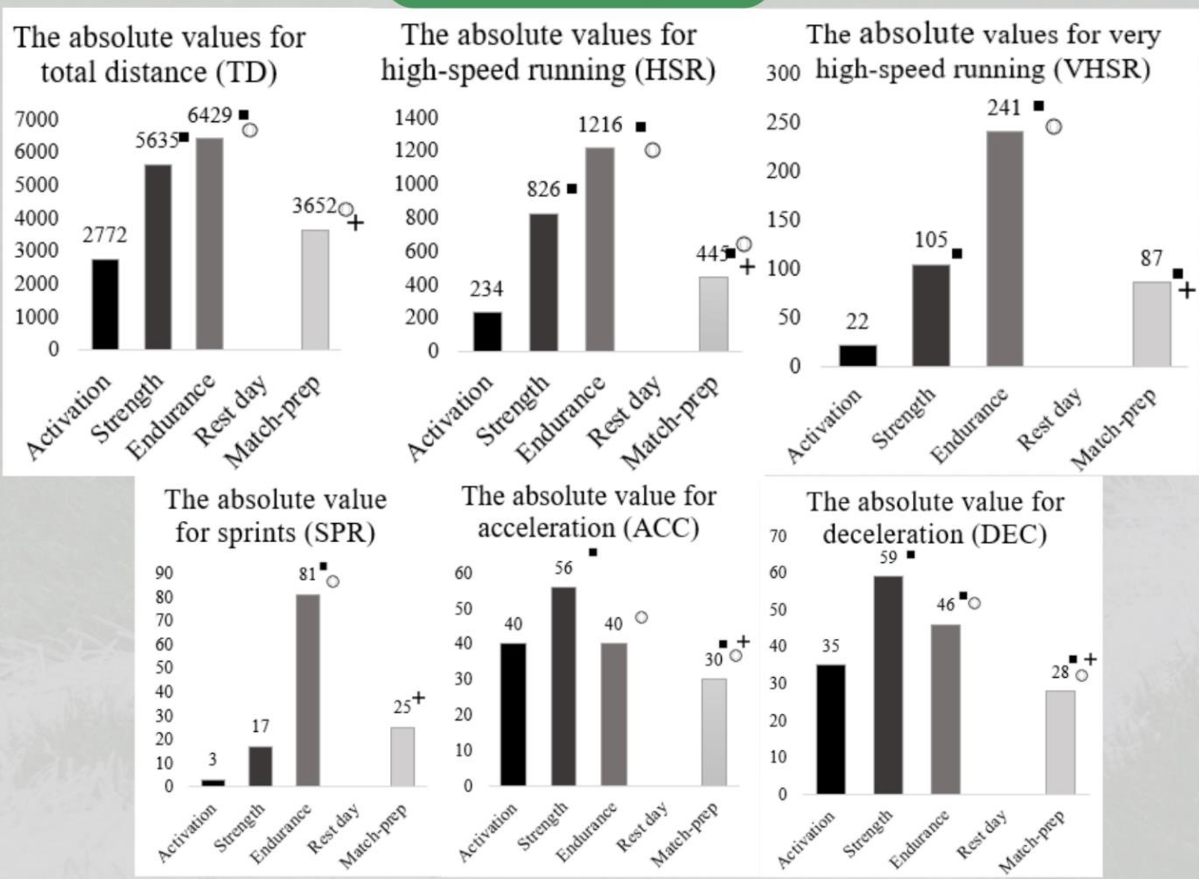
Methods:

- Twenty-one norwegian female players (22.6 ± 3.3 years,
- 170.7 ± 5.9 cm, 66.9 ± 7.0 kg)
- External load collected for 7 weeks
- GSP performance tracker (18Hz)

A typical micro-cycle (1 week of training):

Micro-cycle	MD-5	MD-4	MD-3	Rest Day	MD-1	Match
Type of training	Activation	Strength	Endurance	Rest day	Match prep	Match day

What did we find?



Square = Statistically significantly different from ACT. Circle = Statistically significant different from STR. Cross= Statistically significant different from END.

Discussion:

- Endurances sessions had the highest load (MD-3)
- Match-prep had the lowest load (MD-1)
- Training SPR and VHSR does not replicate match demands
- Defensive midfileder had the highest load for TD, HSR
- Central forward had the highest for VHSR, SPR and ACC

Conclusion: External load of a micro-cycle varied based on playing position and session type, specifically bigger variations in load between positions in matches compared to trainings.

Abstract

Purpose: The primary aim of this study was to quantify the external training load in a typical week (Microcycle) with one match for elite female soccer players. A secondary aim was to determine whether there were differences in these parameters between playing position and training sessions. ***Method:*** Twenty-one female soccer players (22.6 ± 3.3 years, 170.7 ± 5.9 cm, 66.9 ± 7.0 kg) from one elite team in Norway took part in the study. Seven microcycles with complete data from training sessions and matches were included in the analysis. The one-weekly-match-microcycle consist of the following: Match day (MD), MD+1 is the day after the match, MD-5 is five days before the next match and the start of the microcycle, MD-4 is four days before match etc. The data was collected with Global Navigation Satellite System (GNSS) with GPS data collected at 18 Hz. The variables included to quantify external load were total distance covered (TD; m), distances in high-speed running (HSR: 12.5-19.0 $km \cdot h^{-1}$), very-high speed running (VHSR: 19.0-22.5 $km \cdot h^{-1}$), sprinting (SPR: >22.5 $km \cdot h^{-1}$), acceleration (ACC: >3 $m \cdot s^{-2}$) and deceleration (DEC: >-3 $m \cdot s^{-2}$). Weekly training load was compared with external load experienced during matches. For this purpose, we used the average external load of seven matches. A linear mixed model was used to compare the total accumulated external load between positions and sessions, separately. ***Results:*** Overall, MD-3 had the highest load, and MD-5 had the lowest. The accumulated HSR, SPR, ACC and DEC load during training in the microcycle were a lot higher compared to match data. An exception was seen for defensive midfielder which had higher match data for HSR and SPR. Defensive midfielders had highest values for TD and HSR whilst central forwards had highest SPR and ACC. ***Conclusion:*** External load of a microcycle varied based on playing position and session type, specifically bigger variations in load between positions in matches compared to trainings. This information may be useful for practitioners when planning training load a microcycle and gives the opportunity to adapt position-specific load from match demands to the training week.

Abstrakt

Hensikt: Hovedmålet med denne studien var å estimere ytre treningsmengde i en typisk uke (Mikrosyklus) med en kamp for kvinnelige eliteseriespillere. Et sekundært mål var å undersøke om det var forskjeller in disse parameterne mellom posisjoner og treningsøkter. Tjue-en kvinnelige fotballspillere (22.6 ± 3.3 år, 170.7 ± 5.9 cm, 66.9 ± 7 kg) fra et elitelag i Norge deltok i studien. Syv microsykluser med komplett data ble samlet inn med et globalt navigerings satelittsystem (GNSS) med GPS data samlet på 18 Hz. Variablene som ble inkludert for å estimere ytre belastning var felttid (FT; m), total distanse (TD; m), høy intesitetsløping (HSR: 12.5-19.0 $km \cdot t^{-1}$), veldig høy intensitetsløping (VHSR: 19.0-22.5 $km \cdot t^{-1}$), sprinter (SPR: >22.5 $km \cdot h^{-1}$), akselerasjon (ACC: >3 $m \cdot s^{-2}$) og deselerasjon (DEC: >3 $m \cdot s^{-2}$). Ukentlig treningsmengde ble sammenlignet med treningsmengde opplevd under kamp. For denne dataen brukte vi gjennomsnittlig ytrebelastning for syv kamper. En «mixed linear model» ble brukt for å sammenligne total akkumulert ytre treningsmengde mellom posisjoner og treningsøkter, separat. ***Resultat:*** MD-3 hadde høyest belastning, og MD-5 hadde lavest. Den akkumulerte belastningen for HSR, SPR, ACC og DEC for trening i microsyklusen var en del høyere sammenlignet med kamp, med unntak av defensive midtbanespillere defensive midtbanespillere som hadde høyere kampdata for HSR og SPR. Defensive midtbanespillere hadde høyere verdier for TD og HSR, og sentrale angrepsspillere hadde høyest for SPR og ACC. ***Konklusjon:*** Funnene demonstrerer at ytre belastning av en mikrosyklus varierer basert på posisjon og type økt. Spesifikt er det større variasjoner i belastning mellom posisjoner i kamp sammenlignet med trening. Denne informasjonen kan være nyttig for trenere når de planlegger treningsbelastning for en mikrosyklus og gir mulighet til å tilpasse posisjon spesifikk belastning fra kamp til treningsukene.

List of abbreviations

GPS:	Global positioning system
GNSS:	Global navigation satellite system
TD:	Total distance
HSR:	High-speed running
VHSR:	Very high-speed running
SPR:	Sprinting
ACC:	Acceleration
DEC:	Deceleration
FB:	Fullback
CM:	Central midfielder
CD:	Central defender
WM:	Wide midfielder
DM:	Defensive midfielder
CF:	Central forward

1. Introduction

Soccer is a physically demanding sport where both individual performance and team effort is important (Castagna et al., 2005; Martín-García et al., 2018). It is a sport characterized by intermittent low-intensity activities like passing, walking, or standing and high-intensity activities such as acceleration and directional changes during high-speed. A former study showed that professional female soccer players in the U.S league, who also played for their national team performed more high intensity running and sprints compared to female elite athletes who played the best Danish and Swedish league but did not represent their national team (Mohr et al., 2008). This is because the intensity and the match demands are generally higher and/or that national team players have higher physical capacities compare to their non-national-team-peers (Andersson et al., 2010). On average female elite soccer players cover a distance about of 10 000 meters per match, where 300 meters is sprinting (>20.1 $km \cdot h^{-1}$) (Diaz-Seradilla et al., 2022). Sprinting abilities is very different between levels of competition and depends highly on playing positions (Krustrup et al., 2005). Defenders often have fewer sprints and less distance in high intensity running than attackers (Mohr et al., 2008). Therefore, it is important that training staff is able to adapt training plans to a whole team and individualize training for players with different sets of skills, experience and role demands (Favero & White, 2018).

Periodization is a training concept widely used in sport to optimize athletic performance by using a strategic approach (Lyakh et al., 2016). It involves dividing the training cycle into specific periods, where each has its own focus, workload and goals. Challenges to implement a good and adapted periodization strategy in soccer includes number of days between matches, late, mid-, or early season games, the opponent’s tactics and level, and travelling to away games and tournaments (Favero & White, 2018). If there are weeks with multiple matches, or few days in between training and match this will add extra mental and physical pressure for players. It is therefore important to adapt the training sessions so the players can recover and at the same time be ready for the next match. The training week might also be affected by which formation the opponent plays and depend on the team’s placement in their division (i.e., qualifying to advance or go down one division). The training cycle can range from a few days to several months and is designed to address different aspects to ensure optimal performance and minimize fatigue through recovery activities and training methods (Favero & White, 2018). The goal is to try to develop physiological capacities as a team and still individualize enough so players can reach their full potential. The periods can include off-season, in-season and pre-season, and each period focuses on different objectives like strength or endurance specific for sports. The off-season often has its focus on building a strong foundation with heavy and frequent trainings, the pre-season, on the other hand, is more focused on developing abilities of speed and power. The in-season aims to maintain the foundation that was made in pre-season as well as optimize match performances through training and restitution (Jeong et al., 2011; Nobari et al., 2020). The match is often the most demanding session of the week, and this should be key knowledge when planning training load and strategies. The training week prior to the match must be used widely to create a good transition to prepare the players for the upcoming match demands (Lago-Peñas et al., 2022).

In soccer, a microcycle is often used as periodization for one week of training, typically labelled with the number of days before or after match i. e., MD+1 is the day after the match, MD-5 is five days before the next match and the start of the microcycle, MD-4 is four days before match etc. (Martín-García et al., 2018). A microcycle will often contain sessions with soccer specific focus on strength, endurance, and speed in both female and male soccer when playing one match a week (Diaz-Seradilla et al., 2022). This structure makes it possible to focus more on one objective at a time and maximizing the efforts for that specific objective. The soccer specific strength sessions often contain elements of small-sided games with longer duration and little rest, while endurance sessions utilize the big pitch with more room per player to reach higher speed. Speed sessions also have small-sided games, but often give the players longer breaks to provoke maximum output (Diaz-Seradilla et al., 2022). The general finds on training load distribution during a microcycle with one match in the weekend is that there is a higher load in the middle of the week, and then it decreases closer to the match (Ahenhead, Harley & Twiddle, 2016; Chena et al., 2021; Martín-García et al., 2018; Rydning, 2021). To meet the match demands it is beneficial to manipulate intensity and volume by decreasing or increasing the load of the microcycle to optimize the training structure (Martín-García et al, 2018; Malone et al., 2015).

To optimize physical performance and maximal response to training in elite soccer there is a need to plan and track the training load in detail (Duggan et al., 2021). This will contribute to avoid over- and underloading and secure continuous improvement (Diaz-Seradilla et al., 2022). Training load is a concept used in physical activity and sports that can be divided into internal and external load (Halson, 2014). External load is the work completed by the athlete whereas internal load is the physiological stress placed on the athlete during a period or training session. In recent years, there has been an increase in primarily using external load monitoring (Halson, 2014). To estimate an athletes external training load global positioning system (GPS) is widely used (Martín-García et al., 2018). This allows practitioners to understand the distinct and individual requirement of different positions on the field With GPS data training staff can monitor athletes' movements on the field, which includes accumulated field time, distance covered, speed, acceleration, and deceleration (Martín-García et al., 2018).

Previous research state that external load is higher in official matches compared to training, and during training the load is often similar between positions (Romero-Moraleda et al., 2021). Ramos and colleagues (2019) found that when elite female players participate in international competition, they complete 217.6 accelerations (ACC) and 167.1 decelerations (DEC) per match (Ramos et al., 2019). Similarly, another study found that female 1. Division players covered 1108 m in high-speed running (HSR) and perform 255 accelerations (ACC) and 78 decelerations (DEC) compared to their match position (Romero-Moraleda et al., 2021). They cover 9-11 km total distance (TD), of which 420-700 meters was at high intensity (HSR) (19.8–25.1 km·h^{-1}), 500-1000 total very high-speed running (VHSR) (>19.8 km·h$^{-1)}$ and 100-250 meters sprinting (SPR) (>25.1 km·h^{-1}) distance (Datson et al., 2017; Romero-Moraleda et al., 2021; Mohr et al., 2008). This information can be used to adapt training programs to better suit the needs of the players on the team, as well as to identify areas for improvement.

It is the content of the microcycle that will determine the total external load of all training sessions, and this is often adapted and customized in relation to how big the game demand is (Manson, Brughelli, & Harris, 2014). The total load is often view through accumulated load. Accumulated load referees to the external load a player have performed throughout a week. In a study investigating male soccer players accumulated load, they found that when taking weekly accumulated load and comparing it to match demands they suggested that three training sessions is equal to match demands in terms of external load (Clemente et al., 2019). It is not only important what to include in the different training sessions, but also which day of the microcycle it is. A former study found that the load was greatest on MD-4, which is 4 days prior to the match (Martín-García et al., 2018). For external load one of the most predominant variables is the playing position of the player (Diaz-Seradilla et al., 2022). Despite the agreement of that periodization has great benefits (Duggan et al., 2021; Malone et al., 2015; Manson, Brughelli, & Harris, 2014), research has only recently investigated match demands and accumulated training load in female soccer athletes, but with little data on position specific demands. More knowledge is needed when it comes to position specific external load in elite female soccer. This will allow for more adequate distribution of training load within the microcycle for each player of the team (Diaz-Seradilla et al, 2022).

Over the past 10 years female soccer has had a 32% increase in participation (Hermann & Vollmeyer, 2016; Manson, Brughelli, & Harris, 2014). Concurrently, research on female soccer has increased dramatically during the last two decades (Olson, 2008), but still the number of research papers on male players physical performances, far outnumber the ones of female soccer players (Manson, Brughelli, & Harris, 2014; Milanovic et al., 2017). Too our knowledge there is very limited research specifically on external training load and microcycles with one match in female elite soccer players that also include position specific numbers (Manson, Brughelli, & Harris, 2014; Martín-García et al., 2018).

The primary aim of this study was to quantify the accumulated external training load demands in a typical microcycle with one match in elite female soccer players. Secondary aim was to study potential position specific differences in external load, as well as investigating difference between training sessions. I hypothesize that external load, specifically high-speed running (HSR), very high-speed running (VHSR), sprints (SPR), acceleration (ACC) and deceleration (DEC) will be greater in the matches compared to what is accumulated in training sessions in the microcycle. I hypothesize that total distance (TD) will vary a lot throughout the week with lower values on all days compared to match. I also hypothesize that the differences between positions will be largest between midfielders and central defenders. Lasty, I hypothesize that training sessions in the middle of the week will have the highest load.

2. Materials and methods

2.1 Participants

The participants in this study were 21 female soccer players (mean ± SD: 22.6 ± 3.3 years, 170.7 ± 5.9 cm, 66.9 ± 7.0 kg) from the Norwegian elite league (Toppserien). During the data collection period the team participated in three competitions (Toppserien, Norwegian cup and Champions league). The season was played in a formation of 4-2-3-1, therefore the players was divided into the following positions: fullback (FB), central defender (CD), defensive midfielder (DM), central midfielder (CM), wide midfielder (WM) and central forward (CF). Goalkeepers were excluded from the sample due to their specific role. This study conformed to the declaration of Helsinki, and prior to the study the participants gave written informed consent.

2.2 Design

This study is a longitudinal cohort study during the 2022 Norwegian soccer season (March-October). Workload during training sessions and matches were collected with an international multi-constellation satellite system (GNSS), containing GPS data. There were seven microcycles that followed the required structure, and these weeks contained four training sessions, two rest days and one matchday. The included microcycle used the “match day minus” system of Malone et al (2005). Thus, the microcycle had the following structure: Match day (MD), MD+1 is the day after the match, MD-5 is five days before the next match and the start of the microcycle, MD-4 is four days before match etc., as shown in Table 1. The team participate in three different tournaments leading to multiple weeks with two or more matches, which did not have the correct structure in relation to the microcycle to be included. All players performed the same type of warm up with dynamic movement inside and then dynamic drills outside on the field.

Table 1. Microcycle with one match like shown by Malone et al., (2005) with the “match-day minus” system.

Microcycle	*MD-5*	*MD-4*	*MD-3*	*Rest Day*	*MD-1*	*Match*	*MD+1*
Objectives	Activation	Strength	Endurance	Rest day	Match-prep	Match day	Rest day

MD= Match Day

2.2.1 Inclusion criteria

In order to include the data in a microcycle the players had to complete full group sessions. The microcycle had to follow this structure to be included: Activation, strength, endurance, rest day, match prep and match day.

2.2.2 Exclusion criteria data

Players who did rehabilitation due to injuries or different sessions from the other players were excluded, but only from that specific training session. They were also excluded if they did not participate in >60 minutes of matches. The microcycle was excluded if it contained two or more matches per week. The exclusion criteria were based on previous research (Fernandes et al., 2022; Diaz-Seradilla et al., 2022).

2.3 Data collection and analysis

For the collection of data, a GPS performance tracker with a 18 Hz GPS and 10 Hz augmented GNSS (84 mm x 44 mm x 20 mm) (STATSports, Northern Ireland, United Kingdom) from the Apex pro series was used. The participants wore the vest placed on the upper part of the torso. Both the west and the tracker are shown in Figure 1. After the season ended the data was downloaded from Sonra cloud 4.0 (STATSports, Northern Ireland, United Kingdom) and processed in Excel. Previous research confirms that data from this tracking system is reliable for measuring distance and constant speed (Beato et al., 2018). Internal load was not included due to the lack of ECG technology in the device.

Figure 1. GPS Performance Tracker from Statsports. Sources: eu.shop.statsports.com/products/apex-athlete-series

The velocity thresholds for the chosen variables are in accordance with previous research by Park and colleagues (2019) on elite female soccer athletes. The variables included from the downloaded data was total time used on the field (FT; min), total distance covered (TD; m), distances in high-speed running (HSR; m) defined as a speed between 12.5-19.0 km·h^{-1}, very-high speed running (VHSR; m) determined to a speed between 19.0-22.5 km·h^{-1}, sprinting (SPR; m) defined as speed >22.5 km·h^{-1}, acceleration (ACC; count) with a threshold of > 3 m·s^{-2} and deceleration (DEC; count) with the threshold > -3 m·s^{-2}. To calculate the external load containing TD, HSR, VHSR, SPR, ACC, and DEC all training and match data was summed up and expressed in absolute values.

Table 2. *Number of included observations divided into position for training sessions and match data.*

Positions	*CD (n)*	*CF (n)*	*CM (n)*	*DM (n)*	*FB (n)*	*WM (n)*	*Total (n)*
Training	62 (4)	65 (3)	58 (3)	59 (6)	71 (5)	48 (6)	363 (27)
Match	11 (3)	8 (2)	7 (2)	12 (2)	12 (3)	13 (3)	63 (15)

n= Observations. Number of different players in bracket.

2.4 Statistical analysis

The statistical analysis was performed in SPSS (Program 29.0, windows, IBM, United States). The significance level was set to 0.5. A linear mixed model was used for the statistical analysis. This type of analysis was used to adjust for repeated measures, and to compare the difference between the groups. The subject's ID was used as random factor, and for the dependent variable the following: TD, HSR, VHSR, SPR, ACC and DEC were chosen. The fixed factor was set to position and session, performed in separate analysis. The data was presented as mean, SD and p-value.

Accumulated match data was calculated and was defined as 100%. Accumulated training load was compared and shown in percentage of the calculated match data. To calculate the accumulated match data the average of the clustered means was calculated per playing position, session type and variable. The calculations, and the figures were made in Excel.

3. Results

3.1 Specific external load over a microcycle

The total accumulated external load of match, training week and those two summed up (Microcycle) are presented in Table 3. The total external load for all players during a match was 62 391.6 meters, where 14 749.2 meters were HSR, 2 783.2 meters were VHSR, and 1 012.8 meter were SPR. Thus, the total team load in a microcycle were 173 691.9 meters, of which 30 589.7 meters where in HSR, 5 399.5 meters were VHSR and 1 738.9 meters which were in SPR. ACC and DEC had similar values and ranged from 153.6-276.0 counts.

3.2 Position specific load

Total accumulated training load varied on all variables across the positions. There was 1020.5 m that separates the averaged lowest and highest values for TD during a microcycle, with central midfielder covering least (16 978.5 meters) and defensive midfielder most distance (17 999.0 meters). For HSR all data was between 2100-3100 meters for match data and training load. Fullbacks and wide midfielders had close to the same number of meters for match and training load. During matches central defenders, defensive midfielders and central midfielders covered less meters at VHSR (<400 m) compared to wide midfielders, fullbacks, and central forwards (>500 m). For training load central forwards cover most meters in VHSR (532.7 m) and central midfielders the least (392.2 m). Number of ACC and DEC were higher for all positions during the training week compared to the match. Central midfielders had fewest ACC (108.2) and was the only position with less than 200 counts of DEC (106.2) during the microcycle. Central forwards had most ACC (169.2 counts) and fullbacks performed most DEC (178.6 counts).

Table 3: *Descriptive statistics for the external load for each position.*

Position	*Session*	*TD (m)*	*HSR (m)*	*VHSR (m)*	*SPR (m)*	*ACC (count)*	*DEC (count)*
FB	*Match*	10,718.2 ± 603,7	2,545.9 ± 405.9	559.1 ± 151.1	212.9 ± 132.6	55.4 ± 10.4	83.9 ± 14.9
	Training Load	18,451.7 ± 1397.1 *	2,557.4 ±347.1 *	471.5 ± 96.7 *	156.6 ± 42.8 *	172.8 14.9	192.1 15.4 *
	Microcycle	29,169.9 ± 1746.9	5,103.3 ± 484.1	1,030.6 ± 124.4	369.5 ± 52.7	228.2 ± 14.7	276 ± 16.3
CD	*Match*	10,135.8 ± 327.6	2,192.2 ± 339.4	389.5 ± 162	135.8 ± 59.5	45.6 ± 11.5	54.4 ± 13
	Training load	18,969.5 ± 1348 *	2,482.6 ± 320.3*	402.7 ± 80.1*	112.7 ± 31.2*	154.4 ± 11	160.9 ± 15.4
	Microcycle	29,105.3 ± 3093.6	4,574.8 ± 555.9	779.4 ± 107.6	248.5 ± 37	200 ± 25.1	215.3 ± 27.3
DM	*Match*	11,123.7 ± 1,141.1	3,086.9 ± 556.1	387.2 ± 170.9	68.7 ± 46.3	39.2 ± 8.5	56.6 ± 15
	Training load	18,981.5 ± 1536.5 *	2,863.7 ± 468.7 *	392.2 ± 96.3 *	88.4 ± 29.8	140 ± 14.9 *	156 ± 16.5 *
	Microcycle	30,105.2 ± 2891.6	5,950.6 ± 633.3	779.4 ± 108,4	157.1 ± 30.5	179.2 ± 14.6	212.6 ± 16.5
CM	*Match*	10,441.1 ± 1,141.7	2,335 ± 814.2	394,3 ± 112,4	92.9 ± 31,6	35 ± 5.6	47.9 ± 10.9
	Training load	17,912.4 ±1345.5 *	2,500.3 ± 382.8 *	338.6 ± 68.1 *	71 ± 26.2 *	118.6 ± 8.8	114.5 ± 9
	Microcycle	28,353.5 ± 1,693.9	4,835.3 ± 489,5	732.9 ± 88,0	163.2 ± 29,3	153.6 ± 8,6	162.4 ± 9.4
WM	*Match*	10,746.7 ± 374.9	2,417 ± 321.2	519,8 ± 105	241.8 ± 54,8	52.2 ± 10.3	66.6 ± 11.9
	Training load	17,910.2 ± 1505.8 *	2,464.4 ± 378.5*	491.4 ± 109.4 *	153.6 ±44.3 *	159.6 ± 12 *	139.9 ± 16.2 *
	Microcycle	28,656.9 ± 1842.6	4,881.4 ± 498	1,011.2 ± 130	395.4 ± 57.8	211.8 ± 11.9	206.5 ± 16.7
CF	*Match*	9,226.1 ± 2,027.5	2,172.2 ± 659.6	533.3 ± 162,6	260.7 ± 71.3	62 ± 14.1	62 ± 19.1
	Training load	19,075 ± 1533.5 *	3,072.1 ± 430.3 *	532.7 ± 105.9 *	143.5 ± 42.2 *	184.5 ± 16.7 *	179.9 ± 18.5*
	Microcycle	28,301.1 ± 1702.5	5,244.3 ± 493.7	1,066 ± 127.2	404.2 ± 58.6	246.5 ± 16.6	241.9 ± 18.3

*Note. Statistics shown with mean and standard deviation. Match represents the load for 1. And 2. Half of the game, training load is the sum of all individually averaged training session, and microcycle is the sum of match and training load. TD= total distance in meters, HSR= high-speed running in meters (12.5-19 km·h^{-1}), VHSR= very high-speed running in meters (19.0-22.5 km·h^{-1}), SPR= sprints in meters (>22.5 m·h^{-1}), ACC= acceleration in number of efforts (>3 m·s^{-2}), DEC= deceleration in number of efforts (<-3 m·s^{-2}), *= statistically significant different from match.*

Figure 1 shows that players in all positions had higher accumulated external load during the training week than the match demand when it comes to TD, ACC, and DEC. TD ranged from 167-207% above match load, while ACC (298-357%) and DEC (210%-296%) had the highest values compared to match data. For the other variables external load varied in both “underperformance” and “overperformance” for all positions. Defensive midfielders were the only position that had lower accumulated external load in HSR during trainings compared to match (93%). Central forward had a larger “overperformance” (141%), while the remaining positions had accumulated load values close to the match data (100-113%). For VHSR the highest and second highest value was observed for central defenders and defensive midfielders with 103% and 101%. The remaining positions ranged from 84-100%. The last variable, SPR, “underperformed” during the training week for all positions. The positions with the highest SPR values compared to match data were defensive midfielders (93%) and central defenders (83%). The remaining and lowest values for SPR were central forwards (55%), wide midfielders (64%), fullbacks (74%) and central midfielders (76%).

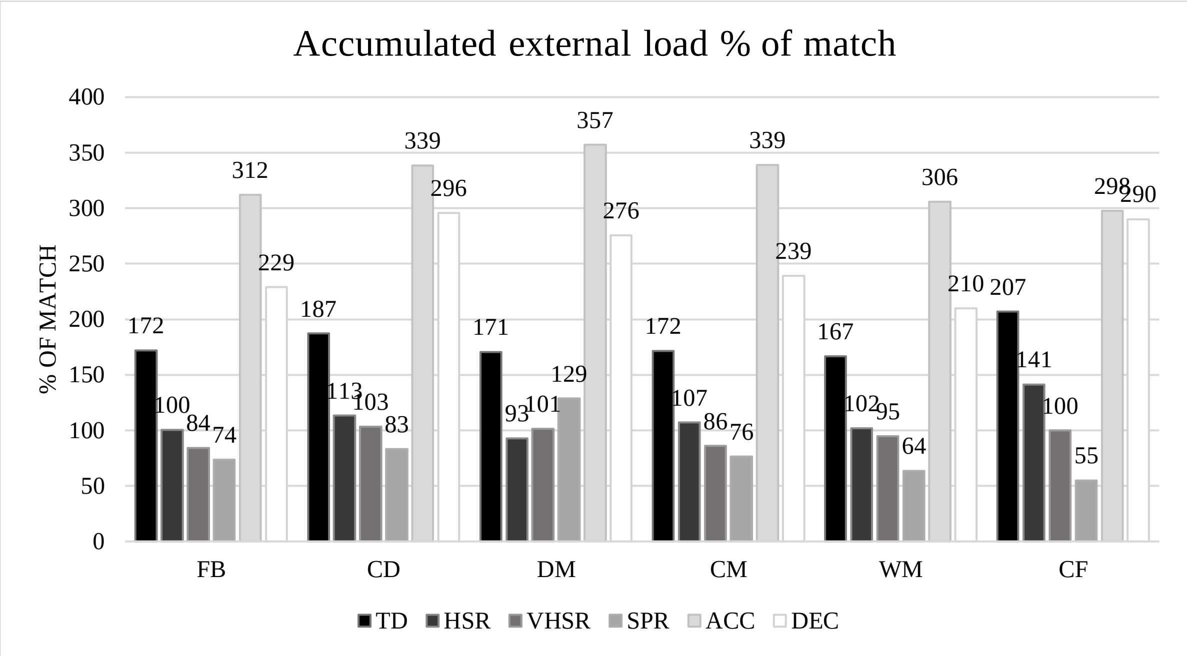


Figure 2: *Accumulated training load presented as a percentage of match demands, where match demands is 100%, divided into positions and variables. CD=central defender, CF=central forward, CM=central midfielder, DM=defensive midfielder, FB=fullback, WM=wide midfielder, TD=total distance, HSR=high-speed run (12.5-19.0 km·h^{-1}), VHSR=very high-speed running (19.0-22.5 km·h^{-1}), SPR=sprint (>22.5 km·h^{-1}), ACC=accelerations (>3 m·s^{-2}), DEC=decelerations (<-3 m·s^{-2}).*

3.3 Comparing session load

Figures 3-8 presents absolute values for accumulated external load in the training sessions. Activation day (MD-5) had the lowest load for all variables except ACC (40 counts) and DEC (35 counts). External load during activation sessions was statistically significantly lower (<0,044) than all other training sessions, except for ACC in endurance sessions (p=0.892), SPR in strength sessions (P= 0.239) and TD in match-prep (p=0.365). Both HSR and SPR in match-prep sessions was marginally significant and not significant (p=0.044, p=0.059) compared to activation sessions. Strength day (MD-4) had the second highest load for TD and HSR and was significantly lower (<0.001) than endurance sessions (MD-3) and significantly higher (<0.001) than match-prep (MD-1). For strength sessions there is only VHSR (p=0.293) and SPR (p=0.494) compared to match-prep that is not statistically different. MD-4 had the highest ACC and DEC values and is significantly higher than all sessions for those two variables (p=<0.001).

The remaining variables for endurance (MD-3) and match-prep (MD-1) had a p-value of <0.001. Endurance (MD-3) both presents the highest values and was significantly higher for TD (p<0.001), HSR (p<0.001), VHSR (p<0.001) and SPR (p<0.001) compared to all training sessions and had second to highest values for ACC (<0.001) and DEC (<0.001). Match-prep sessions (MD-1) had a generally low load and was on the lower half regarding external load for all variables. Match-prep sessions had significantly lower absolute values than endurance sessions on all variables. HSR were significantly lower in match-prep compared to strength (<0.001) and marginally significantly higher in match-prep compared to activation (p=0,044). ACC and DEC were significantly lower for match-prep compared to strength and activation (<0.001).

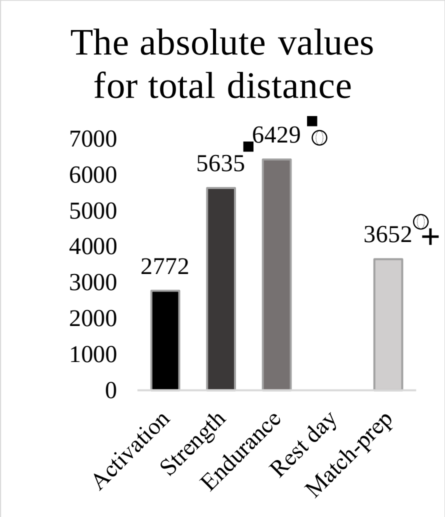


Figure 3: *Accumulated training load presented as average divided into sessions for total distance in meters.*

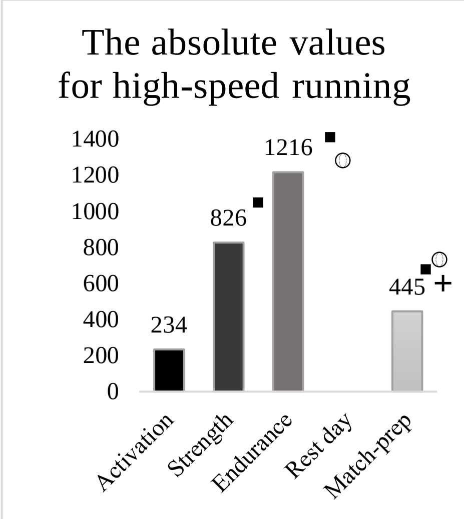


Figure 4: *Accumulated training load presented as average divided into sessions for high-speed running (12.5-19.0 km·h^{-1}).*

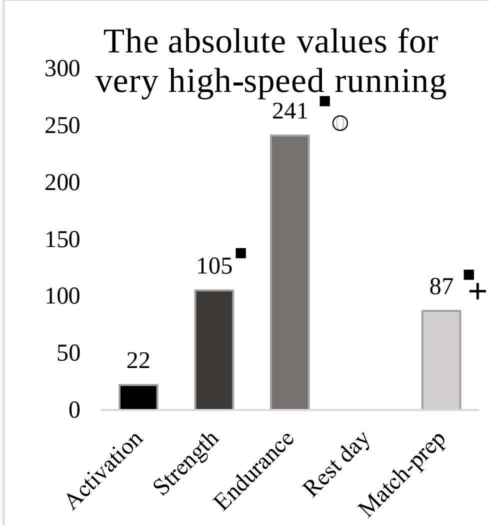


Figure 5*: Accumulated training load presented as average divided into sessions for very high-speed running (19.0-22.5 km·h^{-1}).*

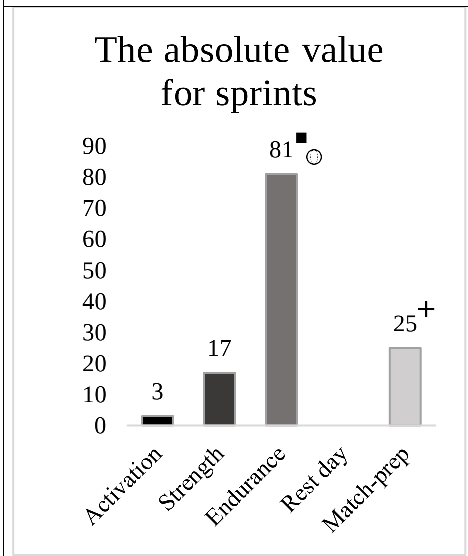


Figure 6: *Accumulated training load presented as average divided into sessions for sprints (>22.5 km·h^{-1}).*

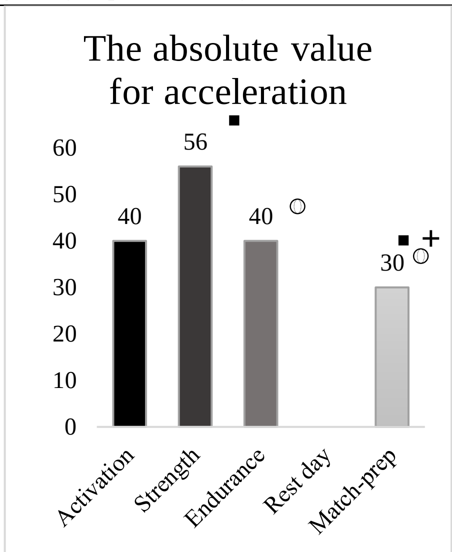


Figure 7: *Accumulated training load presented as average divided into sessions for acceleration (>3 m·s^{-2}).*

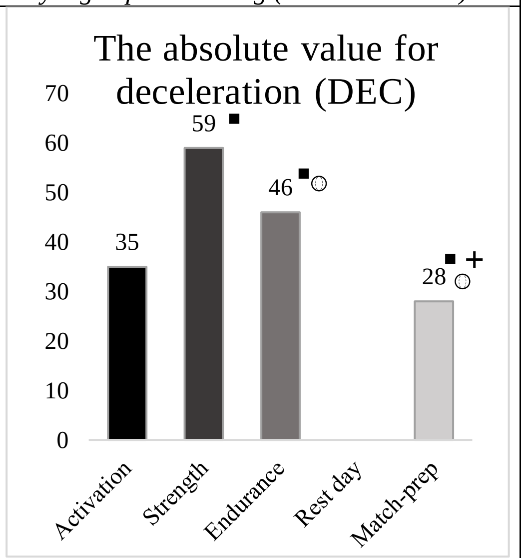


Figure 8*: Accumulated training load presented as average divided into sessions for deceleration (>3 m·s^{-2}).*

4. Discussion

The primary aim of this study was to quantify the external training load demands in a typical one-weekly-match-microcycle in elite female soccer players. To the author`s knowledge, this is one of the first studies investigating specifically this. The accumulated external load was mostly greater during training sessions compared to match. There was a clear trend for TD, ACC, and DEC that the accumulated external load was much higher in training for all positions, while SPR was generally lower during trainings compared to match. Secondary aim for this study was to study potential position specific differences in external load, and differences between training sessions. The analysis showed some differences in external load between positions. Most positions did not have optimal training load for SPR values when comparing to match demands, and one position was lacking optimal HSR values as well. Defensive midfielders were the only position who overperformed compared to match with SPR (129%) and underperformed with HSR (93%). HSR and VHSR were similar between training and match data for most positions, except for central forwards who had 141% overperformance for HSR. Regarding extern load differences in sessions, the analysis showed that external load in days closer to a match (MD-1 and MD-5) was lower, whilst training sessions in the middle of the week (MD-4 and MD-3) had greater load, thus confirming my hypothesize.

4.1 Total external load

The observation of higher absolute values during the training week for TD, HSR ACC, DEC and lower for SPR, compared with match load are in agreement with a former study by Diaz-Serradilla and colleagues (2022). They had a similar structure with one match per microcycle. They found that the external load was lower per session compared to match, except for ACC and DEC which were significantly higher in training compared to match. However, the accumulated external load for the variables are a lot higher for the training sessions compared to the match day. By quantifying the training and match loads, it becomes possible to establish more precise demands profiles for female soccer players. This, in turn, enables effective periodization of training sessions and the implementation of appropriate recovery strategies tailored to this specific population.

4.2 Positions

For most of the positions the external load values varied a lot and there was no apparent trend for which positions had mostly high or low training load. Central forwards had the least number of meters for TD in matches, with 9 226 compared to defensive midfielders with the highest 11 123. Defensive midfielders also had the highest HSR, with the only position with over 3000 meters for that variable. Former studies supported this and found that central defenders covered far less distance compared to midfielders and attackers (Favero & White, 2018; Martín-García et al., 2018; Mohr et al., 2008) and had far less high-speed running values (Diaz-Seradilla et al., 2022; Mohr et al., 2008). Also, the result for central defenders had the second lowest values for TD and HSR, as well as VHSR and DEC. In contrast to the findings of the mentioned studies we observed that central forwards had the lowest values for TD and HSR. However, it is important to note that since it has been used different thresholds (Often not specified) and tracking systems it is difficult to do a direct comparison of these variables.

A former study had similar values for HSR and SPR with as in our study, with 2 520 meters in HSR and 168 meters in SPR (Datson et al. 2017). To underline the importance of HSR, other studies suggest that high-speed activity is widely recognized as a vital part of match performance, given its direct impact on goal-scoring opportunities and consequently, the outcome of the matches. Central forward had the most SPR and amount of ACC, and a lot higher values compared to central midfielders and defensive midfielders. This might be due to the expectation for the position, and that they break into the box as well as run into open spaces to create room and opportunity to score goals (Diaz-Seradilla et al., 2022). Fullbacks and wide midfielders also had more SPR than central midfielders and central defenders, and these positions also have a lot of room on the side of the field where they either sprint to defend their goal or sprint to get closer to the goal. Therefore, it may be beneficial for these positions to have many maximal sprint efforts during the training week. The findings from this study about position specific load indicate that training staff should account for which position the athletes play and adapt drills to allow defensive midfielder to cover great TD and HSR in practice, and central forward to have a high number of ACC and DEC during weekly trainings.

4.3 Sessions

Another important discovery in this study was that MD-3 exhibited the highest external load compared to all other sessions while, the session closer to match day (i.e., MD-1 and MD-5) was found to have lower external load. This is called a pyramid shaped load and is evident in former research claiming the external training load increases towards MD-3 and is highest in the middle of the microcycle and decreases when closing in on the match day (Fernandes et al., 2022; Diaz-Serdilla et al., 2022; Malone et al., 2015; Martín-García et al., 2018; Ramos-Cano, Martín-García & Rizo-Gonzale, 2022; Romero-Romaldera et al., 2021). Former research found that the average of TD covered during conditioning and tactical training (MD-4: 4831 ± 860 m; MD-3 4975 ± 1318 m), slightly higher for findings in the present study (MD-4: 5635 m, MD-3: 6429 m) (Fernandes et al., 2022; Diaz-Serdilla et al., 2022; Malone et al., 2015; Martin-Garcia et al., 2018; Ramos-Cano, Martín-García & Rizo-Gonzale, 2022; Romero-Romaldera et al., 2021). This pyramid load distribution of increasingly higher load and then decreasing it again can seem like is the most used periodization to promote readiness to perform and to recover from accumulated fatigue.

Ramos-Cano and colleuges (2022) suggest that most microcycle should contain a rest day. In addition they state that after a match day often comes a rest day or low load day which in our study was also the case with MD-2 being a rest day and the activation sessions (MD-5). This can give the players time to recover from the high demands of the game. Activation (MD-5) and match-prep (MD-1) sessions were the trainings with the least amount of load for most variables in our study and was statistically different from most of the strength and all of the endurance sessions. Findings from another study builds up under this and found a significant differences for ACC and DCC between MD-1 and the rest of the training sessions (Diaz-Seradilla et al., 2022). The lower values observed for MD-5 and MD-1 compared to the other sessions may be explained by the content of the sessions with lower load, containing higher intensity for shorter periods of time.

Endurance had significantly more TD, HSR, VHSR and SPR compared to all other sessions, and significantly higher ACC and DEC compared to activation and match-prep while being signfincantly lower than strength. As mentioned earlier, our “strength session” had a significantly higher number of ACC and DEC than the other sessions. This may be because they had a maximal effort focus, often involving small-sided games with high tempo and then longer breaks and maximal sprints (Diaz-Seradilla et al., 2022). Former research that investigated TD, HSR, ACC and DEC found that the external load for these variables where higher in matches compared to training ($p=<0.05$), this aligns with findings for the same variables except for ACC and DEC in our study (Diaz-Seradilla et al., 2022). Our study also found that players cover between 9 226-11 124 meters for TD and perform HSR between 2 172-3 086 meters for match days. Compared to another study, which reported that in a match day TD was 8760-10 050 m and HSR was 620-2200 meters (Ramos-Cano, Martín-García & Rizo-Gonzale, 2022) our findings were a bit higher for TD and a lot higher than HSR. On the other hand, it can be difficult to compare since they might have used different thresholds and inclusion and exclusion criteria for the included data. For example, in this study we used 12.5-19.0 $km \cdot h^{-1}$ threshold for HSR, while in the study by Ramos-Cano and colleagues (2022) they used >16 $km \cdot h^{-1}$, which to some extent explains why our findings were a lot higher that their findings for HSR.

4.4 Limitations

Despite the importance of studying training load for female soccer players this study does not come without limitations. The recalculation to full match probably leads to an overestimation of match load because it does not take into consideration that players get fatigued towards the end of a match (Mohr et al., 2008). This might impact the findings and resulting in the external load being slightly higher than it would have been if the athletes had played the whole match. Due to lack of research on the topic and population there is less reference data and fewer protocols to follow when research female elite players. Due to the small study population of only 21 in one specific team only, it is not recommended to generalize the results from this study. Due to the rapid changes in schedule and competing in multiple tournaments there were fewer weeks with the adequate structure with one match per microcycle. We did not include any internal load measurements due to the lack of such features on the devices. This might lead to a different view on the training load. Lastly, it is important to interpret with caution when comparing data across studies that have employed varying data capture methods, thresholds, and tracking systems (Datson et al., 2017).

4.5 Conclusion

HSR, VHSR, SPR, ACC and DEC had both higher and lower load in trainings compared to match when investigating positional differences which was in partial agreement with my hypothesize. TD varied and was higher in match compared to the absolute values in training sessions which is in line with my hypothesize. On the other hand, midfielders only had higher load than defenders on some variables, which was partially supported compared to my hypothesize. Lastly, the results revealed that the external load was highest for MD-3 compared to the remaining training sessions confirming my hypothesize. The load also increases from MD-5 until MD-3 and then decreases from MD-3 towards the match day. This specific information can be used to plan to make the load better fitted for every player. The data demonstrate that the external load of a microcycle varied based on the players training day of the week and position. This could be useful knowledge for practitioners to manage load and give a better understanding about position specific external load and contribute to minimizing the existing research gap on female soccer players.

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4. Practical application

It is important to have good knowledge about training load and how this impacts different players. The present study revealed that there is a large difference in match demands compared to training, which should be considered when players are preparing for competition. It is important to note that having a micro-cycle structured week makes it easier to adjust intensity and focus on different objectives which in turn can enhance the match performance. By tracking players external training load throughout a training week and match day it can give insight into effectiveness of trainings as well as minimizing fatigue and injuries. Further, more research is needed on different types of microcycles with 2-3 matches per week, to find the impact that type of training load will have on this population.

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