Master's thesis

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

Sivert Falle Risan

Position-Specific Weekly External Training Load Relative to Match Demands in Elite Male Football

Master's thesis in Physical Activity and Health - Movement Science
Supervisor: Ulrik Wisløff
Co-supervisor: Arnt-Erik Tjønna
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Infographic

Position-specific Weekly Training Load relative to Match Demands in Elite Football

Aim: Quantify and compare the position specific weekly training load in a one- and two-match structured microcycle and determine match demands.

Methods: 22 elite football players. Data from 35 games, 6 one-match structured microcycle and 7 two-match structured microcycle.

Weekly training load as percentage of match demands:

One-match structured microcycle

High-intensity Running
92-154%

Sprint distance
71-163%

Number of Sprints
58-100%

Distance >90% of max velocity
0-222%

Two-match structured microcycle

High-intensity Running
6-25%

Sprint distance
0-13%

Number of Sprints
0-14%

Distance >90% of max velocity
0%

Conclusion

- Lack of specificity
- Some positions at risk of underloading and overloading
- Two-match scheduled microcycle provoked the lowest load

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Abstract

Purpose: This study aimed to quantify the position specific weekly external training load of a one- and two-match structured microcycle and determine match demands in professional Norwegian male elite football players.

Methods: Twenty-two male elite football players playing in the highest league in Norway participated in the study. Physical performance in sixteen home games, nineteen away games, six one-match structured microcycles and seven two-match structured microcycles were tracked with the same global navigation system and analyzed through linear mixed models. Players were split into full backs, central defenders, defensive midfielders, central midfielders, wide midfielder, and central forward.

Results: Sprint (71-163%), number of sprints (58-100%) and distance >90% of maximum velocity (0-222%) showed wide variations in weekly training load of a one-match structured microcycle relative to match demands. High-intensity running (92-154%) was close to replicate match demands in all positions, although not all differences reached significance. Total distance (175-204%) and accelerations (179-230%) overperformed match demands. Weekly training load of a two-match structured microcycle displayed lower load compared to one-match structured microcycle and underperformed match demands in all variables.

Conclusion: The results expressed positional differences in weekly training load of sprint, number of sprints and distance >90% of maximum velocity relative to match demands. There is a need of more specificity and individualization during training in male elite football players. As expected, two-match structured microcycle provoked lower training load compared to one-match structured microcycle.

Keywords: High-intensity actions, high-intensity running, sprint, >90% of max velocity, number of sprints, playing position, starters

Sammendrag

Hensikt: Hensikten med denne studien var å kvantifisere posisjonsspesifikk ukentlig ekstern treningsbelastning i en-kamp og to-kamp strukturert treningsuke og fastslå kampkrav hos profesjonelle norske mannlige elite fotballspillere.

Metode: 22 mannlige elite fotballspillere i den øverste ligaen i Norge deltok i studien. Fysisk prestasjon i 16 hjemmekamper, 19 bortekamper, 6 en-kamp strukturerte treningsuker og 7 to-kamp strukturerte treningsuker ble målt med samme globale navigasjonssystem og analysert gjennom lineære blandede modeller. Spillerne ble fordelt i seks ulike posisjoner: sidebacker, midtstoppere, defensive midtbanespillere, sentrale midtbanespillere, brede midtbanespillere og sentrale angripere.

Resultater: Sprint (71-163%), antall sprinter (58-100%) og distanse >90% av maksimal hastighet (0-222%) viste store variasjoner i ukentlig treningsbelastning ved en-kamp strukturert treningsuke i relasjon til kampkrav. Høyintensitetsløp (92-154%) var nær å gjenskape kampkrav i alle posisjoner, selv om ikke alle forskjellene var signifikante. Total distanse (175-204%) og akselerasjoner (179-230%) overgikk kampkrav. Ukentlig treningsbelastning i to-kamp strukturert treningsuke viste lavere belastning sammenlignet med en-kamp strukturert treningsuke, og underbelastet kampkravene i alle variabler.

Konklusjon: Resultatene uttrykker posisjonelle forskjeller av ukentlig treningsbelastning i sprint, antall sprinter og distanse >90% av maksimal hastighet i relasjon til kampkrav. Det er et behov for mer spesifisitet og individualisering i trening for mannlige elite fotballspillere. To-kamp strukturert treningsuke viste som forventet lavere treningsbelastning enn en-kamp strukturert treningsuke.

List of Abbreviations

No. ACC = Number of accelerations

CD = Central defender

CF = Central forward

CM = Central midfielder

DM = Defensive midfielder

FB = Full back

GNSS = Global navigation satellite system

HIR = High-intensity running

MD = Matchday

MC1 = Microcycle-1

MC2 = Microcycle-2

No. Sprint = Number of sprints

WM = Wide midfielder

>90%MV = Above 90% of maximum velocity

1. Introduction

Football is a complex team sport that involves eleven starting players who will perform their best in their assigned playing position and tactical role. Many factors such as technical/biomechanical, tactical, mental, and physiological can affect the performance (Stolen et al., 2005). The game includes a great variety of movements and intensities ranging from walking to standing to sprinting and maximal accelerations (Bradley et al., 2010; Ingebrigtsen et al., 2015; Mohr et al., 2003; Rampinini et al. 2007). Tracking players physical performances during training sessions and matches has become an essential instrument of modern footballs planning and application of training loads (Akenhead & Nassis, 2016). Analysis of high-velocity actions during match play can help practitioners and coaches to control players training load to optimize preparation for upcoming competitions (Di Salvo et al., 2007). Training load should simulate or intensify the match demand of high-intensity actions (Campos-Vazquez et al., 2021) to avoid decline of physical performance during a season (Di Salvo et al., 2007) and reduce risk of injuries (Buchheit & Simpson, 2017; Cummins et al., 2013; Gabbett, 2016).

External load is the physical work prescribed in training or match and can in team sports be assessed as total distance covered in specific speed bands and accelerations (Impellizzeri et al., 2005; Impellizzeri & Marcora, 2019; McLaren et al., 2018). External physical load is measured by Global Position Systems and Clemente et al. (2019) defines it as physical demands that arise in training and match situations. High-intensity actions are short activity of intense actions including high-intensity running, sprint and number of sprints (Di Salvo et al., 2009). According to Mohr et al. (2003) is running at higher velocities related to success, as players at higher levels are found to perform greater distances of high-intensity running during a game than moderate professional players. But the distance of high-intensity running differs between playing positions on the field (Baptista et al., 2018; Bradley et al., 2009; Di Salvo et al., 2009; Ingebrigtsen et al., 2015**).** Modern football is evolving, and the physical requirements are changing, which is shown by an increase of 30-35% of sprint and high-intensity running distance in the English Premier League (Barnes et al., 2014). A recent study in Spanish La Liga found an increase of 2-10% in high-intensity (>21 $km \cdot h^{-1}$) distance and 9-14% increase in number of high-intensity runs (Lago-Peñas et al., 2022). Previous studies on match play in the Norwegian elite league (Ingebrigtsen et al., 2015) and English Premier League (Bradley et al., 2009) have found lateral players to cover 9-56% more sprint distances compared to central playing positions. Di Salvo et al. (2010) and Ingebrigtsen et al. (2015) found that sprint characteristics are dependent on playing position, and lateral playing positions performed a 15-52% higher number of sprints compared with central playing positions. Research has shown that individual maximal running velocity increased between 2006-2013 in the English Premier League (Barnes et al., 2014). This actualizes the use of higher speed bands, and a recent study investigated the number of runs above 90% of players individual maximum sprint velocity. To the best of authors knowledge, no study has quantified and compared the distance >90% of maximum velocity in training with match play.

Several previous studies have investigated the position specific match load of professional football players among others, Europa League (Andrzejewski et al., 2013), Norwegian elite league (Baptista et al., 2018; Ingebrigtsen et al., 2015) and the English Premier League (Bloomfield et al., 2007; Bradley et al., 2009; Di Salvo et al., 2009). However, there is a lack of information about the position specific weekly external training load compared to match demands. Reporting training load relative to match demands can facilitate individual training prescription with the goal of preparing players for competitions (Stevens et al., 2017). A microcycle is normally considered as one week of training (Anderson et al., 2016), where training sessions are characterized by the number of days before matchday (MD). For instance, MD-1 refers to the session one day before the next match. Most of previous research have compared the load of separate training days within a microcycle (Akenhead et al., 2016; Martin-Garcia et al., 2018; Oliveira et al., 2019; Stevens et al., 2017). Some players participate in international matches for their country, in addition to national- and European competitions for their club, which often leads to weeks that include more than one competitive match. Two recent studies have investigated the training load of separate days during one- two- and three game week schedules in the English Premier League (Anderson et al., 2016) and a top European team participating in the UEFA Champions League (Oliveira et al., 2019). Both studies, supported by previous research, observed a decrease in external training load as the matchday approaches, with particularly MD-1 displaying the lowest load (Akenhead et al., 2016; Anderson et al., 2016; Malone et al., 2015; Oliveira et al., 2019).

In order to optimize the conditions for performance and identifying players that are inadequately loaded, there is a need of in-depth knowledge of competition and training loads within a microcycle (Drew & Finch, 2016; Gabbett, 2016; Gabbett & Whiteley, 2017). Recently three studies on teams in Dutch Eredivisie (Stevens et al., 2017), Portuguese first league (Clemente et al., 2019) and Norwegian elite league (Baptista et al., 2019) reported the relationship between weekly training load and match demands. However, only Baptista and colleagues (2019) included position specific load in the comparison, and despite the importance of understanding relationships between match demands and weekly external training load there is still a need of analyzing how such relationships occur in football players. The primary objective of training should be to replicate the high-intensity actions demanded by the game to be prepared for upcoming competitions (Campos-Vazquez et al., 2021; Di Salvo et al., 2007).

Thus, the aim of this study was to quantify position specific weekly external training load of a one- and two-match structured microcycle, and determine match demands in professional Norwegian male elite football players.

We hypothesize that 1) players will cover more sprint distance and distance >90% of maximum velocity during a full match compared to both microcycles (one-match structured microcycle and two-match structured microcycle) and 2) that the training load of a one-match structured microcycle is higher compared to a two-match structured microcycle due to the decrease of load as matchday approaches.

2. Material and methods

2.1 Subjects

Twenty-two male football players (mean ± SD: 25.5 ± 4.8 years, 183.8 ± 5.9 cm, and 79.5 ± 7.9 kg), from the first team of a Norwegian elite club competing on the highest level (Eliteserien) participated in this study. They played in a 1-4-3-3 formation and the players were split into the following six playing 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. During the season players played matches in different positions. The specified position for each player during the microcycle was decided by the players playing position in the game in each specific week. Investigation has been performed in accordance with the requirements presented in the Declaration of Helsinki.

2.2 Design

An observational cohort study was used in this study. Data from all matches and training sessions were collected during the 2021 season through the same portable tracking system. The football team in this study competed in three different competitions including national league (Eliteserien), national cup (Norwegian Cup), and qualifiers for European tournament. A total of 39 games were played, but due to change of playing formation in two of the games and an early given red card in two of the games, four games were excluded. Consequently, data from 35 competitive games both home (n=16) and away (n=19) were analyzed. For the match observation to be included in the final analysis players had to play at least 60 minutes and play in the same position throughout the game as established by Stevens et al. (2017). Only players playing minimum 60 minutes were included in match and microcycles analyses and are characterized as starters. All included match observations were recalculated to the average of a full-game durations of all included games (95.4 minutes).

Training session were characterized by the number of days before matchday (MD). For instance, MD-3 refers to sessions three days before the next game. This study includes two different structured microcycles. The typical full microcycles included six full days of training, match, and restitution day in two different combinations. A microcycle including one matchday (microcycle-1) includes four main sessions, one match and one restitution day (MD-4, MD-3, MD-2, MD-1) (Table 1). The typical microcycle for a week including two matchdays (microcycle-2) includes two main sessions, two matches and two restitution days (MD-1, MD-1) (Table 2). The season was shortened due to the outbreak of COVID-19, leading to an increased number of weeks with multiple matches. A total of six microcycle-1 and seven microcycle-2 were included in the study. Only players who participated and finished all sessions and played a minimum of 60 minutes in the matches are included in the study and are characterized as starters. The day after match starters normally performed a restitution session inside which is not included in the study, unless given the day off.

Table 1: *Structure of microcycle-1 with one match*

Week	Training	Training	Training	Training	Match	Rest day
Microcycle-1	MD-4	MD-3	MD-2	MD-1		

Table 2: *Structure of microcycle-2 with two matches*

Week	Training	Match	Rest day	Training	Match	Rest day
Microcycle-1	MD-1			MD-1		

2.3 Data collection and Analysis

The external load was collected by using a combination of a 10Hz global navigations system (GNSS) position (Catapult, Melbourne, Australia) and a local portable system at 10Hz (Catapult Clearsky, Melbourne, Australia). 10Hz position systems are in previous studies found to be a reliable and valid method for measuring external load (Rampinini et al., 2015). All players wore their own vest with a portable 10Hz GNSS tracking unit (figure 1) placed in a specially designed pocket between the shoulder blades, which collected physical performance data. Data was analyzed after data collection using Openfield Cloud Analytics (Catapult Openfield 3.3.1). The external load variables included total distance (m), high-intensity running (m, 19.8-25.2 $km \cdot h^{-1}$), sprint distance (m, >25.2 $km \cdot h^{-1}$), distance above 90% of max velocity (m, >90% of individual maximum velocity), number of sprints (counts >25.2 $km \cdot h^{-1}$), and accelerations (counts >2$m \cdot s^{-2}$). Velocity thresholds are based on previous research (Bradley et al., 2009; Dalen et al., 2016; Ingebrigtsen et al., 2015; Rampinini et al., 2007). The accelerations counts are set by the standards of catapult and the three criteria for an acceleration in the Catapult Tracking System are 1) the acceleration reaches the minimum of 2 $m \cdot s^{-2}$, 2) the acceleration must remain above this threshold for at least 0.6 seconds, and 3) the acceleration must drop below the minimum limit for at least 1 second before the player can reach another effort. This threshold was standardized by Catapult Sports.

The weekly training load was calculated by summing all main sessions in each individual microcycle. Then calculated the means for each physical performance variable in each position. Match demands was calculated by pooling players into their playing position. Then averages were calculated in each physical performance variable for each position.

Figure 1: *Illustration of a Catapult Vector S7 Vest and 10Hz GPS tracking unit.*

2.4 Statistical Analyses

All statistical analyses were performed in SPSS (IBM Corp Released 2020. IBM SPSS Statistics for Macintosh, Version 27.0. Armon, NY: IBM Corp). All data are presented as mean ± standard deviation (SD), unless otherwise stated. Descriptive statistics were used to find means and, minimum and maximum values (range) for all variables and positions in the different sessions. Differences within positions and between match, microcycle-1 and microcycle-2 were analyzed through linear mixed model. Subject ID was defined as random factor, with position and session type as fixed effects, and all external load variables as dependent variable. The same procedure was performed comparing match demands to microcycle-1 and microcycle-2. The level of significance was set to $P<.05$.

3. Results

3.1 Overview of observations

The final analyzed data and distribution of observations in match play, microcycle-1 and microcycle-2 data can be found in *Table 3*.

Table 3: *Number of included observations across session types and playing position.*

Session	FB	CD	CM	DM	WM	CF	Total Files
Match	65 (n=4)	67 (n=6)	34 (n=6)	57 (n=10)	50 (n=7)	29 (n=3)	302 (n=22)
Microcycle-1	11 (n=4)	8 (n=4)	4 (n=3)	5 (n=3)	5 (n=3)	1 (n=1)	32 (n=15)
Microcycle-2	11 (n=2)	10 (n=5)	1 (n=1)	2 (n=2)	4 (n=2)	5 (n=3)	33 (n=15)

Data are presented as number of included match data observations (number of separate player observations). FB=full back, CD=central defender, DM=defensive midfielder, CM=central midfielder, WM=wide midfielder, CF=central forward.

3.2 Match demands

External load of match demands is presented in *Table 4*. All positions across covered an average of 541 ± 206 meters of high-intensity running distance. Fullback covered 28-58% ($p<.05$) more high-intensity running distance than central defender, defensive midfielder and central forward. Wide midfielder covered 45% ($p<.05$) and 19% ($p<.05$) more high-intensity running distance than central defender and defensive midfielder in match play. No other differences were found in high-intensity running. All positions across covered an average of 137 ± 93 meters distributed over an average of 7 ± 4 number of sprints. Fullback was the position with the greatest (240 ± 88 m) sprint distance covered resulting in 42-71% ($p<.05$) more than every other position. Fullback performed 42-67% ($p<.05$) greater number of sprints than central defender, defensive midfielder, central midfielder, and central forward. Central-forward performed 43% ($p<.05$) higher number of sprints than central defender. No other differences were found in sprint distance or number of sprints. All positions across covered an average of 12 ± 17 meters >90% of maximum velocity. As the only difference found between all the positions for distance >90% of maximum velocity, wide midfielder presented 44% ($p<.05$) more distance than centra midfielder.

Table 4: *Quantification of external match load across playing positions in a Norwegian elite male football team.*

	Variables	Average mean +- SD Match load	P<0.05 Match load	Range Match load
FB	**Total distance**	10973 ± 418	*bcd*	9560-11773
	HIR	715 ± 138	*bcf*	326-1018
	Sprint	240 ± 88	*bcdef*	73-445
	Distance >90%MV	13 ± 20		0-86
	No. Sprints	12 ± 4	*bcde*	2-23
	No. Acceleration	132 ± 16	*b*	95-179
CD	**Total distance**	9661 ± 545	*acde*	8312-11172
	HIR	302 ± 91	*acdef*	68-535
	Sprint	69 ± 46	*ad*	0-195
	Distance >90%MV	10 ± 13		0-44
	No. Sprints	4 ± 3	*adef*	0-10
	No. Acceleration	96 ± 15	*acdef*	63-129
DM	**Total distance**	10968 ± 833	*abef*	9471-13957
	HIR	447 ± 172	*abde*	153-775
	Sprint	88 ± 69	*a*	6-264
	Distance >90%MV	14 ± 16		0-57
	No. Sprints	4 ± 3	*ad*	0-12
	No. Acceleration	130 ± 24	*bd*	77-183
CM	**Total distance**	11461 ± 647	*abef*	10218-13363
	HIR	685 ± 181	*bcf*	223-1268
	Sprint	137 ± 82	*ab*	0-296
	Distance >90%MV	9 ± 13	*e*	0-44
	No. Sprints	7 ± 4	*abc*	0-17
	No. Acceleration	142 ± 24	*bcef*	42-193
WM	**Total distance**	10331 ± 723	*bcdf*	8667-12012
	HIR	553 ± 113	*bc*	393-814
	Sprint	139 ± 73	*a*	0-361
	Distance >90%MV	17 ± 24	*d*	0-126
	No. Sprints	7 ± 3	*ab*	0-15
	No. Acceleration	118 ± 24	*bd*	14-157
CF	**Total distance**	9904 ± 648	*cde*	8320-11801
	HIR	515 ± 105	*abd*	273-664
	Sprint	120 ± 60	*a*	31-221
	Distance >90%MV	8 ± 15		0-60
	No. Sprints	7 ± 3	*b*	1-11
	No. Acceleration	112 ± 15	*bd*	83-141

Data are presented as mean ± SD and Coefficient of variation as percentage (Range, Min-Max). Significance is presented as comparison between all positions in the team. Total Distance, High-Intensity Running, Sprint distance and >90%MV are presented in meters and Number of Sprints and Accelerations are in efforts (counts). FB=full back, CD=central defender, DM=defensive midfielder, CM=central midfielder, WM=wide midfielder, CF=central forward, HIR=high-intensity running (19.8-25.2 km · h^{-1}), Sprint= sprint distance (m, >25.2 km · h^{-1}), No. Sprints=number of sprints, No. Acceleration=number of accelerations (>2 m·s^{-2}). Statistically significant difference p<.05. a=statistically significant to FB, b=statistically significant to CD, c=statistically significant to DM, d=statistically significant to CM, e=statistically significant to WM, f=statistically significant to CF.

3.3 Total external training load

3.3.1 Quantification of microcycle-1 and microcycle-2

The external weekly training load of microcycle-1 and microcycle-2 is presented in *Table 5*. During microcycle-1, fullback covered more high-intensity running distance compared to central defender (38%, p<.05) and defensive midfielder (38%, p<.05). No other positional differences were found for high-intensity running or sprint distance in microcycle-1. Although, fullback showed a tendency towards higher sprint distance compared to defensive midfielder (56%, p=.083) and less sprint distance compared to central midfielder (19%, p=.074). Fullback, central midfielder, and wide midfielder performed a higher number of sprints compared to central defender (50-57%, p<.05) and defensive midfielder (57-62%, p<.05). Central midfielder also showed a tendency towards higher number of sprints than fullback (12%, p=.056). During microcycle-2, fullback and wide midfielder covered more high-intensity running distance compared to central defender (55%, p<.05), central midfielder (70-71%, p<.05) and central forwards (62%, p<.05). Fullback covered 72-100% (p<.05) more sprint distance compared to central defender, wide midfielder, and central forward during microcycle-2. No positional differences (p>.05) found in total distance and >90% of maximum velocity in either microcycle-1 or microcycle-2.

3.3.2 Comparison between microcycle-1 and match demands

During the microcycle-1 central defender covered 35% (p<.05) less high-intensity running distance in match play compared to microcycle-1. No other differences were found in high-intensity running. Fullback showed 29% (p<.05) less sprint distance and 43% (p<.05) lower number of sprints compared to match demands. No other differences were found in sprint distance and number of sprints between microcycle-1 and match play. Although central defender showed a tendency towards more sprint distance in microcycle-1 (37%, p=.058). Fullback and wide-midfielder covered 56% and 57% (p<.05) lower distance >90% of maximum velocity in microcycle-1 compared to match play. All positions across covered an average of 48% (p<.05) more total distance in microcycle-1 than in match play.

3.3.3 Comparison between microcycle-2 and match demands

In microcycle-2, every position covered between 75-94% (p<.05) less high-intensity distance compared to match play. More sprint distance was covered in match play for fullback (87%, p<.05), central defender (90%, p<.05), defensive midfielder (100%, p<.05), wide midfielder (95%, p<.05) and central forward (92%, p<.05) than during training in microcycle-2. Every position performed 87-100% (p<.05) lower number of sprints than the match demands. Fullback and central defender covered respectively 97% (p<.0.5) and 100% (p<.05) less distance >90% of maximum velocity in training compared to match play.

3.3.4 Comparison between microcycle-1 and microcycle-2

All positions covered 73-94% (p<.05) greater distance of high-intensity running in microcycle-1 compared to microcycle-2. More sprint distance was observed in microcycle-1 for fullback (82%, p<.05), central defender (94%, p<.05), wide midfielder (100%, p<.05) and central forward (100%, p<.05) than microcycle-2. Fullback (80%, p<.05), central defender (83%, p<.05) and wide midfielder (93%, p<.05) also performed a higher number of sprints in microcycle-1. No differences in distance >90% of maximum velocity were found in any positions between microcycle-1 and microcycle-2.

Table 5: *Quantification of total external training load across playing position for microcycle-1 & microcycle-2.*

Position	Variable	Average mean ± SD MC1	MC2	P<0.05 MC1	MC2	Range MC1	MC2
FB	**Total distance**	20744 ± 2197	7130 ± 976	#	#	17799-23993	5659-8852
	HIR	752 ± 137	137 ± 63	*bc* #	*bdf* #	336-1290	62-264
	Sprint	171 ± 103	32 ± 30	#	*bef* #	31-338	0-88
	>90%MV	6 ± 15	0 ± 1			0-50	0-4
	No. Sprints	7 ± 3	1 ± 1	*bc* #	#	2-13	0-3
	No. ACC	273 ± 51	72 ± 19	*b* #	#	186-368	46-205
CD	**Total distance**	19747 ± 2338	6686 ± 970	#	#	16874-23045	5283-8407
	HIR	464 ± 199	62 ± 29	*a* #	*ae* #	258-854	11-98
	Sprint	109 ± 95	7 ± 9	#	*a* #	15-290	0-20
	>90%MV	4 ± 7	0 ± 0			0-16	0-0
	No. Sprints	3 ± 2	1 ± 1	*ade* #	*a* #	0-6	0-2
	No. ACC	221 ± 40	51 ± 16	*ad* #	*a* #	172-271	21-70
DM	**Total distance**	20687 ± 3530	7066**	#	#	17846-25834	7066**
	HIR	463 ± 170	32**	*a* #	#	308-647	32**
	Sprint	76 ± 56	0**			18-145	0**
	>90%MV	10 ± 20	0**			0-39	0**
	No. Sprints	3 ± 2	0**	*ade*		1-4	0**
	No. ACC	260 ± 50	75**	#	#	219-333	75**
CM	**Total distance**	20961 ± 1692	6873 ± 697	#	#	18809-23135	6380-7365
	HIR	669 ± 261	42 ± 28	#	*ae* #	457-1111	22-61
	Sprint	211 ± 158	1 ± 1			69-458	0-2
	>90%MV	20 ± 34	0 ± 0			0-79	0-0
	No. Sprints	8 ± 3	0 ± 0	*bc*		4-11	0-0
	No. ACC	283 ± 33	55 ± 22	*be* #	#	247-317	39-70
WM	**Total distance**	18716 ± 1322	6914 ± 962	#	#	16903-20547	5874-7850
	HIR	506 ± 201	138 ± 77	#	*bdf* #	332-839	70-243
	Sprint	127 ± 83	7 ± 5	#	*a* #	75-274	0-13
	>90%MV	0 ± 0	0 ± 0			0-0	0-0
	No. Sprint	7 ± 2	1 ± 1	*bc* #	#	5-9	0-1
	No. ACC	228 ± 15	72 ± 24	*d* #	#	109-243	37-84
CF	**Total distance**	17357**	6347 ± 1134	#	#	17357**	5179-7478
	HIR	608**	52 ± 42	#	*ae* #	608**	15-124
	Sprint	196**	9 ± 10	#	*a* #	196**	0-25
	>90%MV	0**	0 ± 0			0**	0-0
	No. Sprints	6**	1 ± 1	#	#	6**	0-1
	No. ACC	200**	52 ± 23	#	#	200**	22-82

Data are presented as mean ± SD and Coefficient of variation as percentage (Range, Min-Max). Significance is presented as comparison between all positions in the team. Total Distance, High-Intensity Running, Sprint distance and >90%MV are presented in meters and Number of Sprints and Accelerations are in efforts (counts). FB=full back, CD=central defender, DM=defensive midfielder, CM=central midfielder, WM=wide midfielder, CF=central forward, HIR=high-intensity running (19.8-25.2 km·h^{-1}), Sprint= sprint distance (m, >25.2 km·h^{-1}), No. Sprints=number of sprints, No. ACC=number of accelerations (>2 m·s^{-2}), MC1=microcycle-1, MC2=microcycle-2. Statistically significant difference p<.05. a=statistically significant to FB, b=statistically *significant to CD, c=statistically significant to DM, d=statistically significant to CM, e=statistically significant to WM, f=statistically significant to CF, #=significant to similar position in the other microcycle.*

3.4 High-intensity action profiles of microcycles including match load

Figure 2 presents the distribution of high-intensity actions (high-intensity running, sprint distance, >90% of maximum velocity and number of sprints) between training load of microcycle-1 and match demands. 100% refers to a total microcycle including match. High-intensity running was equally distributed between training and match with a range of 44-55% of the distance occurred in training. It is a clear tendency that training load of microcycle-1 consists of lower percentage of the higher-intensity actions. 39-54% of sprinting distance and 0-61% of distance >90% of maximum velocity occured during training. Number of sprints was underperformed in every position with 32-48% occurred in training.

Figure 3 presents the distribution of high-intensity actions between training load (microcycle-2) and match demands. 100% refers to a complete microcycle including two matches. 3-16% of high-intensity running distance occured in the training load (microcycle-2). 0-6% of sprint distance and 0-6% of the number of sprints is performed during training in the total microcycle including two matches. Fullback was the only position presenting any percent of distance >90% of maximum velocity in the microcycle-2.

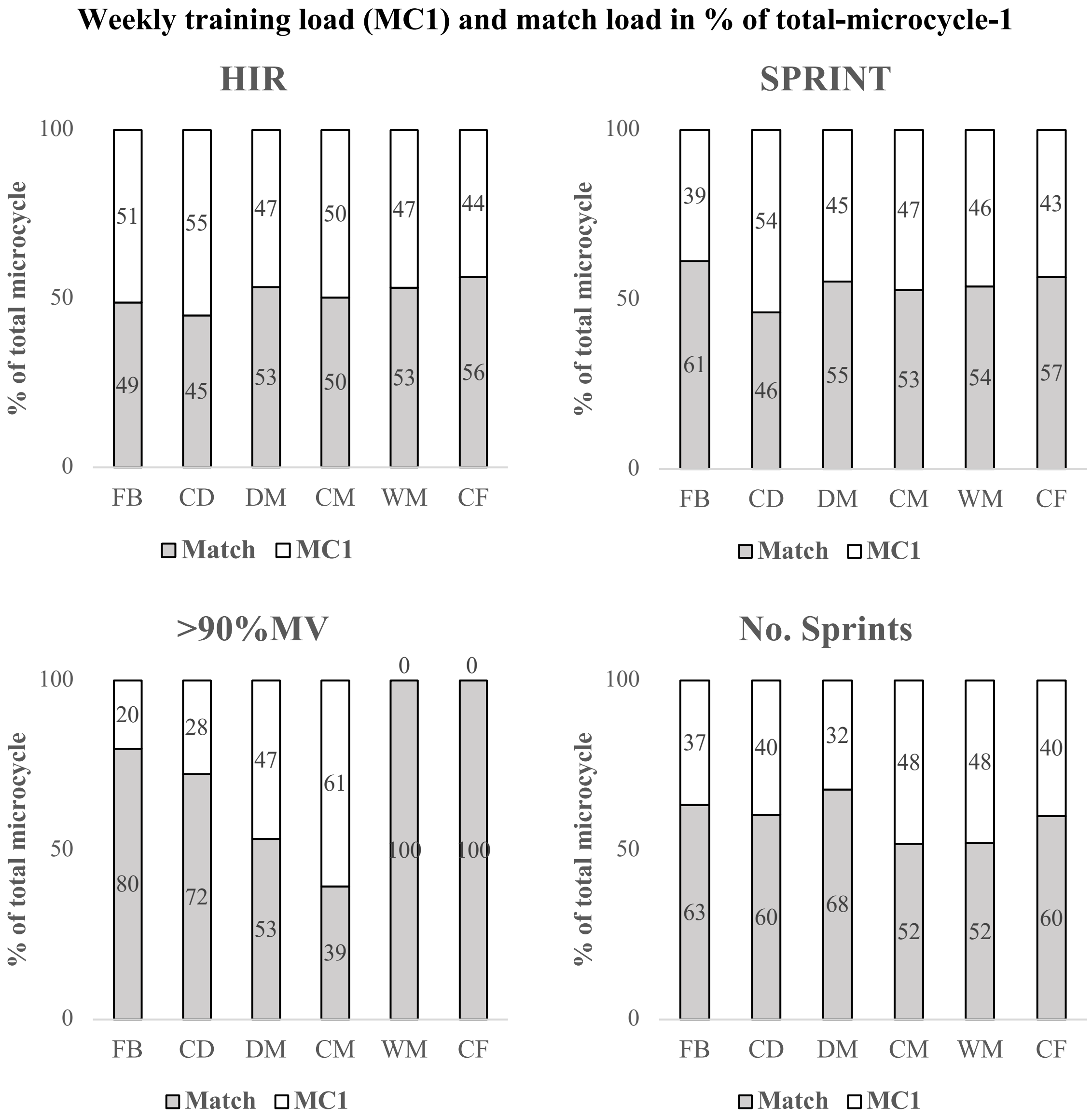

Figure 2: *Distribution of high-intensity actions in microcycle-1 and match demands per position and variable presented as a percentage of a total microcycle including one match (100%).*
MC1= microcycle-1, Total-microcycle-1= microcycle-1 and match load, FB= fullback, CD= central defender, DM= defensive midfielder, CM= central midfielder, WM= wide midfielder, CF= central forward, HIR= High-Intensity running (19.8-25.2 km· h^{-1}), Sprint = sprint distance (>25.2 km· h^{-1}), >90%MV= distance above 90% of maximum velocity, No. Sprints= Number of sprints.

Weekly training load (MC2) and match load in % of total-microcycle-2

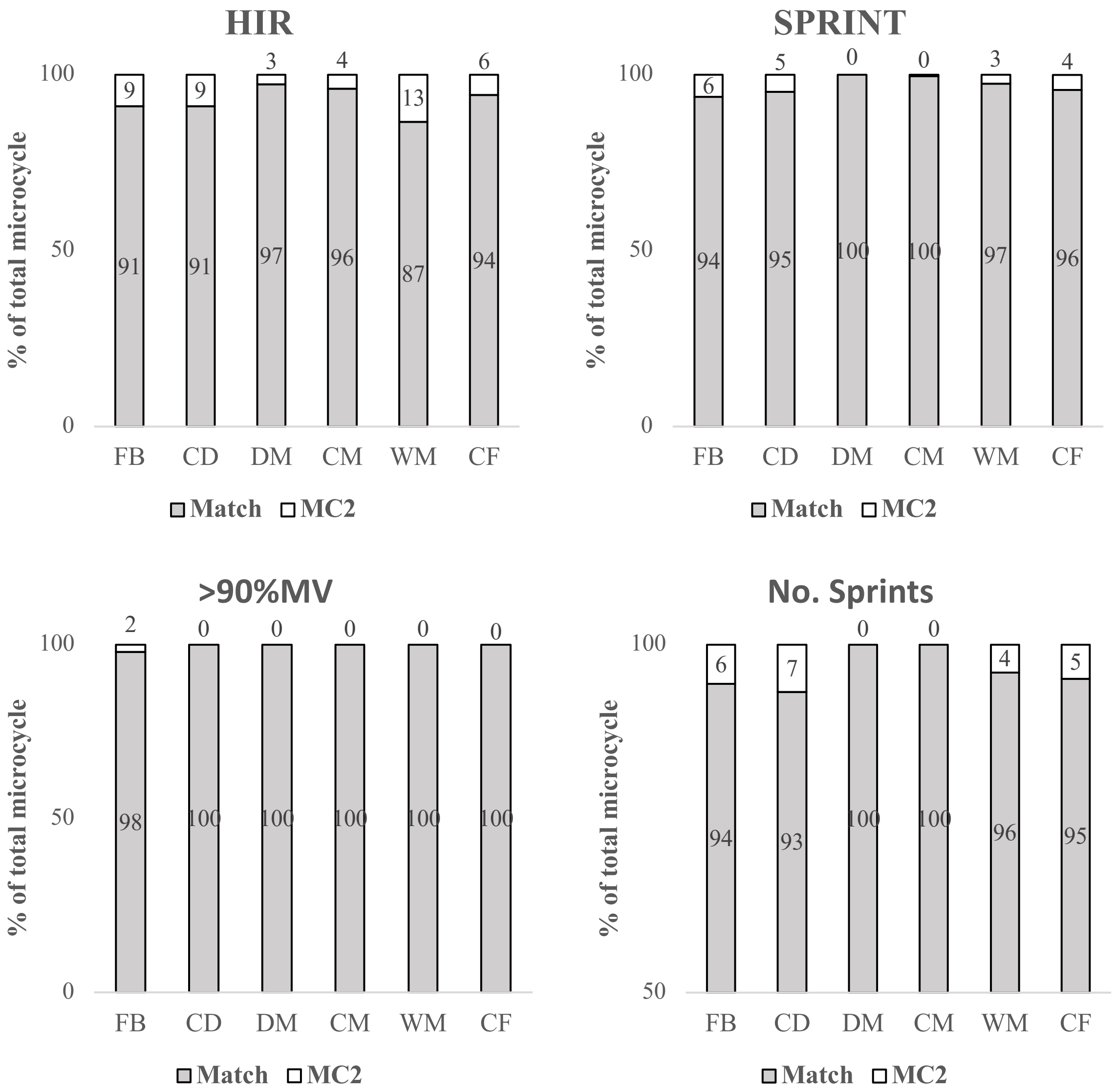

Figure 3: *Distribution of high-intensity actions in microcycle-2 and match demands per position and variable presented as a percentage of a total microcycle-2 including two matches (100%).*
MC2= microcycle-2, Total-microcycle-2= microcycle-2 and match load, FB= fullback, CD= central defender, DM= defensive midfielder, CM= central midfielder, WM= wide midfielder, CF= central forward, HIR= High-Intensity running (19.8-25.2 km· h^{-1}), Sprint = sprint distance (>25.2 km· h^{-1}), >90%MV= distance above 90% of maximum velocity, No. Sprints= Number of sprints.

4. Discussion

The present study objectively quantified the weekly external training load of a one- (microcycle-1) and a two- (microcycle-2) match structured in-season competitive microcycle, and determined match demands of a professional Norwegian male elite football team. The results of this study revealed positional differences in match demands, and positional differences in replicating the match demands in the weekly training load. Even though not all differences reached significance, in line with the hypothesis microcycle-2 presented lower weekly training load compared to microcycle-1 and underperform the match demands. Fullbacks was found to be the most demanding position during match play, and central defenders the less demanding position. Central defenders, as the only position, had significantly higher load of high-intensity running in microcycle-1 relative to match demands. Interestingly, only fullbacks presented significantly lower sprint distance and lower number of sprints in microcycle-1 relative to match demands, while central defenders showed a tendency towards significance of more sprint distance in microcycle-1. Consistent with the hypothesis all positions, except central midfielders, showed higher average of distance >90% of maximum velocity during match play compared to weekly training load. Somewhat, contrary to the hypothesis not all positions cover more sprint during a full match compared to both microcycles.

Match demands

The data of match demands demonstrated that every position across covered an average of 10 564 ± 905 meters of total distance. This observation is in line with previous research reporting players to cover an average of 9 000-14 000 meters during a full match (Bradley et al., 2010). Previous research has found fullbacks and wide midfielders to cover greater distances in high-intensity running and sprint (Bradley et al., 2013; Bradley et al., 2009; Ingebrigtsen et al., 2015). However, the present study observed greatest distance of high-intensity running in fullbacks and central midfielders (715 ± 138 m and 669 ± 261 m), covering significantly more compared to central defenders, defensive midfielders and central forwards. Central defenders covered the lowest distance of high-intensity running, 32-58% less compared to every other position.

All positions across covered an average of 137 ± 93 meters of sprint distributed over an average of 7 ± 4 number of sprints during match. The observed team covered 37-48% less sprint distance compared to previous reports from the Norwegian elite league (Ingebrigtsen et al., 2015) and highly ranked European teams (Bradley et al., 2010; Di Salvo et al., 2010). Moreover, the results in this study showed substantially lower number of sprints compared to previously published data (Bradley et al., 2010; Di Salvo et al., 2010; Ingebrigtsen et al., 2015). Fullbacks covered the greatest distance of sprint, 42-71% more than every other position. This can be related to the 42-67% higher number of sprints performed by fullbacks compared to all other positions (only central forwards not significantly different). Central midfielders, wide midfielders and central forwards showed similar averages of sprint distance, although they sprinted more on average, it was not significant to central defenders and defensive midfielders. These results are in certain degree of agreement with previous research finding lateral players (fullbacks and wide midfielders) to cover the highest sprint distance and tended to sprint more often (Ingebrigtsen et al., 2015). Central defenders and defensive midfielders showed the lowest sprint distance and number of sprints, which can be explained by their given tactical role and tasks which limit the position to reach higher velocities (Bradley et al., 2013; Di Salvo et al., 2009).

It is difficult to compare data on distance >90% of maximum velocity as there is little published research regarding this in football. The present study is, to the best of authors knowledge, the first study to investigate the positional match demands in distance >90% of maximum velocity. A recent published report investigated the number of runs >90% of maximum velocity and reported that the occurrences of runs at near to maximum velocity are low (Buchheit et al., 2021). This is to a certain degree of agreement with the low distance discovered in this study (12 ± 17 meters) of distance >90% of maximum velocity. Wide midfielders covered the greatest distance >90% of maximum velocity, only significant to central midfielders.

<u>*External load microcycle-1*</u>

Weekly training load during microcycle-1 expressed as percentage of match demands (100%) showed that match demands was clearly overperformed in total distance (175-204%) and accelerations (179-230%). These results are in line with earlier research in Norwegian (Baptista et al., 2019), Dutch (Stevens et al., 2017) and Portuguese (Clemente et al., 2019) elite teams that provided clear evidence that accelerations are one of the variables to have the greatest training/match ratio. In microcycle-1, presented in *Table 5*, the weekly training load of high-intensity running (92-154%), sprint (71-163%), number of sprints (58-100%), and distance >90% of maximum velocity (0-222%) expressed wider variations in percentage relative to match demands. The results of high-intensity running and sprint distance differ compared to previous reports with similar design including the same amount of training sessions. Baptista et al. (2019) investigated the accumulated weekly training load of four sessions relative to match demands in a Norwegian elite team and reported heavy underperformed training load of high-intensity running (57-71%) and sprint distance (36-61%). Similar results of underperforming high-intensity running were reported in Dutch (Stevens et al., 2017) and Portuguese (Clemente et al., 2019) teams. In present study all positions performed a higher load of high-intensity running in microcycle-1 relative to match demands, except central midfielders (98%) and wide midfielders (92%). Although, only central defenders presented significantly higher load of high-intensity running (157%) relative to match demands. Central defenders also showed a tendency towards significantly higher load of sprint distance (158%) relative to match demands. Interestingly, only fullbacks, as the position covering the greatest sprint distance during match play, presented a significant lower load of sprint (71%) relative to match demands. This is similarly to Baptista et al. (2019) that found wing backs to perform the lowest load of sprint (36%) relative to match demands. In this study fullbacks were also the only position to perform significantly lower number of sprints in training compared to match, presenting the lowest load of number of sprints (58%)

in microcycle-1 relative to match demands. Although, all positions performed an average of lower number of sprints during training compared to match.

To authors knowledge, no previous studies have investigated the weekly training load in distance >90% of maximum velocity relative to match demands. Fullbacks and wide midfielders covered significantly less distance >90% of maximum velocity in training than in match, presenting 46% and 0% relative to match demands. Central midfielders were the only position to cover an average distance overperforming the match demands in microcycle-1 (222%, non-significant).

<u>*External load microcycle-2*</u>

The present study also quantified the weekly training load of a two-match structured microcycle (microcycle-2) presented in *Table 5*. Weekly training load in microcycle-2 underperform the match demands. Similar to microcycle-1 total distance (60-69%) and accelerations (39-61%) presented the highest load relative to match demands. High-intensity actions heavily underperformed relative to match demands, high-intensity running (6-25%), sprint (0-13%), number of sprints (0-14%) and distance >90% of maximum velocity (0%). Fullbacks and wide midfielders covered significant higher sprint distance compared to central defenders, central midfielders, and central forwards. No other major positional differences were observed in weekly training load. Microcycle-2 consisted of two main sessions, where both sessions were MD-1. In previously published data MD-1 has showed to provoke lower values of external load (Akenhead et al., 2016; Malone et al., 2015; Martin-Garcia et al., 2018; Anderson et al., 2016). The objective of training sessions in weeks including multiple matches trends towards rehabilitation, recovery, and preparation for the next game (Dupont et al., 2010). In microcycle-2 it is reasonable to believe that the external training load might have been manipulated towards preparing for the upcoming match leading to reduction in external load. This provoked lower weekly training load relative to match demands and microcycle-2. As presented in *Table 5*, most variables showed higher training load in microcycle-1 compared to the similar position in microcycle-2. Similar results were found in previous published data comparing microcycle including three training sessions and microcycle including five training sessions (Clemente et al., 2019). Microcycle-1 consisted of four main sessions, MD-4, MD-3, MD-2, and MD-1. The higher load in microcycle-1 can be explained by previously published data finding MD-4 and MD-3 to present the highest training load during the week (Akenhead et al., 2016; Anderson et al., 2016; Stevens et al., 2017). Although, out of scope of this article *Figure 2* and *Figure 3* presented the distribution of high-intensity actions between weekly training load and match load in a total microcycle-1 and a total microcycle-2. The distribution indicated that nearly all load of high-intensity actions occurred during match play in microcycle-2. This emphasizes the need for specificity in training for players not involved in match play.

Previous research has examined accumulated weekly training load in teams in English Premier League (Akenhead et al., 2016), Dutch Eredivisie (Stevens et al., 2017), Portuguese first league (Clemente et al., 2019) and a Spanish La Liga reserve team (Martin-Garcia et al., 2018). These results are particularly relevant as cultural and competition demands across leagues could result in distinct loading variations in attempt to optimize performance (Casamichana et al., 2022). In common when comparing external physical load across previously published data in other leagues, the results consistently display positional differences. However, studies are use different loading metrics, speed bands, and tracking systems which makes comparison complicated (Casamichana et al., 2022).

The high values of accelerations discovered in training could be a result of small-sided games, which is found to cause increased number of accelerations compared to running based drills (Ade et al., 2014). This is a popular and commonly used training drill including different number of players often on smaller pitch sizes (Dalen et al., 2021; Gomez-Carmona et al., 2018; Rampinini, Impellizzeri et al., 2007). The observed team often used small-sided games in their training sessions. On the other side, small-sided games are found to reduce demands in high-intensity actions compared to competitive matches (Gomez-Carmona et al., 2018). Reproducing or even intensifying match demands of high-intensity actions is suggested to be the primary target in training (Campos-Vazquez et al., 2021). This is highlighted by the strong correlation between ability to perform high-intensity actions and success (Buchheit et al., 2014; Haugen et al., 2013; Mohr et al., 2003). For instance, sprint ability has also shown to be crucial in goal scoring situations in football (Faude et al., 2012). The observed team sometimes included running-based drills to reach more distance in higher speed bands. Previous research has shown running-based drills to be effective to induce high-intensity running distance and sprint distance (Ade et al., 2014). Based on the weekly training load of high-intensity running in microcycle-1 relative to match demands, the observed team was close to replicate the match demands in all positions. It can be speculated whether this was a result of the running-based drills. Dalen et al., (2021) indicated that small-sided games do not impose the same sprint distance as match play and suggested that smaller pitch size may limit the possibility of sprinting. Taken this into account and the wide variations in replicating match demands of sprint activity, there might be a need of larger pitch sizes in training.

In present study, fullbacks showed the greatest sprint distance and highest number of sprints during match play. Although, fullbacks did not replicate the sprint actions in weekly training load relative to match demands and presented the lowest relative training load of all positions in both sprint distance and number of sprints. In contrast, central defenders performed the highest load of high-intensity running and the highest load of sprint distance in microcycle-1 relative to match demands. Based on these results supported by Baptista and colleagues (2019) findings this could indicate that all positions are receiving similar training stimuli and a lack of specificity between positions during microcycle-1. This is supported by the few positional differences found between variables within the microcycles. Also, this might lead to underloading the most demanding positions (fullback) and overloading the less demanding positions (central defender) in high-intensity actions. The observed ranges in variables presented in *Table 5* showed large gaps between minimum and maximum value for all positions. This could be caused by lack of planning and structure within the microcycles leading to higher or lower external physical load one week compared to other weeks with the same number of training sessions. For instance, including running-based drills may have led to higher distance of high-intensity running and sprint in some of the weeks. More specificity is needed to achieve the match demands in sprint distance of all positions, suggesting that players should train in the same position as they play in competitive matches**.** The author believes this also will be beneficial for technical and tactical reasons in addition to increased physical performance. It is the coach decision to design drills and facilitate training to replicate the match demands. Further research on football specific exercises and drills is suggested for coaches' ability to adjust training to meet the demands of sprint activity during training.

Wide midfielders and central forwards did not cover any distance >90% of maximum velocity during microcycle-1. This is somewhat in line with previous published data finding low number of runs >90% of maximum velocity during match play (Buchheit et al., 2021). Previous research has found that central forwards need pitch size relatively similar to match standards to meet the match demands in high-intensity running and sprint (Riboli et al., 2020). The results in present study may indicate that the pitch size used in training is not large enough for central forwards to reach higher velocities. Increased distances and exposures hitting up to the individual maximum velocity has been suggested to have a protective effect on injuries (Malone et al., 2015). Haugen et al. (2014) suggested that players reaching >90% of maximum velocity may be enough to be protective. Further, both under- and over-exposure of players maximum velocity could increase risk of injury (Malone et al., 2017). Given these reports, wide midfielders and central forwards in this study may have an increased risk of injuries if the observed trend continues. Further investigation of distance and number of runs >90% of maximum velocity is recommended.

Of interest

Taken in mind that the training stimuli given in microcycle-1 are recommended to reproduce or even intensify the match demands, comparing weekly training load in microcycle-1 to weekly training load in microcycle-2 including the first match as part of the training load of the week could be of interest. The weekly training load in microcycle-1 relative to microcycle-2 including first match of the week presented slightly overload in total distance (107-121%) and accelerations (120-150%) across all positions. Similar to the comparison of weekly training load in microcycle-1 relative to match demands it showed wider variations in high-intensity running (73-127%), sprint (63-153%), number of sprints (54-114%) and distance >90% of maximum velocity (0-222%). This can of interest be further investigated in future studies to see if this can potentially be used as a recommended target of weekly training load in a one-match structured microcycle.

Strengths and limitations

Quantification of weekly training load and determining match demands are of importance due to individualizing training stimuli provided to players for the demands of the match. By analyzing weekly training load relative to match demands coaches and practitioners are given information to identify players that are inadequately loaded, which can optimize preparation, increase physical performance, and reduce the risk of injury. This study emphasized the importance of individualizing training to achieve positional differences demanded by the game, nevertheless the results might be specific for the observed team and generalization of the findings is not recommended. A large sample size of 302 individual observations from matches distributed over six positions was included in this study. Only competitive matches, both home and away, was included in this study. Match observations of samples that played less than 90 minutes and more than 60 minutes was recalculated to the average of a full match. This could potentially lead to overestimating full match activity as shown in previous research including a total of 37 match observations that found about 2% overestimation of external load variables (Stevens et al., 2017). Taken in mind the large sample size and previous published data the potential inaccuracies caused by recalculation do not affect our main findings and conclusion. The sample size of microcycle-1 and microcycle-2 is rather smaller, especially it is of importance to mention that the results only included one observation of central forwards in microcycle-1 and one observation of defensive midfielders in microcycle-2. Taken in mind the wide range of minimum and maximum values in every other position this could have affected the results in current positions. Further, this could be a result of only including players participating in all training sessions during a week and involved in >60 minutes in the same weeks match. Nevertheless, this choice was made to find precise relationship between weekly training load and match demands, as done by Clemente et al. (2019). Another limitation relates to the number of microcycles included in the study. A total of six microcycle-1 and seven microcycle-2 were included in the study, which could not be controlled by the researcher as the match schedule were changing a lot due to COVID-19 and the decisions on weekly structure of the microcycle was made by the coach. The microcycles included in this study are from different part of the season, which could cause variations in the results based on previous reports of decline in physical performance during the season (Ingebrigtsen et al., 2015).

Finally, this study is to the best of authors knowledge the first study to quantify and compare number of sprints and distance >90% of maximum velocity in weekly training load relative to match demands. The results clearly revealed positional differences in replicating sprint distance, number of sprints and distance >90% of maximum velocity in weekly training load of microcycle-1 relative to match demands. Moreover, match demands in total distance, high-intensity running and accelerations are more closely to achieved or even intensified. As expected, microcycle-2 presented lower load than match demands and microcycle-1.

5. Conclusion

In summary, as expected microcycle-2 heavily underperform relative to match demands and presented a lower weekly training load compared to microcycle-1. The major findings of this study showed fullbacks to be the most demanding and central defender the less demanding position. If all positions are given the same training stimuli this could lead to overload and underload of external physical load. For instance, fullbacks struggled to replicate their match demands of sprint, number of sprints and distance >90% of maximum velocity during microcycle-1. In contrast, central defenders overloaded the sprint distance demanded by the match. Based on these results, the observed team showed lack of specificity and structure in training which could affect preparation for upcoming competitions, reduce physical performance and increase risk of injury. As hypothesized, all positions, except central midfielders, covered higher average of distance >90% of maximum velocity during a full match compared to a full week of training. Wide midfielders and central forwards did not cover any distance >90% of maximum velocity during training, might increasing the risk of injury. The present study gives detailed information to coaches and practitioners highlighting the positional differences in weekly training load relative to match demands in a Norwegian male elite football team. Future research on training load of specific training drills to facilitate training for replicating match demands are recommended, including more research on distance >90% of maximum velocity. Also, future research should further investigate if weekly training load of a two-match structured microcycle including the first match could be used as a target for weekly training load in a one-match structured microcycle.

Practical Implications

The present study has important practical applications for the weekly training of male elite football players. The position specific differences of external physical load demanded by the game must be considered when planning and designing weekly training programs. Moreover, players should be able to cope with their specific demands of the game. Based on the results of this study the author recommends larger pitch size in training and suggest that players train in the same position as they play in match to obtain a sufficient degree of specificity in training. The author also believes this would be beneficial for technical and tactical reasons. It might be necessary for coaches to redesign training program to promote positional differences in sprint activity between weekly training load and match demands and increase intensity of training in MD-4 and MD-3 to reach more sprint distance, higher number of sprints and distance >90% of maximum velocity.

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