NORWEGIAN SCHOOL
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Training/match load and physical performance in an elite female football team utilizing a tactical periodization model

A one-season long prospective cohort study

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Abstract

Purpose: Traditional models of training periodization fault in their application to football. The tactical periodization model has been developed to solve programming challenges specific to football. The purpose of this study was to investigate if an elite female football team utilizing a tactical periodization model is successful in differentiating training loads between specific training days within the microcycle, and if microcycle training loads are maintained across the season. Accompanying and associated changes in physical qualities were also investigated.

Methods: Data were collected over the course of a full season from a team playing in the premier women's division in Norway. A 10 Hz GPS system with a built in 200 Hz IMU (Polar Team Pro) was used to quantify external load. Total distance, high-speed running distance, sprint distance, and the combined number of accelerations and decelerations (ACC/DEC) were used as external load variables. Internal load was assessed through rating of perceived exertion (RPE), which was multiplied by session duration to investigate session RPE (sRPE). The season was divided into two periods. Endurance, sprinting ability, change of direction ability, strength, power, and countermovement jump was tested before, between and after the two periods.

Results: Differences in training load were observed between all training days within the microcycle across all parameters except from sRPE between MD-4 and MD-3. All measures of training load were reduced from the first to the second period on all training days within the microcycle except total distance and ACC/DEC on MD-2. All physical qualities were maintained across the season but were either improved or maintained during the first period and either maintained or reduced during the second period. No significant correlations were observed between the physical qualities that showed significant changes and any of the training load metrics.

Conclusion: Elite female football teams utilizing a tactical periodization model can be successful in differentiating training loads between specific training days. The lack of significant associations between specific metrics and changes in physical qualities should not be attributed unwarranted significance due to the complex nature of training load in football, and changes in physical qualities and training loads followed the same pattern. Since training loads decreased between periods it is uncertain if reduced physical performance can be avoided from in- to post-season by maintaining these training loads, but physical qualities were nonetheless maintained across the season.

Contents

Preface

This thesis marks the end of a five-year journey at the Norwegian School of Sports Sciences. I feel very fortunate to have studied at a school with so many great people and I will look back on this period of my life with great joy.

I want to start by giving a special thanks to my two supervisors for this thesis: Live Luteberget and Markus Vagle. Live Luteberget has been my main supervisor for both my bachelor and master thesis. Thank you for all your guidance and for always keeping your door open for questions these last few years, it has meant a lot. Markus Vagle, without you allowing me to conduct my master thesis underneath your PhD-project this project idea would have been harder to fulfill. Thank you for all your guidance and directions to help make this project what it is. I have learnt a lot from both of you these last couple of years and there is no doubt that you are both very devoted to your craft!

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Ulrik Berg Karlsson

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1. Introduction

The interest and popularity of women’s football has grown significantly in recent years, evident by the increased participation worldwide, the expansion of the world cup ahead of the FIFA Women's World Cup Canada 2015™, and the record-breaking viewership, attendances, and digital engagement across the globe during the FIFA Women’s World Cup France 2019™ (Datson et al., 2014; Kryger et al., 2021; D. Scott et al., 2020). This increase in popularity has led to several advancements in the professionalism of women’s football, some of which include more players having access to full-time training environments, improved training facilities and medical support, but this also means that players are exposed to greater training volumes and competition demands than ever before (Datson et al., 2014; D. Scott et al., 2020). The growing popularity has also led to an increased attention on women’s football in the scientific literature (Kryger et al., 2021). In spite of this, the available scientific literature on female athletes in general and on the training and match load of elite female football players in particular, is still lacking (Datson et al., 2017; Mujika & Taipale, 2019; Rago et al., 2019; D. Scott et al., 2020). Such information is of importance to better inform training and monitoring practices in this population (Datson et al., 2017).

Like many other team sports, the competitive season in football lasts several months, with matches being played almost every weekend, and sometimes twice a week. Contrary to many individual sports where athletes train to peak for one, two or maybe three times per year, this puts footballers in a unique situation (Gamble, 2006). During the weekly cycle from one game to the next, often termed the *microcycle*, teams need to train at a level that allows them to maintain their physical performance over the course of the season and at the same time be recovered for the upcoming game (Mujika et al., 2018). In recent years, a growing body of studies has investigated training loads within the microcycle of elite male footballers (Lopategui et al., 2021; Malone et al., 2015; Martin-Garcia et al., 2018; Oliveira, Brito, Martins, et al., 2019; Oliveira, Brito, Mendes, et al., 2019; Stevens et al., 2017), but currently only one study has investigated training loads within the microcycle of elite female footballers (Moraleda et al., 2021). As observed through the different studies investigating training loads in men’s football, the structure and training load distribution within the microcycle can be organized in several ways. An approach that has gained a lot of traction in recent years is *tactical* *periodization*. The tactical periodization model aims to incorporate the tactical, technical, psychological and physical components of the game, all through a holistic approach (Delgado-Bordonau & Mendez-Villanueva, 2012). In particular, two principles are key to the development and maintenance of the physical component: (1) *Horizontal alternation* of the physical qualities, and (2) *performance stabilization* through a maintained standard microcycle. To achieve this, the model aims to (1) differentiate training loads between the different training days within the microcycle, and to (2) keep microcycle training contents almost invariable over the course of the season (Delgado-Bordonau & Mendez-Villanueva, 2012). Despite being a widely deployed model and some of its proponents being among the most renowned football managers in the world, a recent systematic review concluded that no empirical studies were available on the concept and that scientific support for the model is lacking (Afonso et al., 2020). Descriptive studies conducted among teams that deploy a tactical periodization model was proposed as a good starting point, and the authors also stated that a dose-response relationship should be investigated, aiming to establish the impact of training load on some performance variables of the players and the team during a given period (Afonso et al., 2020).

Therefore, the aim of this study is to investigate training loads and accompanying/associated physical performance levels and changes in a team utilizing a tactical periodization model, in general, but also specifically in the elite female football population. The following research questions were formulated:

(1) What differences can be observed in training load and intensity between the different training days within a tactical periodization microcycle?

(2) What changes in training load and intensity occur within the microcycle between two different periods of the season in a team utilizing a tactical periodization model?

(3) What physical performance levels and changes are associated with, and accompany, the training loads observed in a team utilizing a tactical periodization model?

2. Theory

2.1 *Physical qualities in women's football*

The main performance indicator of the team is whether they win, draw, or lose their competitive matches, which amounts to either success or failure come end of season. Several key performance indicators have been identified that facilitate desirable team results, many of which are related to the technical and tactical aspects of the game (Herold et al., 2021). Higher ranked teams are not necessarily observed to run more than lower ranked teams (Bradley et al., 2013; Rampinini et al., 2009), but players playing at higher standards possess superior physical performance levels across several physical qualities in both men's and women's football (Haugen et al., 2012, 2013; Haugen, Tønnessen, Hem, et al., 2014). Furthermore, players who show fewer signs of physical fatigue during matches are observed to better sustain technical and tactical abilities (Rampinini et al., 2009). Consequently, physical performance is considered an integral part that facilitates overall team success, which is also reflected in the increased demand for strength and conditioning coaches in professional football in recent years (Springham et al., 2018). To investigate the effect of training load on the physical performance of elite female football players, the physical qualities and parameters of relevance must first be established. This has been studied extensively, and physical qualities typically considered important for performance in elite women's football include endurance, sprinting ability, agility, strength, power and jumping ability (Griffin et al., 2021).

2.1.1 Endurance

Endurance is a broad term and must therefore be seen in context of the sport in question. Based on physical performance data from matches and the intermittent nature of football, high-intensity endurance capacity is typically considered key to performance in elite level football (Datson et al., 2014). High-intensity endurance capacity refers to the ability to repeatedly produce efforts and periods of high intensity, which must be sustained while simultaneously covering long distances at lower intensities during matches. Players experience fatigue after and towards the end of matches, but they also experience temporary fatigue during the game (Bangsbo, 2014). The more permanent fatigue observed after matches is thought to be largely linked to depletion of muscle glycogen stores and possibly associated impaired intramuscular Ca^{2+} release, as well as increased muscle damage that may negatively affect several neuromuscular systems (Bangsbo et al., 2007; Mohr & Iaia, 2014; Ørtenblad et al., 2011). The more acute fatigue experienced during the game following intense periods or actions is thought to be associated with a transient reduction in phosphocreatine stores and increased levels of lactate, with associated increases in acidity and inorganic phosphate, as well as possible disturbances to the resting membrane potential and accumulation of interstitial potassium (Bangsbo, 2014; Bangsbo et al., 2007; Mohr & Iaia, 2014). The ability to re-synthesize phosphocreatine stores and return metabolite and ion conditions towards homeostasis quickly during periods of lower intensity during the match is therefore key to players' high-intensity endurance. This ability is related to several underlying factors, but players with a higher maximal oxygen uptake (VO_{2max}) are seen to have improved lactate-removal capability and enhanced phosphocreatine resynthesis (Haugen, Tønnessen, Hem, et al., 2014). Average heart rate values observed during matches (84-87% of maximal heart rate) show that the aerobic system is highly taxed during match play (Andersson et al., 2010; Krustrup et al., 2005), and average VO_{2max} values ranging from about 50 to 57 $ml \cdot kg^{-1} \cdot min^{-1}$ are typically observed in elite female footballers (Bangsbo et al., 2007; Datson et al., 2014; Haugen, Tønnessen, Hem, et al., 2014). Female players at higher playing levels and standards are also observed to have higher VO_{2max} values than players at lower standards (Haugen, Tønnessen, Hem, et al., 2014). This is contrary to findings in men's football, where players at the higher tiers seem to have similar values (Tønnessen et al., 2013). The similar values observed in male players indicate that a certain level of aerobic capacity is needed, beyond which, other physiological factors might better explain differences in endurance capacity between standards, such as the upregulation in relevant enzymes and increased energy storages seen with specific training (Fransson et al., 2018; Mohr et al., 2016). It is possible that aerobic demands are relatively higher in women's football considering only small effect sizes are observed for differences in total distance between sexes, despite of the physiological differences that exist (Bradley et al., 2014). The specificity of VO_{2max} for football has, however, been questioned. Intermittent running tests, such as the Yo-Yo intermittent recovery test level 1 (YYIR1), that better reflect the physical nature of football, are now commonplace in field-based testing for both men and women (Datson et al., 2014). The YYIR1 is observed to differentiate between selected and non-selected national team players in women's football (Ramos, Nakamura, Penna, Mendes, et al., 2019), and has been seen to correlate strongly with high-speed running during matches for both female and male football players (Krustrup et al., 2003, 2005). However, contrary to findings in male players (Krustrup et al., 2003), VO_{2max} also correlated strongly with high-speed running during matches for female players, further indicating that VO_{2max} could play a more important role in women's football (Krustrup et al., 2005).

In summary, it seems that high-intensity endurance capacity is a distinguishing factor in women's football and that VO_{2max} possibly plays a bigger role compared to men's football. Data from both Haugen et al. (2014) and Krustrup et al. (2005) were gathered before 2007, and the significant growth of women's football and advancements in professionalism in the last 10-15 years may have led to improvements across several playing levels and standards that have minimized differences (Griffin et al., 2021). Findings by Ramos et al. (2019) do, however, indicate that YYIR1 results still differentiate between player levels. Moreover, average YYIR1 results gathered from national teams range from 1310-1590 m, and seem to be higher than YYIR1 results gathered from elite domestic teams (1224-1379 m) (Castagna et al., 2020; Doyle et al., 2021; Krustrup et al., 2005; Mujika et al., 2009; Ramos, Nakamura, Penna, Mendes, et al., 2019), but this cannot be stated with certainty based on the available evidence.

2.1.2 Sprinting ability

Sprinting ability is by many considered one of the most important physical attributes in football, and female players perform approximately 20-70 efforts per game above velocities of 19.4-25.1 $km \cdot h^{-1}$ (Datson et al., 2019; Mara et al., 2017a; Trewin et al., 2018). The importance of these efforts have been clearly demonstrated in men's football, where linear sprints have been observed to be the most frequent action by both the scoring and assisting player in goal situations (Faude et al., 2012). Differences between players of 0.04-0.06 s across 20 m sprints are considered large enough to be decisive in 1-on-1 duels (Haugen, Tønnessen, Hisdal, et al., 2014), and even larger differences have been observed to separate female players of different playing standards (Haugen et al., 2012). Additionally, Vescovi (2012) observed that selected players were faster than non-selected players in a professional league draft. It is uncertain to what degree sprinting ability differentiates between players of different levels (national vs non-national team players) playing at the same standard (D. Scott et al., 2020), but differences between the fastest and slowest players at the elite level are more than large enough to entail practical significance (Haugen, Tønnessen, Hisdal, et al., 2014).

Sprinting ability is usually evaluated over distances of 30 to 40 m in female football players (Haugen et al., 2012; D. Scott et al., 2020; Vescovi, 2012). They reach higher speeds when evaluated over 35 m compared to 20 m (Vescovi, 2012), but average split times seem to be similar in the segment from 20 to 30 m and from 30 to 40 m (Haugen et al., 2012). This means that sprint performance should be tested over at least 30 m, with additional split times, if both early acceleration and top speed is to be investigated. A common misconception is that top speed is not relevant to football since the majority of sprints are observed to occur over distances shorter than 10 m (Mara et al., 2017a). However, most sprints are leading sprints, and sprint distances are often calculated from beyond a given threshold (Datson et al., 2019; Vescovi, 2012). As a result, such remarks are often misinterpreted, and results from 10-meter sprints from a stationary start will not necessarily reflect how fast a player covers the first 10 m above a threshold of, for example, 25.1 $km \cdot h^{-1}$. Of course, there is a large carryover, and the fastest players across 10 m are usually also the fastest across 30 or 40 m, but such correlations become weaker with the increasing distance (Young et al., 2008).

To compare sprint results between studies is difficult due to the different triggering devices and starting procedures used to evaluate sprint performance. At the extreme, this can cause larger differences in sprint results than what is associated with years of conditioning. Even smaller factors like air resistance, footwear, and running surface, that in isolation lead to trivial or small differences, can in combination lead to moderate to large time differences (Haugen & Buchheit, 2016). Regardless, 20 and 30 m sprint times are reported to range from 3.12-3.30 s and 4.35-4.63 s, respectively, in the elite female population (Andersson, Raastad, et al., 2008; Emmonds et al., 2019; Gabbett, 2010; D. Scott et al., 2020; Stepinski et al., 2020). Additionally, average top speeds seem to demonstrate top speeds of about 28-29 $km \cdot h^{-1}$ for elite female football players (Haugen et al., 2012; Park et al., 2019; D. Scott et al., 2020).

2.1.3 Agility

The importance of good agility in football has been emphasized by several authors in the literature (Haugen, Tønnessen, Hisdal, et al., 2014). Agility has previously been regarded as the isolated ability to perform changes of direction but has more recently been defined as the ability to perform “a rapid wholebody movement with change of velocity or direction in response to a stimulus” (Sheppard & Young, 2006). Therefore, agility and change of direction (COD) ability are now considered to be two independent sets of skills (Young et al., 2015). Despite of this acknowledgement, due to the complex cognitive elements of sport-specific agility, valid and reliable standardized tests of agility have proven challenging to develop. As a result, it is more common to assess a player’s COD ability, even though no gold standard exists for how to assess this ability either (Haugen, Tønnessen, Hisdal, et al., 2014; Sporis et al., 2010). The most common way to test COD ability is through tests involving a maximal effort throughout the test (Haugen, Tønnessen, Hisdal, et al., 2014), but observations from the English premier league seem to indicate that rarely do changes of direction contain a sprint leading both into and out of a COD (Bloomfield et al., 2008). Irrespective, COD tests containing 180 degree turns seem to offer the most valid and reliable measures of COD ability and are therefore often used (Sporis et al., 2010).

Female football players are reported to perform 158-423 accelerations and 161-430 decelerations above thresholds of 1-2.26 $m \cdot s^{-2}$ during matches, indicating that players perform a large amount of directional changes (Mara et al., 2017b; Ramos, Nakamura, Penna, Wilke, et al., 2019; Trewin et al., 2018). COD ability seems to differentiate between player levels and standards in men’s football (Haugen et al., 2014), but few studies have investigated such differences in women’s football. Furthermore, the previously mentioned challenges with timing equipment and the fact that several different tests exist to evaluate this ability, mean that the foundation for comparisons between studies is very limited. Qualities such as speed, strength and power are, however, seen to strongly correlate with measurements of COD ability in female football players (Andersen et al., 2018; Emmonds et al., 2019; P. Jones et al., 2017; Vescovi & Mcguigan, 2008). Considering that some of these qualities are observed to differentiate between standards in women’s football it is not unlikely that similar observations can be found for COD ability (Haugen et al., 2012).

2.1.4 Strength, power and jumping ability

The benefits for footballers in having high levels of strength are several. Higher strength levels are seen to correlate strongly with better sprinting and jumping abilities in both male and female football players (Andersen et al., 2018; Emmonds et al., 2019; Wisloff, 2004), and well-developed strength in musculotendinous units susceptible to injury is seen to significantly reduce the risk of injury (Lee et al., 2018; Moreno-Pérez et al., 2019; Opar et al., 2015). Measures of absolute lower limb extensor strength in footballers often include exercises such as the back squat and leg press, but unilateral exercises and exercises more isolated to specific muscle groups are also used to assess strength in players (Andersen et al., 2018; Emmonds et al., 2019; P. Jones et al., 2017; Nilstad et al., 2014). Investigations into differences in strength between playing levels and standards in women's football are limited, and comparisons between studies are hindered by the different exercises, protocols and equipment used, thus making comparisons difficult (Datson et al., 2014).

The ability to produce power, specifically mechanical power, is considered a key physical component in many sports due to its relation with several qualities important for athletic performance (Cormie et al., 2011; Linthorne, 2021; Morin et al., 2019). Mechanical power is the rate at which, in this case a player, can perform work or transfers energy to complete a movement task, and, considering these dimensions, can also be calculated as force multiplied by velocity (Morin et al., 2019; van der Kruk et al., 2018; Winter et al., 2016). When assessing mechanical power in athletes it is typically the external peak mechanical power that is evaluated, which is the result of the system's ability to converse metabolic power into muscle power and subsequent joint power. The sum of the power produced at the joints results in the measured external mechanical power, but this is also influenced by factors such as friction and air resistance, and consequently not a direct measurement of the muscular power produced (van der Kruk et al., 2018). Since countermovement jump (CMJ) height is seen to correlate very strongly with the measured peak power using force plates during CMJs, it is considered and frequently deployed as a measure of both jumping ability and power in the lower extremities (Datson et al., 2014; T. Jones et al., 2016; Linthorne, 2021; Morin et al., 2019). Reported CMJ results average in the range of 28.1 to 35.0 cm for elite female football players (Andersson, Raastad, et al., 2008; Castagna & Castellini, 2013; Emmonds et al., 2019; Haugen et al., 2012; Krustrup, Zebis, et al., 2010; Loturco et al., 2019; Ramos, Nakamura, Penna, Mendes, et al., 2019; Stepinski et al., 2020). Castagna & Castellini (2013) concluded that CMJ results exceeding 34.4 cm should be regarded as a sign of superior vertical jumping ability. CMJ performance has also been observed to differentiate between player level (Ramos, Nakamura, Penna, Mendes, et al., 2019) and playing standard (Haugen et al., 2012) in elite women's football. The importance of jumping ability during matches is difficult to quantify as other factors such as timing leading into jumping duels and efforts will influence success, but observations from elite men's football have nonetheless shown a jump to precede 16% of all goals (Faude et al., 2012).

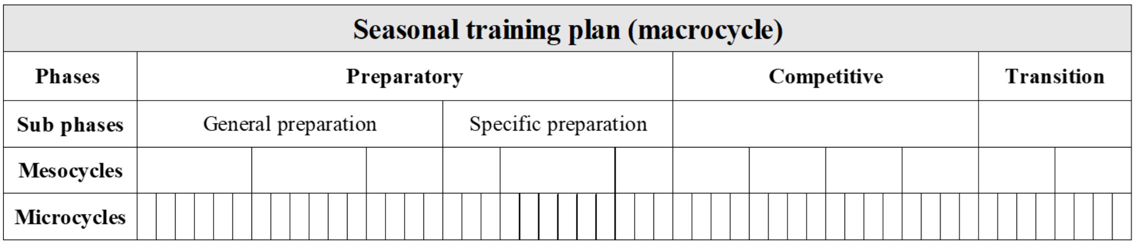
2.1.5 Seasonal changes in physical qualities

Few studies have reported on seasonal changes in the physical qualities of elite female football players. Mara et al. (2015) observed that sprint performance measured as 5, 15, and 25 m times improved from the start of pre-season towards the end of pre-season and mid-season before either remaining stable or declining towards the end of the season. The same study also tested endurance performance through YYIR2 at different stages of the season but observed no changes despite observing reductions in training load over the course of the season (Mara et al., 2015). The sensitivity of this test for measurements in the female population can, however, be questioned due to the short distances covered during the test duration and the relatively high velocity at which the YYIR2 test begins. Another study assessed seasonal changes in CMJ, COD and sprinting ability in Polish national team players through testing before the start of the season and during the in-season phase (Stepinski et al., 2020). They observed improvements in CMJ performance from the start of the season to the in-season period, but observed no significant changes in neither COD or sprint performance (Stepinski et al., 2020). Studies have also assessed seasonal changes in the female youth population but the transferability of such results to the elite senior female population is questionable due to the influence of growth and maturation in this population (Emmonds et al., 2020). Observations from men's football seem to indicate that most qualities are improved through the pre-season phase (Caldwell & Peters, 2009; Fessi et al., 2016; Meckel et al., 2018), and that speed, COD and power qualities are either maintained or further improved through the in-season phase and towards the end of the season (Caldwell & Peters, 2009; Casajús, 2001; Fessi et al., 2016), whereas endurance is seen to both increase and decrease during these periods (Caldwell & Peters, 2009; Fessi et al., 2016; Meckel et al., 2018; Rago et al., 2020).

In summary, the little evidence that exists in women's football indicate that players either improve or maintain power, COD, and sprinting ability during pre-season and the in-season phase, followed by either a stabilization or decline towards the end of the season. Endurance capacity is seen to be maintained over the course of the season but taking the limited amount of evidence and observations from men's football into consideration means further investigations are needed.

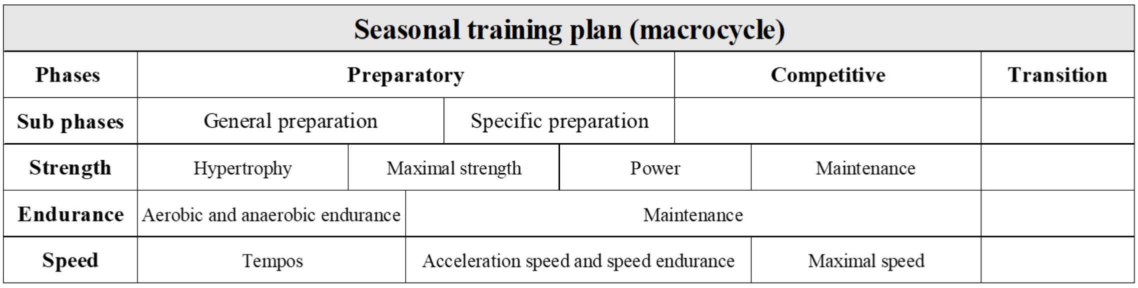
2.2 Training periodization in sports and football

Periodization originally refers to the concept of phase-based training and describes (1) the subdivision of a seasonal program into different phases and (2) the changing periodic emphasis on different physical qualities and physiological targets (Bompa & Buzzichelli, 2018). Evidence suggests that training periodization has existed in one form or another since the ancient Greek and Romans, and training templates showing periodized cycles of training used by Olympic runners in the early 19th century are also available (Bompa & Buzzichelli, 2018; Issurin, 2010; Laursen & Buccheit, 2018). However, the foundations for the modern concept of training periodization stems from the former USSR, where Matveyev is by many considered the first to properly summarize and conceptualize the traditional theory of training periodization, in the 1960s (Issurin, 2010). The goal of training periodization is to help coaches and athletes design training programs that allows them to optimize their physiological adaptions and peak at desired moments in order to maximize their performance during competition (Bompa & Buzzichelli, 2018; Mujika et al., 2018). At the upper level of the structural components that make up a periodized training plan we find the macrocycle, which is a seasonal plan consisting of months and usually lasting for about a year. The macrocycle is typically divided into a preparatory, competitive and transition phase, which may again be divided further (e.g., into general and specific preparation). Within the macrocycle we find the next level of a periodized training plan, which is a mesocycle consisting of weeks and usually lasting for about a month. The last of the main structural components is the microcycles that make up the mesocycle. A microcycle consists of days and typically lasts for about a week (figure 2.1). Within and across all these phases, the focus and emphasis on the development and maintenance of different physical qualities like strength, speed, endurance etc., and physiological targets like maximal strength, acceleration speed, aerobic power, anaerobic capacity etc., will also be periodized (figure 2.2).



Seasonal training plan (macrocycle)				
Phases	**Preparatory**		**Competitive**	**Transition**
Sub phases	General preparation	Specific preparation		
Mesocycles				
Microcycles				

Figure 2.1: *Illustration of the different phases and cycles within a periodized macrocycle. Figure inspired by Bompa & Buzzichelli (2018).*



Seasonal training plan (macrocycle)					
Phases	**Preparatory**			**Competitive**	**Transition**
Sub phases	General preparation		Specific preparation		
Strength	Hypertrophy	Maximal strength	Power	Maintenance	
Endurance	Aerobic and anaerobic endurance	Maintenance			
Speed	Tempos	Acceleration speed and speed endurance		Maximal speed	

Figure 2.2: *Illustration of how the focus and emphasis on different physical qualities and physiological targets can be periodized within a macrocycle. Figure inspired by Bompa & Buzzichelli (2018).*

Periodization assumes that manipulation of different training variables will lead to different adaptions and responses that are essential for optimal athletic performance and success in competition. Central to the concept of traditional periodization is (1) an early emphasis on high volume followed by a transition to lower volume and higher intensity, and (2) a reduction in training variation accompanied by an increase in specificity as the plan progressed through the different phases of the macrocycle (Mujika et al., 2018). Evidence for the efficacy of training periodization exist extensively in the anecdotal literature, but to document this scientifically has proven harder due to the many factors involved in a periodized training plan (Afonso et al., 2017). However, there is good documentation to show that endurance and strength athletes experience an increase in physical performance when periods of high volume are followed by a period of tapering towards competition (Bosquet et al., 2007; Pritchard et al., 2015). Where traditional periodization schemes fault in their application to team sports in general, and football in particular, is that they were originally designed for a one-peak annual plan, and despite having been adapted to two- and three-peak preparation models, they still distinct themselves from long competitive seasons where players have to peak for competition on a weekly basis across several months (Gamble, 2006; Issurin, 2010). Where individual athletes may spend a full mesocycle with a specific training focus, football players must often recover, train for adaptions and peak for competition, all within the space of a microcycle. Despite some considering different models of load patterns a concept separate to that of training periodization (Bompa & Buzzichelli, 2018), different loading patterns (e.g. linear or undulating) are commonly also referred to as different methods of periodization (Mujika et al., 2018). Despite evidence existing for the successful effects of periodized programs within individual sports, less evidence exists on the efficacy of different periodized load schemes within the microcycle in football. It is important to point out here that we refer to the periodization of training load (load pattern) within the microcycle, and that some concepts of training periodization still are applicable to football. A taper phase at the end of pre-season (i.e., before the competitive phase) is often observed within the football codes (Mujika et al., 2018), and a periodized emphasis on different physical qualities over the course of a season, where, as an example, strength developed during pre-season is maintained through a maintenance focus during the season, has been observed to be successful (Rønnestad et al., 2011). However, even here, the many qualities that must be developed simultaneously in football present challenges not accounted for in the traditional theory of training periodization, as individual sports often focus on fewer qualities that are more compatible. This is especially true for high-level athletes, as they need a potent and specific stimulus to continually improve their physical qualities, making the programming puzzle in elite football even more challenging (Issurin, 2010).

2.2.1 Tactical periodization

As observed through the different studies investigating microcycle training loads, the microcycle can be structured in several different ways (Malone et al., 2015; Moraleda et al., 2021; Stevens et al., 2017). One approach that has gained a lot of traction in recent years, with proponents such as Portuguese coaches José Mourinho and André Villas-Boas, is the concept of tactical periodization. The concept stems from Portugal and was developed by Vítor Frade, who at the time was a lecturer at the sports faculty of the University of Porto (Afonso et al., 2020; Delgado-Bordonau & Mendez-Villanueva, 2012). Despite developing the concept, Vitor Frade has never himself written an article or book on the concept (Afonso et al., 2020), meaning it has been left to others such as

Delgado-Bordonau & Mendez-Villanueva (2012). Where the concept of tactical periodization significantly differs from other existing periodization models that usually focus exclusively on the manipulation of physical components, which may also help explain some of its popularity with coaches, is that it integrates the tactical, technical and psychological components of performance in addition to the physical (Afonso et al., 2020; Delgado-Bordonau & Mendez-Villanueva, 2012; Lopategui et al., 2021). To achieve this, several proposed principles such as the principles of specificity, complex progressions, and tactical fatigue and concentration are accounted for. However, since this thesis is primarily concerned with the physical component of the model and its rational, readers are referred to Delgado-Bordonau & Mendez-Villanueva (2012) for more information on the other components that constitute the concept of tactical periodization. To integrate the physical component, the model uses what is referred to as horizontal alternation of the physical qualities on a microcycle level, meaning they are alternated horizontally along the week as opposed to vertically within the same session/day (figure 2.3). Assuming a one game training week, the model allocates two days for recovery, meaning that the first training day will be on the third day following a match. The two days of recovery are followed by three *acquisition days* that each aim to target the different physical qualities of strength (first acquisition day), endurance (second acquisition day) and speed (third acquisition day) (Buchheit et al., 2018; Delgado-Bordonau & Mendez-Villanueva, 2012; Lopategui et al., 2021). The three acquisition days are followed by a day of tapering/reduction in training load to allow for recovery and supercompensation on the following match day. The goal of this horizontal alternation is to develop/maintain the different physical qualities by focusing more deeply on a specific physical quality and avoiding large amounts of the same physical stress on consecutive days. This weekly plan is then maintained as a standard with little variation across the season, with the goal of attaining performance stabilization throughout the season rather than having peaks and drops in performance (Afonso et al., 2020; Buchheit et al., 2018; Delgado-Bordonau & Mendez-Villanueva, 2012). Despite clearly deviating from traditional periodization models, one could say that this model periodizes both the different phases and the changing emphasis on different physical qualities, all within the space of a microcycle.

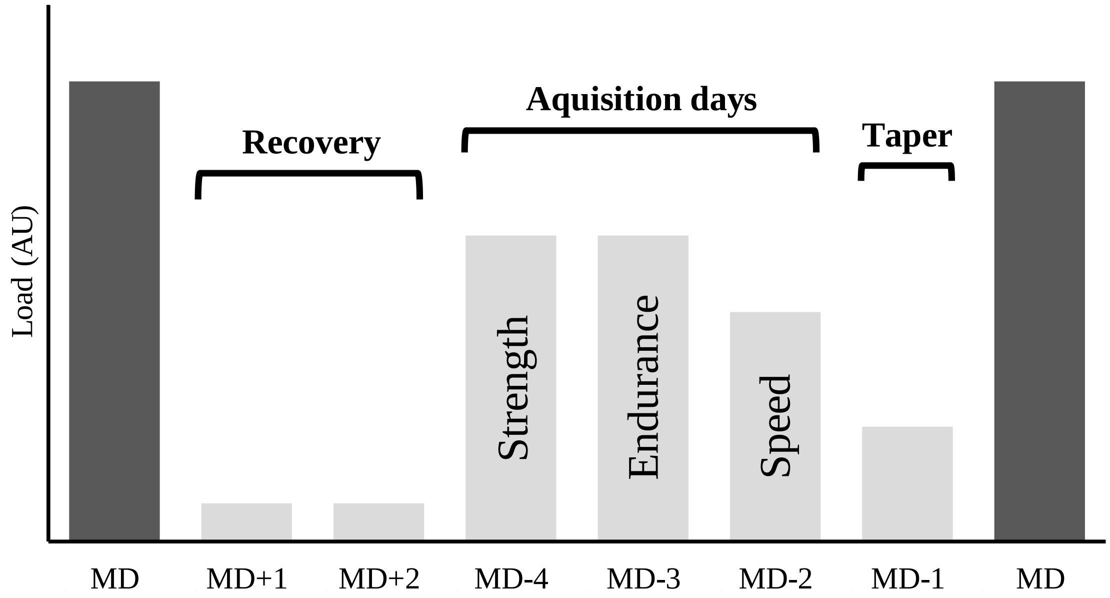


Figure 2.3: *Illustration of how training load is distributed within a tactical periodization microcycle. AU = arbitrary units, MD = match day.*

As pointed out by Buchheit et al. (2018), despite the three acquisition days being referred to as strength, endurance and speed days, these labels and the accompanying physiological stimulus in the sessions do not necessarily coincide perfectly with the physiological definitions of these qualities. This is especially true in the case of the “strength session”, as strength usually pertains to the ability to create maximal force/torque under given conditions (Everett, 1993), which is unlikely to be developed to a significant degree in high-level athletes with the physiological stimulus experienced in these sessions (Buchheit et al., 2018; Tee et al., 2018). Furthermore, despite working within the context of tactical periodization, the exercises and drills used by different coaches will not necessarily be the same on the given days, as these are also chosen based on the coaches’ game model and style of play (Buchheit et al., 2018; Delgado-Bordonau & Mendez-Villanueva, 2012). However, there are still some inherent features to the different acquisition days that are central to the concept. A strength session will typically aim to include a high number of accelerations, decelerations, and changes of direction through drills, game-play sequences, and small-sided games with a low number of players and small spaces (i.e., high player to area ratio). Endurance sessions will typically include longer distances covered through longer sequences of play in larger spaces with more players, whereas speed sessions will include medium/large spaces with lower work/rest ratios to allow for high intensity actions (Buchheit et al., 2018; Lopategui et al., 2021; Tee et al., 2018).

Despite there being a theoretical rational behind the model of tactical periodization, evidence of improved/superior performance outcomes, actual training loads, and neuromuscular adaptions related to this concept, are still largely anecdotal (Afonso et al., 2020; Buchheit et al., 2018; Tee et al., 2018). Afonso et al., (2020) recently published a systematic review on tactical periodization with the aim of establishing what qualitive and quantitative data that exist in peer-reviewed journals on the concept. Based on their inclusion criteria they concluded that no empirical studies were available on the concept and that scientific support remains. However, although not the main objective of the study, Buchheit et al. (2018) reported typical training loads and associated neuromuscular responses using a tactical periodization model. In addition, Lopategui et al. (2021) investigated the external and internal training loads within a typical tactical periodization microcycle, compared the different training days with each other, and investigated the players' physical performance levels. Both the study by Buccheit et al. (2018) and the study by Lopategui et al. (2021) showed differences in training load between training days for several different variables, and Lopategui et al. (2021) also showed evidence of a taper from the first two acquisition days (strength and endurance) to the last acquisition day (speed), and again from the last acquisition day to the tapering day. Despite not investigating direct associations between training loads and physical qualities, Lopategui et al. (2021) also showed that the team maintained their physical performance levels over an extended period.

In summary, it seems that the little evidence existing on tactical periodization indicates that teams are successful in differentiating training loads between the different training days, and that it is possible to maintain physical performance levels over an extended period using this model. However, as mentioned, different teams and coaches utilizing this model will differ in the exact way it is implemented, meaning more studies should be conducted to investigate the external validity of these findings, and whether they can be generalized to the elite female population.

2.3 Quantifying load in football

A comprehensive understanding of the match load experienced by players is essential for practitioners to provide suitable training loads to adequately prepare players to perform and avoid injuries during the season (Datson et al., 2014; Ekstrand et al., 2020).

Training and match load can be quantified through both external and internal load measurements, where the external load is defined as the work done by the athlete and the internal load as the athlete's physiological response to this load (Akenhead & Nassis, 2016; Halson, 2014). Several tools and methods for monitoring external and internal training loads are available to researchers, coaches, and athletes. The use of global navigation satellite systems (GNSS), inertial measurement units (IMU), semi-automated camera systems, heart rate monitors, and questionnaires is now common practice to quantify training and match loads (Akenhead & Nassis, 2016; Halson, 2014). Measures of external load in football typically include the total distance covered, distances covered above or within certain velocity thresholds, and the number of acceleration and deceleration efforts, whereas internal measures of training load often include heart rate measures and rating of perceived exertion (RPE) (Akenhead & Nassis, 2016; Rago et al., 2019).

Total distance covered is typically used as a measure of training volume (Akenhead & Nassis, 2016), but often deemed of higher importance and a better indicator of performance in women's football is the distance covered at high intensities, which gives insights into the intensity distribution of the covered distance (Andersson et al., 2010; Krustrup et al., 2005; Mohr et al., 2008). The distance covered above or within certain thresholds is usually classified as high-speed running (HSR), very high-speed running (VHSR) and sprinting, or analogous (Akenhead & Nassis, 2016; Rago et al., 2019). Similar classifications, such as medium- and high-intensity, are also given to acceleration and deceleration variables (Rago et al., 2019). Accelerations and decelerations are suggested as good variables to quantify the mechanical loading experienced by players and are considered to possibly provide the best available field-based estimates of mechanical loading, despite their accurate depiction of tissue-specific loading being uncertain (Kalkhoven et al., 2021). A lack of consensus on appropriate acceleration/deceleration and velocity thresholds in women's football, despite of several proposed standardizations (Bradley & Vescovi, 2015; Dwyer & Gabbett, 2012; Park et al., 2019), limits the possibility for comparisons between studies (Rago et al., 2019). Further complicating the matter is the different methods used for data collection (Taberner et al., 2020), and a relatively large proportion of the existing time-motion research on women's football has used traditional video-based technology (Andersson, Ekblom, et al., 2008; Andersson et al., 2010; Gabbett & Mulvey, 2008; Krustrup et al., 2005; Mohr et al., 2008). The use of more contemporary technologies in women's football has often been prohibited by high financial costs and the fact that women's matches rarely have been played in stadiums with semi-automated camera system (Datson et al., 2017). Newer studies have, however, implemented the use of GNSS and semi-automated camera systems (Bradley et al., 2014; Datson et al., 2017, 2019; Hewitt et al., 2014; Mara et al., 2017a, 2017b; Ramos, Nakamura, Penna, Wilke, et al., 2019; D. Scott et al., 2020; Trewin et al., 2018).

Several tools can be used to quantify internal load, such as blood, urine and saliva samples, but heart rate and RPE measures are the most commonly used (Akenhead & Nassis, 2016). Heart rate measurements provide good estimates of aerobic demands during steady state exercise, but despite accurately depicting the work performed by the heart during football training and matches, its accurate depiction of physical demands is compromised by the intermittent nature of football deviating from that of steady state exercise and the many actions being conducted far above maximal aerobic speed (MAS) (Alexandre et al., 2012). Therefore, heart rate responses should be analysed in combination with other internal load measures, such as RPE (Alexandre et al., 2012). Developed by Foster et al. (2001), players rate their perceived exertion during the session on an integer scale from 1-10, and this score can also be multiplied with the session duration to evaluate the *session RPE* (sRPE) (Foster, 1998), which has proven to be a good indicator of internal load and has shown strong relationships with other measures of training load such as total distance covered and accelerometer derived metrics (Casamichana et al., 2013; Impellizzeri et al., 2004; Wiig et al., 2020).

2.4 Match load in elite women's football

An overview of match loads in elite women's football from studies that reported data from full matches can be found in table 2.1. Elite female football players are typically reported to cover ~10 km in total distance during a match, and this does not seem to have changed significantly the last 10-15 years (Andersson, Ekblom, et al., 2008; Mohr et al., 2008; Ramos, Nakamura, Penna, Wilke, et al., 2019; D. Scott et al., 2020). This is similar to developments in men's football during this period where only small changes have been observed (Bush et al., 2015). The included studies reported average values ranging from 930 – 3151 m, 338 – 777 m and 20 – 308 m for HSR, VHSR and sprint distance, respectively[1]. Few studies reported on the acceleration and decelerations profiles of elite female football players, and those who did all applied different thresholds. The number of accelerations and decelerations per match from these studies report averages ranging from 158-423 accelerations and 161-430 decelerations, with thresholds ranging from 1-2.26 $m \cdot s^{-2}$ (Mara et al., 2017b; Ramos, Nakamura, Penna, Wilke, et al., 2019; Trewin et al., 2018). Reports on sprint bouts are more consistent, with reported averages ranging from 20-33 bouts per match (table 2.1). Average heart rates during matches are reported to be in the range of 84-87% of maximal heart rate (Andersson et al., 2010; Krustrup et al., 2005), but higher averages of 90% and 89% in the first and second half, respectively, have also been reported (Ohlsson et al., 2015). These discrepancies are likely explained by the different methods used to determine maximal heart rate. Two of the studies determined this through exhaustive protocols (Andersson et al., 2010; Krustrup et al., 2005), whereas Ohlsson et al. (2015) determined this as the highest heart rate observed in either training or match play, where true maximal heart rates are not always reached (Andersson et al., 2010).

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[1] Distances and efforts above thresholds in the range of 12 – 16.5 $km \cdot h^{-1}$, 18 – 20 $km \cdot h^{-1}$ and 22.5 – 27 $km \cdot h^{-1}$ have been classified as HSR, VHSR and sprint, respectively, regardless of the locomotor classification given to these thresholds in the original articles. This was done with the intension of a more consistent approach to locomotor classifications and easier visual comparisons.

Table 2.1: *Match load during full matches in elite women's football (literature search described in appendix I).*

Reference	Year	n	Competition level	Nation/region	Total distance (m)	HSR (m)	VHSR (m)	Sprint (m)	HSR bouts	VHSR bouts	Sprint bouts
D. Scott et al.	2020	7-34	Highest division	USA	9 398 - 10 644#	1936-2659# (≥12.5 km·h^{-1})	316-666# (≥19 km·h^{-1})	59-248# (>22.5 km·h^{-1})			
Datson et al.	2019	107	International	Several						169 ± 49 (>19.8 km·h^{-1})	33 ± 13 (>25.1 km·h^{-1})
Ramos et al.	2019	17	International	Brazilian	9 825 - 10 376#	590-840# (15.6-20 km·h^{-1})	199-379# (>20 km·h^{-1})				
Trewin et al.	2018	45	International		10 368 ± 952	930 ± 348 (>16.5 km·h^{-1})			62 ± 20 (>16.5 km·h^{-1})	20 ± 9 (>20 km·h^{-1})	
Datson et al.	2017	107	International	Several	10 321 ± 859	2520 ± 580 (>14.4 km·h^{-1})	776 ± 247 (>19.8 km·h^{-1})	168 ± 82 (>25.1 km·h^{-1})			
Mara et al.	2017a	12	Highest division	Australia	10 025 ± 775	2452 ± 636 (12.2-19.1 km·h^{-1})	615 ± 258 (>19.4 km·h^{-1})		376 ± 90 (12.2-19.1 km·h^{-1})	70 ± 29 (>19.4 km·h^{-1})	
Hewitt et al.	2014	15	International friendlies	Australia	9631 ± 175	2407 ± 125 (12-19 km·h^{-1})	338 ± 30 (>19 km·h^{-1})				
Bradley et al.	2014	59	Champions league	Europe		3151 ± 87 (>12 km·h^{-1})	777 ± 33 (>18 km·h^{-1})	20 ± 4 (>27 km·h^{-1})			
Andersson et al.	2010	17	International	Scandinavia	9900 ± 1800°	1530 ± 100° (>15 km·h^{-1})		256 ± 57 (>25 km·h^{-1})	187 ± 15 (>15 km·h^{-1})		23 ± 2 (>25 km·h^{-1})
		17	Highest division	Scandinavia	9700 ± 1400°	1330 ± 900° (>15 km·h^{-1})		221 ± 45 (>25 km·h^{-1})	168 ± 12 (>15 km·h^{-1})		20 ± 2 (>25 km·h^{-1})

Reference	Year	n	Competition level	Nation/region	Total distance (m)	HSR (m)	VHSR (m)	Sprint (m)	HSR bouts	VHSR bouts	Sprint bouts
Andersson, Ekblom et al.	2008a	21	Highest division	Sweden	10 330°	1870° (>15 km·h^{-1})		320° (>25 km·h^{-1})	186 (>15 km·h^{-1})		22 (>25 km·h^{-1})
Gabbet & Mulvey	2008	13	National league	Australia	9706 ± 484	2461 ± 491*					
		13	International	Australia	9968 ± 1143	2014 ± 301*			965 ± 305*		
Mohr et al.	2008	19	Highest division & International	USA & national teams	10 330 ± 150°	1680 ± 100° (>15 km·h^{-1})		460 ± 20° (>25 km·h^{-1})	154 ± 7 (>15 km·h^{-1})		30 ± 2 (>25 km·h^{-1})
		15	Highest division	Scandinavia	10 440 ± 150°	1300 ± 100° (>15 km·h^{-1})		380 ± 50° (>25 km·h^{-1})	125 ± 7 (>15 km·h^{-1})		26 ± 1 (>25 km·h^{-1})
Krustrup et al.	2005	14	Highest division	Denmark	10 300°	1310° (>15 km·h^{-1})		160° (>25 km·h^{-1})	125 (>15 km·h^{-1})		26 (>25 km·h^{-1})

Data are presented as mean ± SD unless otherwise stated. HSR = high-speed running, VHSR = very high-speed running.
 # = Overall average not reported, data presented as range from lowest to highest positional average.
** = Qualitative classification of locomotor activity.*
° = Data converted from kilometers to meters.

Differences in match load are observed across playing standards, levels and positions, which needs to be accounted for when determining the appropriate training loads and approach (Datson et al., 2014). Mohr et al. (2008) observed that national team players in the U.S. top league (defined as top class players) performed more efforts and covered more distance above HSR and sprint thresholds compared to elite players in the top league in Denmark/Sweden who did not represent their national team (defined as high-level players). Moreover, both Andersson et al. (2010) and Gabbett & Mulvey (2008) observed that the same group of players covered significantly more distance and performed more efforts of HSR and sprint when playing international matches for their respective national teams compared to domestic club matches. The most recent study comparing elite female players of different performance levels did so between national team players and non-national team players who played at the same standard of play (D. Scott et al., 2020). D. Scott et al. (2020) observed only small and trivial effect sizes in favor of national team players, which raises the question whether all elite female players possess the ability to increase their match output if called up to international duty or if national team players perform less work during domestic matches due the lower level of competition. Regardless, despite several studies reporting differences in the work performed at high intensities, none of the studies reported significant differences in the total distances covered. This suggests that potential differences between playing standards and player levels likely lie within the work performed at high intensities, but more research is needed to better understand potential differences and to what extent they exist in the modern game. Andersson et al (2010) also investigated heart rates but found no differences in neither peak heart rate nor average heart rate during matches of different standards despite observing differences in external load variables.

Several studies have also investigated match loads of different playing positions, and an overview is presented in appendix II. Despite several studies reporting on the match load of different positions, not all have conducted statistical analyses on differences between positions (Bradley et al., 2014; Gabbett & Mulvey, 2008; Ramos, Nakamura, Penna, Wilke, et al., 2019; D. Scott et al., 2020; Trewin et al., 2018). Remarks made with regards to observations from these studies are therefore of a qualitive nature to some extent. It seems clear that central defenders cover less total distance than all other positions (Andersson et al., 2010; Datson et al., 2017; Hewitt et al., 2014; Mara et al., 2017a; D. Scott et al., 2020; Trewin et al., 2018). Some studies also report numbers indicating that attackers might cover less total distance than the remaining positions (Andersson et al., 2010; Gabbett & Mulvey, 2008; Mara et al., 2017a), while central midfielders seem to cover the longest total distances (Datson et al., 2017; D. Scott et al., 2020). At higher intensities (HSR and VHSR) it seems clear that all positions cover more distance than central defenders (Bradley et al., 2014; Datson et al., 2017; Mara et al., 2017a; D. Scott et al., 2020), and at the highest intensities (VHSR and sprint) some studies indicate that attackers and players playing in the wider positions cover more distance than central defenders and midfielders (Bradley et al., 2014; Datson et al., 2017; Mara et al., 2017a; D. Scott et al., 2020). Attackers and wide midfielders also show small and moderate count ratios compared to wide defenders, central defenders and central midfielders in favor of more sprints (Datson et al., 2019). Few studies have reported on the difference in acceleration and deceleration profiles between positions, but those who have seem to report similar numbers across all playing positions (Ramos, Nakamura, Penna, Wilke, et al., 2019; Trewin et al., 2018). There does not seem to be differences in the average heart rate during match play (Krustrup et al., 2005), but few studies have investigated this in the elite female population.

2.5 Training load in elite women's football

Players are reliant on suitable training loads in order to adequately prepare them for match play (Datson et al., 2014; Ekstrand et al., 2020). Knowledge of what training loads in elite women's football looks like in practice is therefore of importance for practitioners and researchers to determine whether these training loads are appropriate, and how to best adapt training to facilitate the desired responses (Datson et al., 2014). The literature examining training loads in elite women's football is, however, scarce, and only three studies where found (Costa et al., 2019; Mara et al., 2015; Moraleda et al., 2021). Out of these studies, only one study reported on the distribution of training loads across the different training days within a typical microcycle (Moraleda et al., 2021), as has been done by several studies in men's football (Martin-Garcia et al., 2018; Oliveira, Brito, Martins, et al., 2019; Stevens et al., 2017). Similarly, only one study reported training loads from different periods of the season, where the average session training loads during three different periods of the season were reported (Mara et al., 2015). Lastly, Costa et al. (2019) recorded individual and team average training loads from training sessions during an international tournament with the Portuguese national team.

When investigating training loads within the microcycle, training days are typically classified with regards to how many days they precede or succeed match day (MD) (Akenhead & Nassis, 2016), as illustrated in figure 2.3. Moraleda et al. (2021) quantified training loads during recovery sessions on MD+1 and during training sessions on MD-4, MD-3, and MD-2, in addition to match load on match days. They observed that external and internal loads were higher on match day than on recovery and training days. Focusing on the three training days, both MD-4 and MD-3 showed higher training loads than MD-2 for all parameters except HSR. Differences were also observed between MD-4 and MD-3, where higher accelerations counts but lower values of total distance and HSR were observed on MD-4 compared to MD-3. Despite not stating to follow a tactical periodization model, the authors pointed out that the team typically used reduced spaces and small-sided games on MD-4 and larger spaces and large-sided games on MD-3, which they attributed these differences to (Moraleda et al., 2021). Across the three training days, average duration, total distance, HSR and sRPE ranged from 70 to 82 min, 3025 to 4975 m, 172 to 494 m, and 222 to 579 arbitrary units, respectively (Moraleda et al., 2021). Similar measurements from the Portuguese national team showed that team average exposure time, total distance, HSR, and sRPE during training sessions ranged from 34 to 76 min, 2201 to 4284 m, 130 to 756 m, and 131 to 360 arbitrary units, respectively (Costa et al., 2019). Regarding seasonal changes in training load, Mara et al. (2015) observed a decline in training loads over the course of the season for all variables measured, and except for sprint and deceleration counts this was evident from both pre-season to early season and from early season to late season. Mean total distances where reported as 6646 m, 5437 m, and 4604 m, and mean HSR distances as 1415 m, 1027 m, and 742 m during pre-season, early season, and late season, respectively (Mara et al., 2015).

Observations from men’s football seem to demonstrate that the lowest training loads are reserved for MD-1 (Lopategui et al., 2021; Malone et al., 2015), and that the highest training loads typically are reported in the middle of the week (MD-4 and MD-3) (Lopategui et al., 2021; Martin-Garcia et al., 2018; Stevens et al., 2017). However, not all studies observe that teams differentiate training loads between training days, nor follow the typical set-up of two recovery days followed by four training days (Malone et al., 2015). Regarding changes in training loads across the season, training loads seem to vary during the in-season phase, but training loads observed at the latter parts of the season are typically at the lower end of those reported (Anderson et al., 2016; Malone et al., 2015; Rago et al., 2020).

In summary, the few studies that have reported on training loads in elite women's football indicate a decline in training loads over the course of a season, as well as distances covered during international training being at the lower end of those reported in domestic league teams. External and internal loads on training days are observed to be lower than those observed on match day and based on observations by Moraleda et al. (2020), the highest training loads are observed on MD-4 and MD-3 followed by a reduction on MD-2. These findings are similar to observations made in men's football, even though differences are observed between teams.

2.5.1 Relationships between training load and physical qualities

Dose-response relationships are typically observed between specific training loads and their targeted abilities during investigations into controlled training environments such as between strength training volume and increases in muscle mass and strength (Grgic et al., 2018; Ralston et al., 2017). The complex nature of football means that several different physiological stimuluses are imposed on players during training and match play, and GNSS systems and other technologies are therefore used to reflect these different external and internal loads. Consequently, investigations into relationships between these metrics and their effect on relevant physical qualities have become a topic of interest (Younesi et al., 2021).

Such investigations have shown conflicting results. Heart rate derived metrics have shown everything from small non-significant correlations to strong significant correlations with changes in endurance performance (Campos-Vazquez et al., 2017; Fitzpatrick et al., 2018; Manzi et al., 2013), and the same is true for sRPE (Campos-Vazquez et al., 2017; Younesi et al., 2021). One study has shown clear relationships between weekly time and distance above MAS thresholds and aerobic endurance improvements (Fitzpatrick et al., 2018), but such relationships are not as clear for generic HSR thresholds (Fitzpatrick et al., 2018; Rabbani et al., 2019; Younesi et al., 2021). Studies seem to find moderate to strong relationships between the number of accelerations, the combined number of accelerations and decelerations, and accelerometer derived metrics with changes in endurance performance (Clemente et al., 2019; Rabbani et al., 2019; Younesi et al., 2021). Few studies have investigated the effect of external and internal load metrics on qualities such as sprinting, COD and jumping, but there does not seem to be clear relationships between isolated metrics and changes to these qualities based on the little evidence that exist (Fitzpatrick et al., 2018; Younesi et al., 2021). The conflicting results described above likely reflects not only the different methods used within different studies, but also the complex nature of training load in football. This likely also explains why multi-mechanical models that summarize the combined training volume of different metrics into a single metric have been developed (Owen et al., 2017). Whether such models are better able to predict adaptions in physical qualities is uncertain. It should also be mentioned that the above presented results are gathered from youth, sub-elite, and elite male players, and no studies were found to conduct similar investigations in the elite female population.

In addition to investigations into specific metrics and their effects, physiological responses related to the specific acquisition sessions of tactical periodization have also been investigated. Buchheit et al (2018) investigated the acute neuromuscular responses to the different types of acquisition sessions (strength, endurance, and speed) through measurements of CMJ performance, adductor squeeze strength, and GPS and accelerometer derived calculations of vertical stiffness and propulsion efficiency during running at 12 and 22-24 $km \cdot h^{-1}$. Despite differences being small, CMJ performance increased after the endurance and speed sessions but not after strength sessions. The authors hypothesized that this could be caused by potentiation effects not evident after strength sessions due to more muscular fatigue, which was supported by a slightly larger decrease in groin strength. In contrast, propulsion efficiency was observed to be significantly lower following endurance and speed sessions compared to strength sessions. The authors hypothesized that this could be due to the longer total and HSR distances observed during these sessions, possibly leading to more posterior chain fatigue in, for example, the hamstrings, that are important for running at higher velocities (Buchheit et al., 2018; Dorn et al., 2012). However, the acute changes to these neuromuscular functions were of a small magnitude, and despite of promising results, further investigation should be conducted to establish relationships between specific acquisition sessions and their neuromuscular responses.

In summary, relationships are observed between certain training load metrics and physical qualities, but results are conflicting, and it is uncertain to what degree single metrics accurately predict changes in physical qualities. The little evidence that exists on differences in physiological responses to acquisition sessions using a tactical periodization model indicates that teams could be successful in achieving not only differentiations in training loads, but also in physiological responses. None of the above investigations were, however, conducted in the elite female football population, and to what degree these findings can be generalized is uncertain.

3. Methods

3.1 Participants

One team (n = 23) playing in the premier women's division in Norway, *Toppserien*, participated in this study (mean ± SD: age 22.0 ± 3.7 years, body mass 62.5 ± 6.0 kg, height 168.4 ± 4.2 cm). The team played in a 4-3-3 structure, and the participating players belonged to the following positional groups: central defender (n = 5), wide defender (n = 4), central midfielder (n = 8), wide attacker (n = 5) and attacker (n = 1). Goalkeepers were not included in this study as the physical characteristics of match play and training differs significantly from that of outfield players (Rago et al., 2019), and the club staff did not allocate tracking devices to the goalkeepers. The study abided by the ethical principles of the Declaration of Helsinki, and accordingly players signed a letter of consent before the commencement of the study (appendix VI). The study was approved by the Norwegian Centre for Research Data (NSD) (appendix VII) and the ethics committee at the Norwegian School of Sport Sciences (appendix VIII).

3.2 Design

The current study was conducted as a prospective cohort study. To investigate training loads within the microcycle, the internal and external loads from training sessions and matches were collected over a period of 20 weeks for the entire duration of the 2020 competitive season lasting from July 5th to November 15th. To investigate seasonal changes to these training loads, the in-season period was divided into two periods. Physical performance testing was conducted before (pre-season), between (in-season) and after (post-season) the two periods to investigate accompanying and associated physical performance levels and changes.

Due to the COVID-19 pandemic, the original start to the season was postponed eight days before the planned start, at which point pre-season testing had already been carried out. Team training could resume one month ahead of the new start to the season, during which time there was no opportunity to take the team through a full testing assessment at the testing facility. Consequently, the pre-season test results presented in this study were obtained 20 weeks before the start of the season. However, physical qualities were seen to be unaffected during this period in another Norwegian female football team (Pedersen et al., 2021). In-season testing was performed in week 12 and post-season testing was performed two weeks after the last league game, as the team had two play-off games following their last league game. Endurance testing was conducted by the club itself and was therefore performed on separate days from the other testing. Pre-season endurance testing was performed 5 weeks before the first league game, in-season testing on the first day of week 13 and post-season testing two weeks after the last league game. The different periods and test days are summed up in figure 3.1.

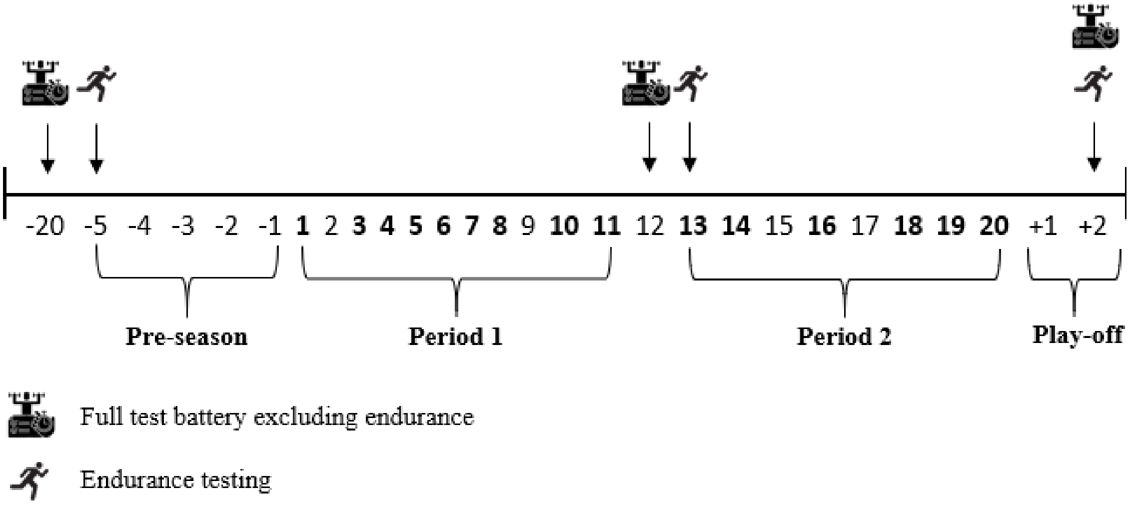

Figure 3.1: *Study design illustration.* ***Bold*** *numbers represent the training weeks included for analyses.*

3.2.1 Inclusion criteria

For the purpose of this study, only field-based team training sessions were considered for analyses. This meant that several types of training sessions were not included, such as individual sessions, additional sessions for non-starters, rehabilitation sessions and gym sessions. Training sessions were classified and analysed in relation to the proximity of the upcoming matchday and were divided into the following classifications: MD-4, MD-3, MD-2, and MD-1. Using terminology specific to the concept of tactical periodization, MD-4 corresponds to strength day, MD-3 to endurance day, and MD-2 to speed day, but will be referred to as MD-X for easier comparisons with other studies investigating microcycle training loads. Since the aim of this thesis was to investigate training loads associated with the specific training days within a tactical periodization microcycle, only weeks with 8, 7 or 6 days between games were included, as training content would often change on the given training days during longer/shorter gameweeks.

Players were only included if they featured in at least one of the 18 league games. As a result, two players were excluded from any further analyses, leaving the total number of participants at 21 (mean ± SD: age 22.2 ± 3.7 years, body mass 64.1 ± 6.6 kg, height 168.6 ± 4.3 cm). For analyses including match load data, only players that had played full matches were included. For comparisons of training loads between the two periods, players had to have training load data from at least half of the sessions investigated on each training day in both periods to make sure that their training loads were reflective and good estimates of potential changes between periods. Individual training load data was only included if the player participated in the entirety of the session. Due to technical problems with the application used to collect internal training load data we were not able to extract data for two of the players, meaning that internal training load was only collected from 19 of the 21 players. There was also one session on MD-3 where external load data from 10 players were observed to be incomplete due to technical malfunctions and we were unable to retrieve this data. The total number of observations are presented in table 3.1, 3.2 and 3.3.

Table 3.1: *Number of external and internal load observations on each training day for the entire duration of the season.*

	External load observations					**Internal load observations**				
	n	**Total**	**Mean**	**Min**	**Max**	**n**	**Total**	**Mean**	**Min**	**Max**
MD	15	117	7.8	1	18	13	105	8.1	1	18
MD-1	21	235	11.2	4	15	19	198	10.4	4	15
MD-2	21	231	11.0	4	15	19	217	11.4	4	15
MD-3	21	227	10.8	5	14	19	224	11.8	5	15
MD-4	21	159	7.6	3	10	19	151	7.9	3	10

Total = total number of observations, mean = average number of observations per player, min = minimum number of observations per player, max = maximum number of observations per player, MD = match day.

Table 3.2: *Number of external load observations on each training day in both periods.*

		Period 1				Period 2			
	n	**Total**	**Mean**	**Min**	**Max**	**Total**	**Mean**	**Min**	**Max**
MD-1	14	112	8.0	7	9	72	5.1	3	6
MD-2	14	110	7.9	6	9	68	4.9	3	6
MD-3	14	108	7.7	6	9	70	5.0	3	6
MD-4	14	51	3.6	3	4	50	3.6	3	4

Total = total number of observations, mean = average number of observations per player, min = minimum number of observations per player, max = maximum number of observations per player, MD = match day.

Table 3.3: *Number of internal load observations on each training day in both periods.*

		Period 1				Period 2			
	n	**Total**	**Mean**	**Min**	**Max**	**Total**	**Mean**	**Min**	**Max**
MD-1	12	92	7.7	6	9	58	4.8	3	6
MD-2	12	94	7.8	5	9	63	5.3	3	6
MD-3	12	93	7.8	6	9	69	5.8	5	6
MD-4	12	45	3.8	3	4	43	3.6	3	4

Total = total number of observations, mean = average number of observations per player, min = minimum number of observations per player, max = maximum number of observations per player, MD = match day.

3.3 Training and match load

The data collection was carried out at the club’s home arena and at oppositions’ arenas during away games. The club’s home arena is a grass pitch measuring 105 meters in length and 65 meters in width where the team both trains and play their home matches. Away games were played on both artificial turf and natural grass.

3.3.1 External load measurements

Players’ external training and match load was monitored using a 10 Hz GPS system with a built-in 200 Hz IMU (Polar Team Pro Sensor, Polar Electro, Kempele, Finland). The Polar Team Pro Sensor is an electronic device with the dimensions 36 mm x 68 mm x 13 mm and weighs 39 grams, with battery duration up to 10 hours and memory up to

65 hours. The system also contains a recharging docking station and a cloud-based analytics software web service with a real-time monitoring application. The players wore the device mounted to a heart rate strap with the device located at the bottom of the sternum for all training sessions and matches. Each player had their own personal device assigned to them, meaning that they used the same device for all training sessions and matches. Players put on their device inside the club house before going out to train, and the recording started as soon as heart rate was detected. The real-time monitoring application (Polar Team Pro App, Polar Electro, Kempele, Finland; Version 2.0.4) was used to mark the exact start and end of each training session, defined as the beginning of the warm-up to the end of the last organised drill. On match days the players put on their device prior to warm up, and the same application was used to mark the exact start and end of each half. After each training session and match the devices were placed back on the docking station for data import and later processing.

The following variables were selected for analyses: total distance (m), HSR distance (>16 km$\cdot$h^{-1}) (m), sprint distance (>22.5 km$\cdot$h^{-1}) (m), and the combined number of accelerations (>2 m$\cdot$s^{-2}) and decelerations (<-2 m$\cdot$s^{-2}) (ACC/DEC). These variables were also divided by session duration in minutes to create intensity variables of total distance covered per minute (TDC$\cdot$min^{-1}), HSR distance covered per minute (HSR$\cdot$min^{-1}), sprint distance covered per minute (sprint$\cdot$min^{-1}), and ACC/DEC per minute (ACC/DEC$\cdot$min^{-1}). The sprint threshold was based on recommendations by Park et al. (2019), and is the same as used in a recent study on match load in elite women's football (D. Scott et al., 2020). The high-speed running and ACC/DEC thresholds are similar to those reported previously in women's football research (Datson et al., 2017; Trewin et al., 2018), and were also standard thresholds for the Norwegian Toppserien in the Polar Team Pro System used by several teams in the league.

Ten Hz GPS systems typically show better validity and reliability than previous models using lower sampling rates for measurements of training loads in team sports, especially at higher velocities (Malone et al., 2017; M. Scott et al., 2015). The specific system used in this project has been shown to have acceptable validity and reliability for measurements of total distances and distances covered above different velocity thresholds, with a tendency towards lower precision at higher velocities (Akyildiz et al., 2020; Randers et al., 2019) as is also the case with other 10 Hz GPS units (Malone et al., 2017; M. Scott et al., 2015). No study was found on the validity and reliability of accelerometer derived data from the Polar Team Pro system, but integrated accelerometers typically show good intra- and inter-unit reliability despite showing questionable validity, meaning that accelerometer data can be used to detect changes or differences but measurements of absolute magnitudes of acceleration should be interpreted with caution (Malone et al., 2017; M. Scott et al., 2015).

3.3.2 Internal load measurements

Internal training load was monitored using the modified CR10 RPE scale (Foster et al. 2001), where players rate their perceived exertion during the session on an integer scale from 1-10 (appendix III). All players were familiarised with the scale and how to rate RPE before the commencement of the study and registered RPE within 30 minutes after each training session and match using a commercial phone application (AthleteMonitoring Pro, FITSTATS Technologies, Moncton, Canada; Version 1.1.6). RPE was also multiplied by the session duration in minutes to calculate sRPE (Foster 1998), which is considered a good indicator of internal training load that has shown strong relationships with other measures of training load such as total distance covered and accelerometer derived metrics (Casamichana et al., 2013; Impellizzeri et al., 2004; Wiig et al., 2020).

3.4 Physical performance testing

Physical performance data was collected through a full test battery developed by the Norwegian FA medical staff and was completed three times during the season (figure 3.1). All tests except from the endurance test were performed on the same day at Idrettens Helsesenter, which is owned by the Norwegian FA, and all players were familiar with the tests. The tests were performed by staff at Idrettens Helsesenter, with the presence of the club’s fitness and medical staff. The following physical qualities were tested: Sprinting ability, COD ability, leg press strength and power, and CMJ. Endurance testing was performed by the club’s staff on a separate day. The sprint test was always followed by the COD test, and these two were always performed as the last two tests. For the remaining tests, the testing order was randomised for each player before test 1 and was maintained for the two following test occasions to make sure that potential changes were not caused by a change to the testing order. The players went through a standardized 10-minute warm-up prior to the commencement of testing and also did an additional warm-up consisting of sprint drills and progression runs before moving on to the two final tests of linear sprint and COD.

3.4.1 Endurance

Football specific endurance capacity was assessed using YYIR1. The test consists of 20-meter shuttle runs with increasing speed, interspersed by 10 seconds active rest during which time the players must move around a cone placed 5-meters behind the starting line and come to a complete stop back at the starting line before commencing the next shuttle run (Figure 3.2). Prior to starting the test, the players performed a 10-minute standardised warm-up. An audio file with the official audio track for the YYIR1 was used. The file starts off with information about the test and thereafter gives the players information about what level they are on, as well as a signal for when to start, reach the turning line, and when they need to be back at the starting line on each shuttle run. When a player received two consecutive warnings or was no longer able to continue, they were withdrawn from the test. The players received a warning if they started before the starting signal, failed to touch the line on the opposite side or failed to reach back to the starting line before the signal. The final score was recorded as the last shuttle run completed before being unable to continue or as the last shuttle run completed before the one where they got their second consecutive warning. The final score was calculated as the total distance reached (40 m per shuttle run). The YYIR1 has proven to be a reliable and valid test that can be used as an indicator of the physical performance of elite female players in competitive matches (Krustrup et al., 2003, 2005).

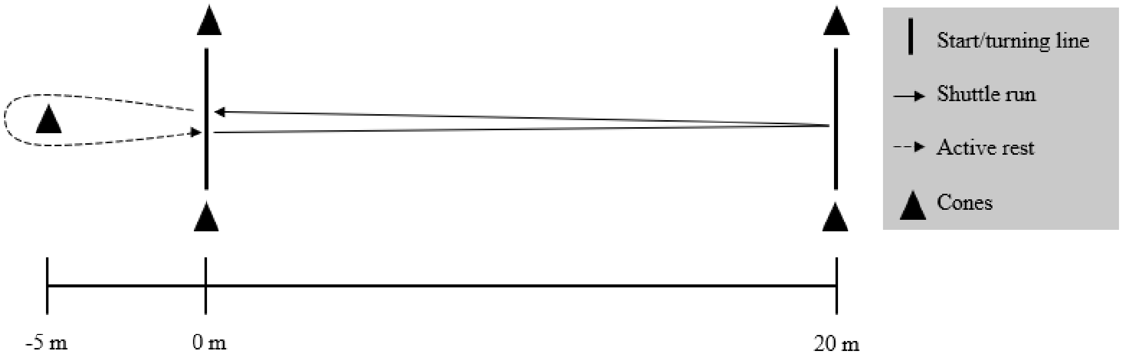

Figure 3.2: *Yo-Yo Intermittent Recovery Test Level 1 illustration.*

3.4.2 Sprinting ability

Sprinting ability was assessed on an indoor 13mm Polytan M synthetic surface (Polytan GmbH, Burgheim, Germany) where players performed a 40-meter linear sprint with split times recorded at 20, 30 and 40 meters (Figure 3.3). Dual beam MuscleLab timing gates (Ergotest Innovation AS, Porsgrunn, Norway) with infrared photocells were placed 1 meter above the ground with a vertical distance of 30 cm between them. A first cell release mechanism at the front foot was used to initiate the timing clock, meaning that timing would start as soon as the front foot lifted away from the infrared release sensor. The system operated with a resolution of 2 milliseconds. Using this starting technology results in the player's centre of mass being displaced in front of the starting line once the recording starts, meaning that sprint times will be faster than those initiated by photocells at the starting line. Once the test leader had ensured that the equipment was ready to record, players were given an all-clear signal after which they started at their own initiative. All players were given two trials with a minimum of three minutes rest between trials but were given an additional trial if there was improvement from the first to the second trial. The best trial for each player was recorded in the manufacturer's software (MuscleLab software, Ergotest Innovation AS, Porsgrunn, Norway; Version 10.5.69.4823) and used for further analyses. Split times investigated were also taken from the trial with the best total 40-meter time. Dual-beam photocells are reported to show greater accuracy than single beam photocells, with a CV of ~1% for short sprints, and are considered a valid and reliable method for measuring short sprints (Haugen & Buchheit, 2016).

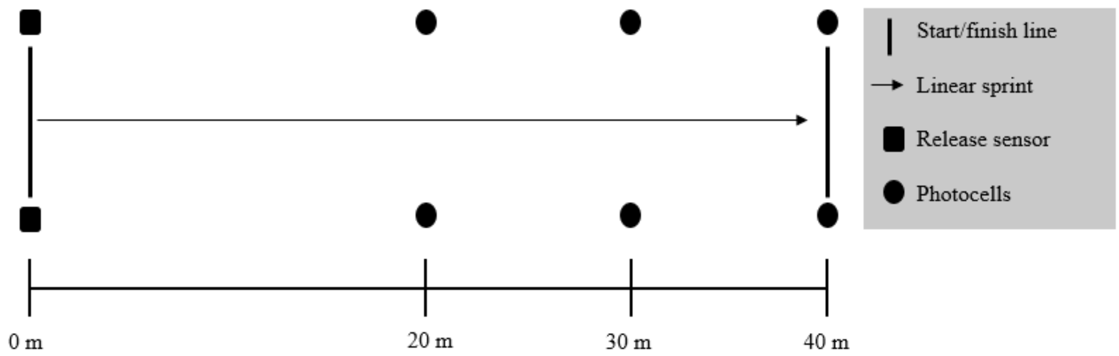

Figure 3.3: *Linear sprint test illustration.*

3.4.3 Change of direction ability

COD ability was assessed using the A180° test, which is the standard COD test used at the Norwegian Olympic Sports Centre. The test is performed by performing four changes of direction on the same leg before running to the finish line (Figure 3.4). Instead of a first cell release mechanism, timing was initiated by an additional pair of dual beam photocells placed at the starting line, but otherwise the same surface and timing equipment used for the linear sprint test was used for the A180°. The score was recorded as the time taken from crossing the starting line to crossing the finish line. Test leaders were placed on both turning lines and controlled that the foot crossed the 12.5-meter and 7.5-meter lines on all changes of direction, and if a player failed to do so the attempt was not recorded. Players were given one trial on each side with a minimum of three minutes between trials but were given additional trials if they failed to reach the line or otherwise had problems during the changes of direction. Results from each side were classified as being on either the dominant or non-dominant side, and the kicking leg was classified as the dominant side as in previous investigations in this population (Brown et al., 2014; Thomas et al., 2020). The A180° test is very similar to the previously investigated S180° test, which has been observed to be one of the must valid and reliable tests for measurements of COD ability in football players when compared to several other tests (Sporis et al., 2010).

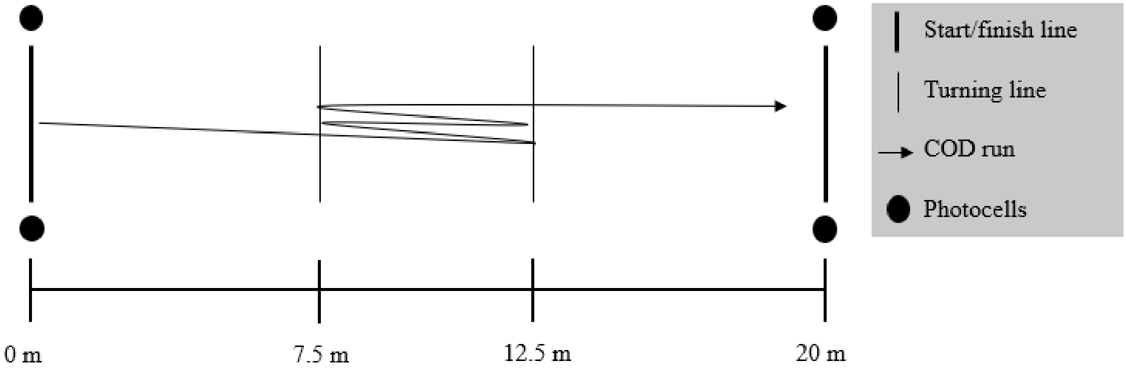

Figure 3.4: Change of direction test illustration.

3.4.4 Leg press strength and power

Leg press strength and power was assessed using the Keiser Air 300 leg press (Keiser Corporation, Fresno, California) device with pneumatic resistance and a left and right footplate that moves independently of each other. A player's seating position was adjusted so that they were sat with the femur perpendicular to the ground while maintaining contact with the back of the seat and sitting in an upright position. Both feet were placed flat towards the bottom of the footplates and hands placed on the handgrips on each side of the seat (Figure 3.5). Players carried out a 10-repetition protocol with progressively increased resistance until they reached failure (table 3.4). The resistance increments between each repetition were pre-programmed in the Keiser A420 software based on the resistance set for the 10th repetition by the test leader, which was set at 219 kg, and rest periods also increased progressively from 5 to 38 seconds between repetitions. Prior to the start of the protocol the players performed three slow repetitions at 60 kg and three fast repetitions at 120 kg. The protocol started with two reps at the starting weight where players were instructed to press with 70% and 90% effort respectively, after which they were instructed to perform all repetitions with 100% effort. Players were instructed to continue until they reached failure, defined as the first resistance they were unable to extend both legs while remaining in a seated position, and thus not all players completed the same number of repetitions. Maximal force (Newton) and power (Watt) were recorded for all players and were also calculated relative to each player's body mass. A recent study on the reliability of the Keiser leg press machine using the same protocol as the one in this study showed good reliability for measures of both force and power in elite football players (Redden et al., 2018).

Table 3.4: *Keiser A420 10-repetition protocol. Adapted from Redden et al. (2018).*

Repetition number	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**	**Subsequent reps**
Resistance (kg)	38**	58	78	98	118	139	159	179	199	219	Previous rep + 20.1*
Subsequent rest (s)	5	5	5	11	16	21	26	32	38	38	38

**Rep to rep resistance increase = (maximal resistance selected-18.14)/10. ** Starting Resistance = Resistance Increase + 18.14.*

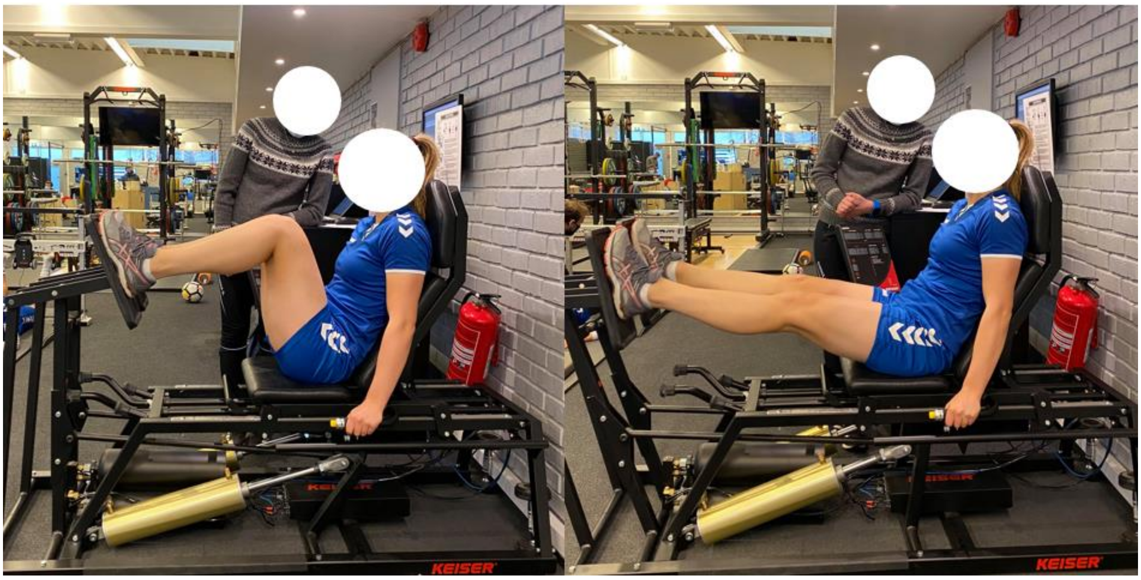

Figure 3.5: *Leg press execution.*

3.4.5 Countermovement jump

The players' jumping ability was assessed via a CMJ performed on a MuscleLab force plate (Ergotest Innovation AS, Porsgrunn, Norway). Players were instructed to stand with their feet placed in their preferred jumping stance (about shoulder width apart) and keep both hands at their hips throughout the entire duration of the movement (figure 3.6). The test leader would ensure that the platform was ready to record before giving the player a signal to jump. If the player commenced the movement prior to getting the signal to jump or released the hands from the hips during the movement, then the jump was not recorded. Players were given three trials to reach their maximal jump height but were allowed one or two more trials if there was clear improvement on their last trial. Jump height was calculated within the manufacturer's software (MuscleLab software, Ergotest Innovation AS, Porsgrunn, Norway; Version 10.5.69.4823) as the displacement of the centre of mass using the force development data and the measured body mass. Force plates are considered the gold standard for measuring CMJ height, and studies report good reliability (ICC = >0.95) for measures of CMJ without arm swing (Heishman et al., 2020; Rago et al., 2018).

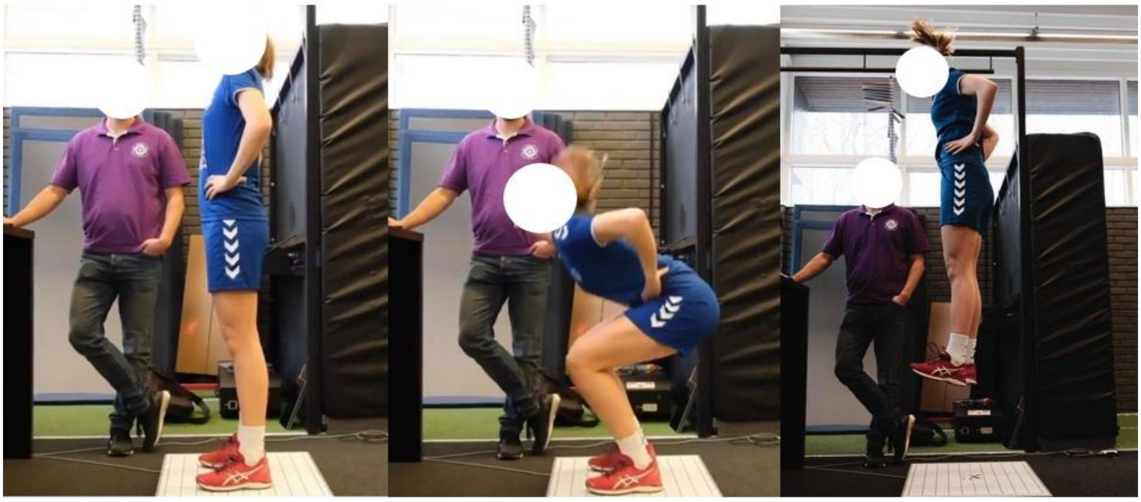

Figure 3.6: *Countermovement jump execution.*

3.5 Data processing and analyses

Once the external load data had been synchronized and imported into the cloud-based web service (Polar Team Pro Web Service, Polar Electro, Kempele, Finland), this software was used to double check that all devices had been recording for the entire duration of the session. The data was thereafter exported as a XLS file to Microsoft Excel Office 365 (Microsoft Corporation, Redmond, WA, USA) for further processing. Internal training load data (RPE) was exported from the AthleteMonitoring web service (AthleteMonitoring.eu, FITSTATS Technologies, Moncton, Canada) as an XLSX file for further processing in Microsoft Excel Office 365. Physical performance data collected at Idrettens Helsesenter was recorded in the previously mentioned software and written into Microsoft Excel Office 365 during the test days at the testing facility. This was also done for the endurance test results on the days when endurance was tested.

To analyse team differences in training loads and intensities between the different days within the microcycle, individual averages for each day (MD-4, MD-3, MD-2, MD-1, and MD) were calculated for all parameters. To analyse team differences in training loads and intensities between periods, a player’s average training load and intensity for each training day in both periods were calculated. To investigate associations between training loads and changes in physical performance, the average weekly training load within all relevant parameters was calculated for each player in both periods by adding together the average training loads from each training day.

3.6 Statistical analyses

Descriptive data are presented as mean ± SD. Data on differences are presented as mean differences, and in accordance with recent recommendations, are reported alongside confidence intervals and effect sizes, with the confidence level set at 95% (Impellizzeri, Meyer, et al., 2019). Effect sizes were interpreted as: <0.2 = trivial, 0.2 to 0.6 = small, 0.6 to 1.2 = moderate, 1.2 to 2.0 = large, 2.0 to 4.0 = very large, and >4.0 = extremely large, as per estimates by Hopkins et al. (2009) based on interpretations of correlation coefficient thresholds suggested by Cohen (1988). As suggested in the paper by Impellizzeri, Meyer et al. (2019), null hypothesis testing was also included as complimentary analysis and is reported with $\alpha = \leq 0.05$ considered as significant. Correlation coefficients were interpreted as: <0.1 = trivial, 0.1 to 0.3 = small, 0.3 to 0.5 = moderate, 0.5 to 0.7 = large, 0.7 to 0.9 = very large, and >0.9 = extremely large (Hopkins et al., 2009).

All statistical analyses, apart from calculation of effect sizes, were performed in GraphPad Prism (Version 9.0.2, GraphPad Software Inc, San Diego, California). For estimations of effect sizes, Cohens' d was calculated in Microsoft Excel Office 365 for all analyses of differences/changes in training load and physical qualities. To investigate differences in training load on the different training days, a repeated measures one-way ANOVA was performed, with Tukey's HSD test used for post hoc analyses to determine where specific difference lay and accompanying confidence intervals and p-values. To investigate differences in training loads between periods, a paired sample t-test was performed between the corresponding training days in each period. Since not all players were able to perform the full test battery at all three timepoints, analyses of accompanying changes in physical qualities were also done using a paired sample t-test between all tests (i.e., test 2 vs 1, 3 vs 1 and 3 vs 2). To investigate the associations between training loads and changes in physical qualities, Pearson's correlation coefficients were calculated. The average weekly training loads in periods 1 and 2 were used to investigate the correlation with change in YYIR1 and were compared to the change from test 1 to test 2 and test 2 to test 3, respectively. For all other physical performance tests, correlations were calculated between the average weekly training loads in period 2 and change in physical qualities from test 2 to test 3. This was done since the results from test 1 were gathered 20 weeks before the start of period 1.

4. Results

4.1 Microcycle training loads throughout the season

The average duration for the different training sessions were 110.9 ± 8.6, 107.4 ± 10.1, 90.3 ± 12.7 and 75.0 ± 12.2 min for MD-4, MD-3, MD-2 and MD-1, respectively, with significant differences observed between all days (p = <0.01, ES = 1.8-12.9). Significant differences in training loads were also observed between all training days across all parameters except from sRPE between MD-4 and MD-3, which were the two days with the highest sRPE values (table 4.1). ACC/DEC values were highest on MD-4, whereas total distance, HSR and sprint distance values were highest on MD-3. All measures of training load were significantly reduced from MD-3 to MD-2 and from MD-2 to MD-1. MD-4 also showed significantly higher values of sRPE, total distance, and ACC/DEC compared to MD-2 and MD-1, but measures of HSR and sprint were higher on MD-2 than on MD-4. MD-1 showed the lowest values across all parameters. Significantly higher values were observed on MD compared to all training days across all measures of training load. Training loads expressed as a percentage of match load for each training day can be found in appendix IV.

Table 4.1: *Training load comparisons between the different days within the microcycle.*

	Mean ± SD		Mean difference	Confidence interval (95%)	Effect size	P-value
TDC						
MD	9978 ± 699					
		vs MD-1	7042	6472 to 7613	13.4	<0.01
		vs MD-2	5270	4814 to 5726	9.6	<0.01
		vs MD-3	3312	2926 to 3698	6.0	<0.01
		vs MD-4	4276	3803 to 4749	8.2	<0.01
MD-1	3039 ± 343					
		vs MD-2	-1787	-1939 to -1635	5.0	<0.01
		vs MD-3	-3805	-3994 to -3617	9.2	<0.01
		vs MD-4	-2775	-2931 to -2620	7.7	<0.01
MD-2	4826 ± 374					
		vs MD-3	-2019	-2170 to -1867	4.7	<0.01
		vs MD-4	-989	-1167 to -810	2.6	<0.01

MD-3	6845 ± 478					
		vs MD-4	1030	875 to 1185	2.4	<0.01
MD-4	5815 ± 375					
HSR						
MD	1247 ± 295					
		vs MD-1	1181	950 to 1412	5.6	<0.01
		vs MD-2	849	644 to 1053	3.9	<0.01
		vs MD-3	533	382 to 683	2.3	<0.01
		vs MD-4	911	703 to 1119	4.2	<0.01
MD-1	74 ± 33					
		vs MD-2	-349	-390 to -309	5.3	<0.01
		vs MD-3	-671	-749 to -593	6.4	<0.01
		vs MD-4	-271	-324 to -217	3.4	<0.01
MD-2	424 ± 88					
		vs MD-3	-321	-379 to -264	2.7	<0.01
		vs MD-4	79	36 to 122	0.8	<0.01
MD-3	745 ± 146					
		vs MD-4	400	333 to 468	3.1	<0.01
MD-4	345 ± 107					
Sprint						
MD	154 ± 64					
		vs MD-1	151	100 to 202	3.3	<0.01
		vs MD-2	104	61 to 146	2.2	<0.01
		vs MD-3	53	9 to 97	1.1	0.02
		vs MD-4	136	89 to 184	3.0	<0.01
MD-1	4 ± 4					
		vs MD-2	-52	-68 to -36	2.6	<0.01
		vs MD-3	-104	-124 to -83	4.2	<0.01
		vs MD-4	-13	-20 to -6	1.5	<0.01
MD-2	56 ± 29					
		vs MD-3	-51	-67 to -35	1.6	<0.01
		vs MD-4	39	25 to 53	1.8	<0.01
MD-3	107 ± 35					
		vs MD-4	90	72 to 109	3.5	<0.01
MD-4	17 ± 12					
ACC/DEC						

MD	195 ± 34					
		vs MD-1	145	118 to 172	5.8	<0.01
		vs MD-2	106	84 to 127	4.1	<0.01
		vs MD-3	64	49 to 79	2.2	<0.01
		vs MD-4	50	28 to 71	1.8	<0.01
MD-1	53 ± 12					
		vs MD-2	-36	-43 to -29	3.1	<0.01
		vs MD-3	-76	-88 to -64	4.4	<0.01
		vs MD-4	-90	-103 to -78	5.3	<0.01
MD-2	89 ± 11					
		vs MD-3	-40	-49 to -31	2.4	<0.01
		vs MD-4	-54	-64 to -45	3.3	<0.01
MD-3	129 ± 21					
		vs MD-4	-15	-22 to -7	0.7	<0.01
MD-4	143 ± 21					
sRPE (au)						
MD	765 ± 76					
		vs MD-1	603	537 to 669	8.8	<0.01
		vs MD-2	401	331 to 471	4.8	<0.01
		vs MD-3	163	90 to 236	1.2	<0.01
		vs MD-4	136	46 to 226	0.8	<0.01
MD-1	142 ± 36					
		vs MD-2	-216	-248 to -185	3.9	<0.01
		vs MD-3	-445	-490 to -400	6.3	<0.01
		vs MD-4	-471	-521 to -422	7.4	<0.01
MD-2	369 ± 73					
		vs MD-3	-228	-275 to -182	2.7	<0.01
		vs MD-4	-255	-297 to -213	3.3	<0.01
MD-3	605 ± 98					
		vs MD-4	-27	-65 to 12	0.3	0.27
MD-4	634 ± 88					

Data are presented as mean ± SD. TDC = total distance covered, HSR = high-speed running distance, sprint = sprint distance, ACC/DEC = combined number of accelerations and decelerations, sRPE = session rating of perceived exertion, MD = match day.

4.2 Microcycle training intensity throughout the season

As for training loads, significant differences were observed between MD and each training day across all measures of training intensity (Table 4.2). The highest average session intensities for all distance variables (TDC·min^{-1}, HSR·min^{-1} and sprint·min^{-1}) were observed on MD-3. ACC/DEC·min^{-1} was slightly higher on MD-4 than on MD-3 (ES = 0.4) but was clearly higher than both MD-2 and MD-1 (ES = 3.3-5.3). RPE was not different between MD-4 and MD-3 but both days showed significantly higher values than both MD-2 and MD-1. TDC·min^{-1} on MD-4 showed no difference compared to MD-2, but HSR·min^{-1} and sprint·min^{-1} was observed to be higher on MD-2 than on MD-4. MD-1 showed the lowest training intensity values across all parameters.

Table 4.2: *Training intensity comparisons between the different days within the microcycle.*

	Mean ± SD		**Mean difference**	**Confidence interval (95%)**	**Effect size**	**P-value**
TDC·min^{-1}						
MD	104.9 ± 8.2					
		vs MD-1	65.0	58.4 to 71.6	10.7	<0.01
		vs MD-2	52.5	46.8 to 58.2	8.4	<0.01
		vs MD-3	42.4	37.3 to 47.5	6.7	<0.01
		vs MD-4	53.8	48.3 to 59.2	8.7	<0.01
MD-1	40.9 ± 3.2					
		vs MD-2	-12.7	-14.3 to 11.1	3.9	<0.01
		vs MD-3	-23.1	-25.4 to -21.0	6.3	<0.01
		vs MD-4	-11.3	-13.1 to 9.5	3.2	<0.01
MD-2	53.6 ± 3.6					
		vs MD-3	-10.4	-11.7 to 14.3	2.7	<0.01
		vs MD-4	1.4	-0.4 to 3.2	0.5	0.15
MD-3	64.0 ± 4.1					
		vs MD-4	11.8	10.1 to 13.6	3.1	<0.01
MD-4	52.2 ± 3.7					
HSR·min^{-1}						
MD	13.2 ± 3.1					
		vs MD-1	12.3	9.8 to 14.7	5.5	<0.01
		vs MD-2	8.7	6.5 to 10.9	3.8	<0.01

		vs MD-3	6.5	4.8 to 8.1	2.7	<0.01
		vs MD-4	10.2	7.9 to 12.4	4.5	<0.01
MD-1	1.0 ± 0.4					
		vs MD-2	-3.8	-4.2 to -3.3	5.3	<0.01
		vs MD-3	-6.1	-6.7 to -5.4	6.4	<0.01
		vs MD-4	-2.1	-2.6 to -1.7	2.8	<0.01
MD-2	4.7 ± 0.9					
		vs MD-3	-2.3	-2.8 to -1.8	2.0	<0.01
		vs MD-4	1.6	1.2 to 2.1	2.8	<0.01
MD-3	7.0 ± 1.3					
		vs MD-4	3.9	3.3 to 3.6	3.5	<0.01
MD-4	3.1 ± 1.0					
Sprint·min^{-1}						
MD	1.7 ± 0.7					
		vs MD-1	1.6	1.0 to 2.1	3.3	<0.01
		vs MD-2	1.1	0.6 to 1.5	2.1	<0.01
		vs MD-3	0.7	0.2 to 1.1	1.3	<0.01
		vs MD-4	1.5	1.0 to 2.0	3.0	<0.01
MD-1	0.0 ± 0.0					
		vs MD-2	-0.6	-0.7 to -0.4	2.5	<0.01
		vs MD-3	-1.0	-1.2 to -0.8	3.6	<0.01
		vs MD-4	-0.1	-0.2 to -0.1	1.1	<0.01
MD-2	0.6 ± 0.3					
		vs MD-3	-0.4	-0.6 to -0.3	1.2	<0.01
		vs MD-4	0.5	0.3 to 0.6	2.0	<0.01
MD-3	1.0 ± 0.4					
		vs MD-4	0.9	0.7 to 1.1	3.2	<0.01
MD-4	0.2 ± 0.1					
ACC/DEC·min^{-1}						
MD	2.1 ± 0.4					
		vs MD-1	1.4	1.1 to 1.7	5.3	<0.01
		vs MD-2	1.1	0.8 to 1.3	3.9	<0.01
		vs MD-3	0.8	0.7 to 1.0	2.9	<0.01
		vs MD-4	0.8	0.5 to 1.0	2.7	<0.01
MD-1	0.7 ± 0.7					
		vs MD-2	-0.3	-0.4 to -0.2	2.4	<0.01

		vs MD-3	-0.5	-0.6 to -0.4	3.2	<0.01
		vs MD-4	-0.6	-0.7 to -0.5	3.7	<0.01
MD-2	1.0 ± 0.1					
		vs MD-3	-0.2	-0.3 to -0.1	1.3	<0.01
		vs MD-4	-0.3	-0.4 to -0.2	1.8	<0.01
MD-3	1.2 ± 0.2					
		vs MD-4	-0.1	-0.1 to -0.0	0.4	0.01
MD-4	1.3 ± 0.2					
RPE (0-10)						
MD	8.1 ± 0.8					
		vs MD-1	5.8	5.1 to 6.6	7.3	<0.01
		vs MD-2	4.0	3.2 to 4.7	4.4	<0.01
		vs MD-3	2.4	1.7 to 3.2	2.2	<0.01
		vs MD-4	2.3	1.4 to 3.3	2.0	<0.01
MD-1	2.2 ± 0.5					
		vs MD-2	-2.0	-2.4 to -1.7	3.1	<0.01
		vs MD-3	-3.4	-3.8 to -3.1	4.7	<0.01
		vs MD-4	-3.5	-3.9 to -3.1	4.8	<0.01
MD-2	4.2 ± 0.7					
		vs MD-3	-1.4	-1.8 to -1.0	1.8	<0.01
		vs MD-4	-1.5	-1.8 to -1.2	1.9	<0.01
MD-3	5.6 ± 0.8					
		vs MD-4	-0.1	-0.4 to 0.3	0.1	0.27
MD-4	5.7 ± 0.8					

Data are presented as mean ± SD. TDC = total distance covered, HSR = high-speed running distance, sprint = sprint distance, ACC/DEC = combined number of accelerations and decelerations, sRPE = session rating of perceived exertion, MD = match day.

4.3 Seasonal changes in training load

The average training duration in period 1 vs period 2 was 111.5 ± 7.5 vs 110.5 ± 10.2, 111.3 ± 8.1 vs 101.5 ± 10.6, 93.2 ± 14.6 vs 86.0 ± 8.5, and 80.0 ± 12.8 vs 66.8 ± 4.7 for MD-4, MD-3, MD-2 and MD-1, respectively, and significant changes were evident on each day ($p = <0.01$, ES = 3.0-6.0) except from on MD-4 ($p = 0.34$). Significant reductions in training load were observed between periods on each training day across all measures of training load (ES = 0.7-2.5) except from total distance covered and ACC/DEC on MD-2 (Figure 4.1). On the two days with the highest values of HSR and sprint distance (MD-3 and MD-2) there were reductions in the range of 17-20% and 24-42%, respectively. On the two days with the highest values of total distance, ACC/DEC, and sRPE (MD-4 and MD-3) there were reductions in the range of 4-6%, 8-11%, and 13-20%, respectively.

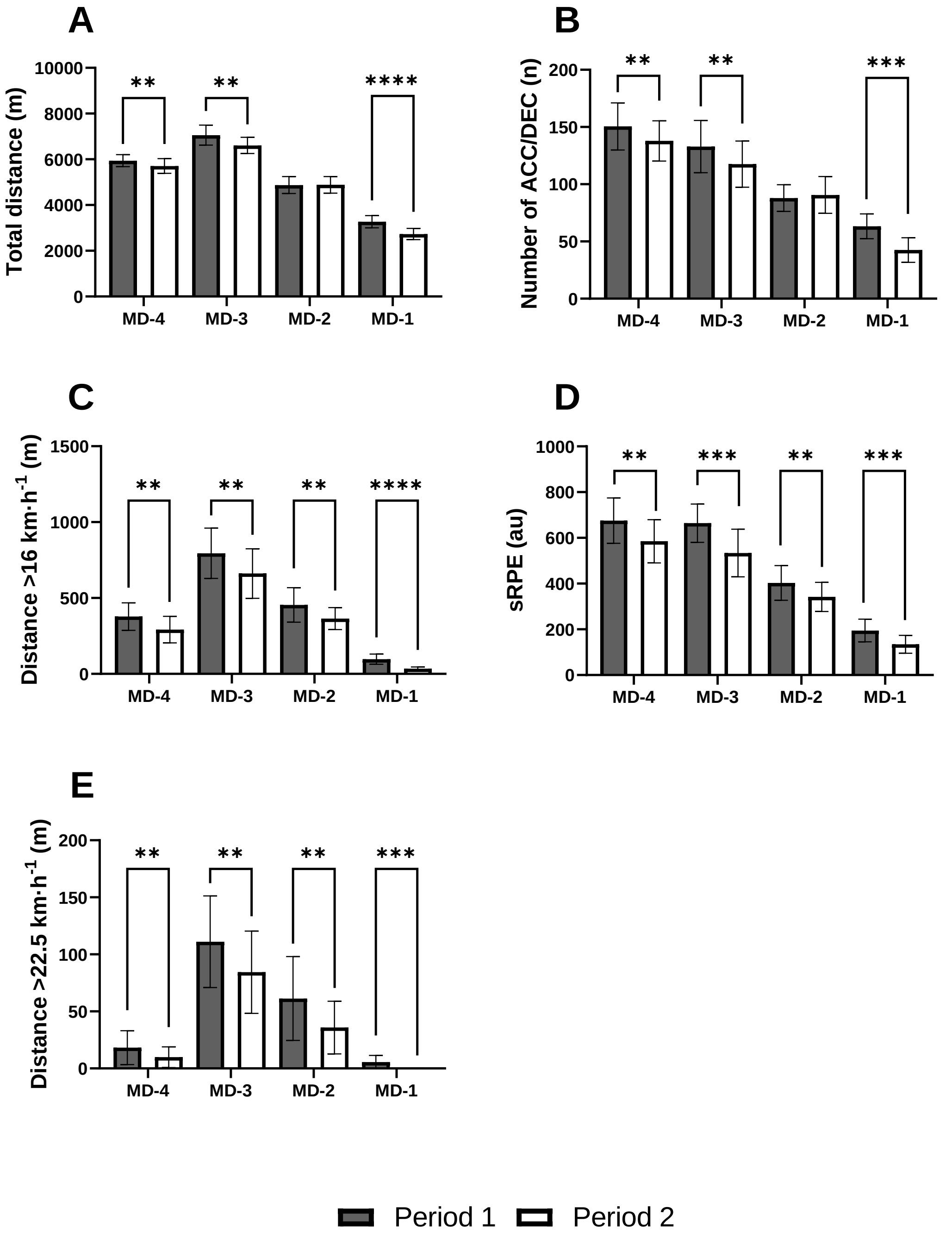

Figure 4.1: *Differences in training load between periods on each training day within the microcycle. Data are presented as mean ± SD. Effect sizes between periods are indicated by the symbols: * = small, ** = moderate, *** = large, and **** = very large. Only significant (p = ≤0.05) effect sizes are presented.*

4.4 Seasonal changes in training intensity

Contrary to changes in training load between periods, both decreases and increases in training intensities were observed between periods (Figure 4.2). MD-4 was the only day to show significant reductions across all parameters (ES = 0.7-1.1). On MD-3 and MD-2 there were significant reductions in HSR·min^{-1}, sprint·min^{-1}, and RPE (ES = 0.4-0.8), but significant increases in TDC·min^{-1} were observed for both days (ES = 0.7-1.2). An increase in ACC/DEC·min^{-1} was also observed on MD-2 (ES = 0.8), whereas this was maintained on MD-3. MD-1 showed significant reductions across all parameters (ES = 0.6-2.0) except TDC·min^{-1}.

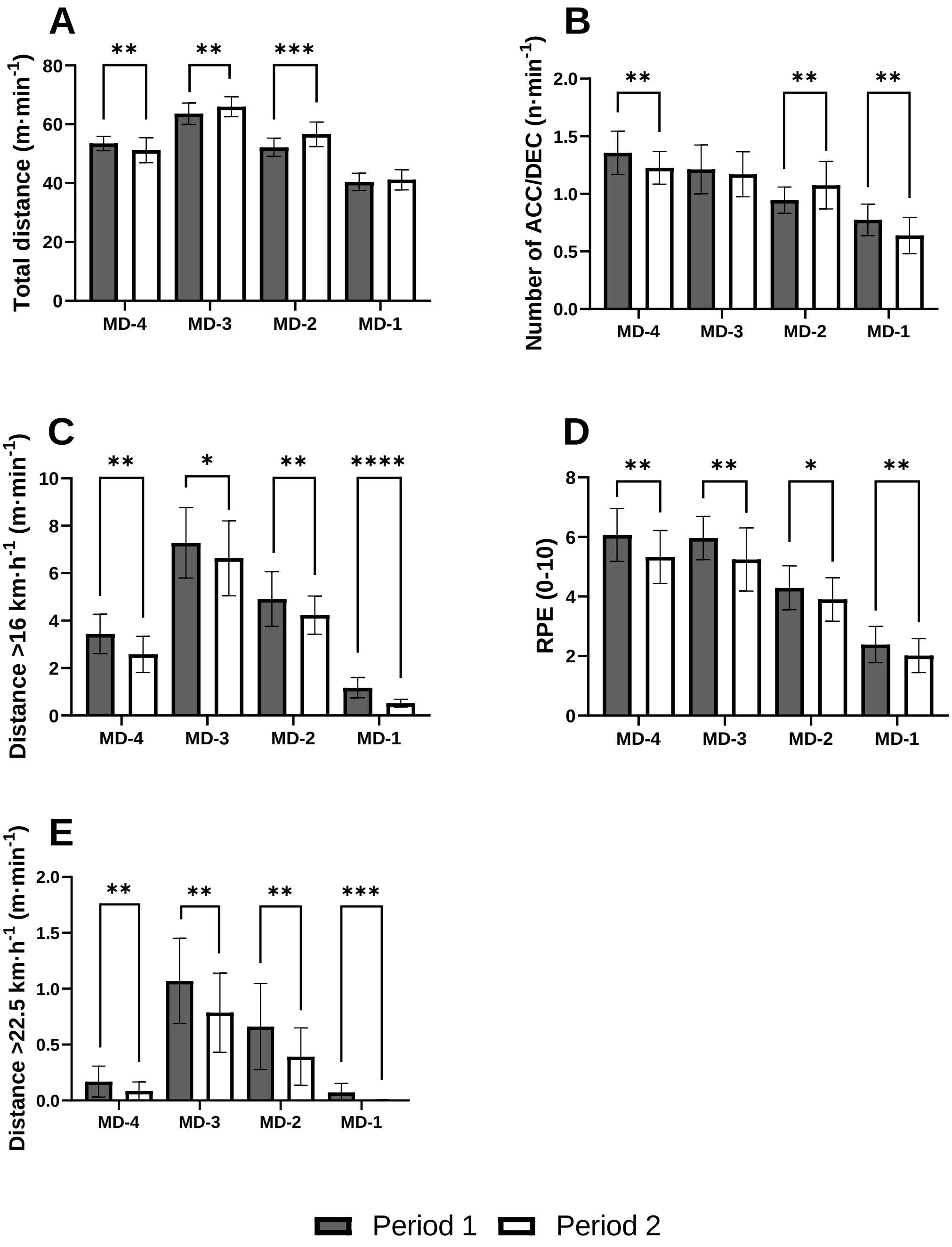

Figure 4.2: *Differences in training intensity between periods on each training day within the microcycle. Data are presented as mean ± SD. Effect sizes between periods are indicated by the symbols: * = small, ** = moderate, *** = large, and **** = very large. Only significant (p = ≤0.05) effect sizes are presented.*

4.5 Physical qualities

Average team physical performance levels across the season were highest at test 2 (in-season) for all physical qualities tested except from CMJ, which displayed its highest average at test 3 (table 4.3). Results from table 4.3 include all players who tested at the various timepoints regardless of whether they tested at one, two or three of the timepoints.

Table 4.3: *Team average physical test results from each testing occasion.*

Test	n	Test 1	n	Test 2	n	Test 3
20 m (s)	10	3.12 ± 0.08	14	3.07 ± 0.08	11	3.09 ± 0.06
30 m (s)	10	4.43 ± 0.10	14	4.35 ± 0.11	9	4.38 ± 0.10
40 m (s)	10	5.74 ± 0.12	14	5.63 ± 0.13	9	5.65 ± 0.15
COD D (s)	12	10.10 ± 0.30	12	10.10 ± 0.32	10	10.20 ± 0.23
COD ND (s)	12	10.14 ± 0.26	13	10.13 ± 0.34	10	10.22 ± 0.18
CMJ (cm)	13	33.8 ± 2.1	17	33.0 ± 2.4	11	35.1 ± 2.4
Max power (W)	13	1020 ± 85	16	1091 ± 213	12	1000 ± 155
Max force (N)	13	1919 ± 140	16	2172 ± 441	12	2003 ± 289
Max W/kg	13	16.2 ± 0.5	16	16.9 ± 1.9	12	16.2 ± 1.7
Max N/kg	13	30.5 ± 2.1	16	33.7 ± 4.1	12	32.5 ± 3.6
YYIR1 (m)	15	1499 ± 325	14	1586 ± 231	11	1335 ± 270

Data are presented as mean ± SD. 20 m = 20 m sprint, 30 m = 30 m sprint, 40 m = 40 m sprint, COD D = change of direction dominant side, COD ND = change of direction non-dominant side, CMJ = countermovement jump, YYIR1 = yo-yo intermittent recovery test level 1.

4.5.1 Changes in physical qualities

From test 1 to 2, both sprinting ability and relative power improved significantly by 1.4-1.5% and 5.0%, respectively (table 4.4). There was also a tendency (p = 0.06) towards improved (10.1%) YYIR1 performance. From test 2 to 3 there were significant reductions in absolute and relative power, COD ability on the dominant side and in YYIR1 performance of 2.8-3.2%, 1.5% and 13.2%, respectively. There was also a tendency (p = 0.07) towards reduced (5.2%) YYIR1 performance from test 1 to 3. All qualities not addressed between the testing timepoints were maintained.

Table 4.4: *Changes in physical qualities between testing occasions.*

Test	n	T2 v. T1	CI	ES	n	T3 v. T1	CI	ES	n	T3 v. T2	CI	ES
20 m (s)	8	**-0,05***	-0.08 to -0.01	1.1	6	-0,03	-0.08 to 0.02	0.7	9	0,02	-0.02 to 0.06	0.4
30 m (s)	8	**-0,07***	-0.10 to -0.03	1.7	4	-0,04	-0.14 to 0.06	0.6	8	0,02	-0.04 to 0.08	0.3
40 m (s)	8	**-0,09***	-0.13 to -0.04	1.7	4	-0,06	-0.19 to 0.06	0.8	8	0,01	-0.05 to 0.07	0.1
COD D (s)	7	-0,04	-0.31 to 0.24	0.4	6	0,02	-0.16 to 0.19	0.1	8	**0,15***	0.01 to 0.29	0.9
COD ND (s)	8	-0,13	-0.34 to 0.08	0.5	6	0,00	-0.17 to 0.16	0.0	8	0,14	-0.09 to 0.36	0.5
CMJ (cm)	10	0,4	-1.2 to 2.0	0.2	8	1,2	-0.6 to 3.4	0.6	10	1,4	-0.4 to 2.8	0.5
Max power (W)	9	33	-32 to 99	0.4	8	12	-61 to 85	0.1	10	**-29***	-51 to -6	0.9
Max force (N)	9	31	-112 to 175	0.2	8	-4	-124 to 116	0.0	10	-7	-121 to 108	0.0
Max W/kg	9	**0,8***	0.0 to 1.6	0.8	8	0,3	-0.6 to 1.3	0.3	10	**-0,5***	-0.9 to -0.2	1.2
Max N/kg	9	0,9	-1.1 to 3.0	0.4	8	0,1	-1.9 to 2.1	0.1	10	-0,2	-2.1 to 1.6	0.1
YYIR1 (m)	9	151	-8 to 310	0.7	10	-76	-160 to 8	0.7	8	**-210***	-325 to -95	1.5

Data are presented as mean ± SD. * *= significant change* ($p = \leq 0.05$), *T1 = test 1, T2 = test 2, T3 = test 3, CI = Confidence interval (95%), ES = Effect size, 20 m = 20 m sprint, 30 m = 30 m sprint, 40 m = 40 m sprint, COD D = change of direction dominant side, COD ND = change of direction non-dominant side, CMJ = countermovement jump, YYIR1 = yo-yo intermittent recovery test level 1.*

4.5.2 Associations with training load

No significant correlations were observed between any of the physical qualities that showed significant changes and any of the training load metrics, but significant positive correlations were observed between HSR and change in maximal force, and between sprint distance and change in both maximal force and maximal force relative to bodyweight (table 4.5). There was also a tendency (p = 0.07) towards a significant very large positive correlation between sRPE and change in 40 m sprint time.

Table 4.5: *Pearson's correlations coefficients for comparisons between training load and changes in physical qualities.*

Test	n	TDC	HSR	Sprint	ACC/DEC	sRPE
20 m	8	-0.01	0.04	0.15	0.05	0.62
30 m	7	0.19	0.05	0.14	0.04	0.64
40 m	7	0.36	-0.00	0.05	-0.06	0.72
COD D	7	-0.42	0.02	0.44	0.00	-0.13
COD ND	7	-0.14	-0.02	-0.01	0.09	-0.60
CMJ	9	0.37	-0.05	-0.09	-0.39	0.40
Max power	9	-0.12	0.05	0.20	0.16	0.03
Max force	9	0.37	**0.67***	**0.67***	0.63	-0.22
Max W/kg	9	-0.11	0.05	0.09	0.09	0.01
Max N/kg	9	0.38	0.65	**0.67***	0.58	-0.15
YYIR1	9	0.34	0.21	0.37	-0.02	0.39

** = significant correlation (p = ≤0.05), TDC = total distance covered, HSR = high-speed running distance, sprint = sprint distance, ACC/DEC = combined number of accelerations and decelerations, sRPE = session rating of perceived exertion, 20 m = 20 m sprint, 30 m = 30 m sprint, 40 m = 40 m sprint, COD D = change of direction dominant side, COD ND = change of direction non-dominant side, CMJ = countermovement jump, YYIR1 = yo-yo intermittent recovery test level 1.*

5. Discussion

In the current study, we investigated training loads on the different days within a tactical periodization microcycle. We also investigated whether changes in microcycle training loads occur between two different periods of the season, as well as accompanying and associated physical performance levels and changes. We observed differences in training load between all days within the microcycle across all parameters except from sRPE between MD-4 and MD-3. All measures of training load were observed to be reduced from the first to the second period except total distance and ACC/DEC on MD-2. All physical qualities were maintained across the season, but changes did occur within the season. No direct associations were observed between the physical qualities that showed significant changes and any of the training load metrics.

5.1 Microcycle training load throughout the season

5.1.1 Differences in training load and intensity between acquisition days

The first aim of this study was to investigate whether there are differences in training loads and intensities between the different training days within a tactical periodization microcycle. Differences were observed between all training days for all measures of training load except from sRPE between MD-4 and MD-3, which were the two training days with the highest sRPE. This indicates that these two training days were perceived to be equally challenging, which is not necessarily surprising considering that these are meant to be the two most demanding training days. The perceived load was, however, as the model states, achieved through different stimuluses. ACC/DEC was significantly higher on MD-4 than all other training days, and higher values of total distance, HSR and sprint distance was evident on MD-3 compared to all other training days.

More accelerations/decelerations and mechanical work on MD-4 (strength day) compared to MD-3 (endurance day) was, contrary to our findings, not observed by neither Lopategui et al (2021) nor Buchheit et al (2018) when investigating tactical periodization training loads. Buchheit et al. (2018) hypothesized that the lack of differences observed could be due to shortcomings of the GPS system used and that it may not have reflected the true demands of the session. Challenges related to the quantification of mechanical loads have also been addressed by other authors

(Kalkhoven et al., 2021). For instance, total distance has been observed to be strongly correlated to COD load (Merks et al., 2021), and considering that the highest total distances are typically reserved for MD-3, this could possibly have hindered distinctions in mechanical load between these two days. Supporting this notion is the fact that both studies did observe total distances to be higher on MD-3 than all other training days (Buchheit et al., 2018; Lopategui et al., 2021). This confirms results observed in our study, and high values of total distance covered and TDC·min^{-1} seem to be distinct features of MD-3, in line with intended training loads (Buchheit et al., 2018; Tee et al., 2018). Despite the total volume of acceleration/deceleration counts and mechanical work not being higher on MD-4 in the two other studies investigating tactical periodization training loads, the density (i.e., actions per min) could have been higher during specific drills and exercises. This would seem logical considering that significantly more accelerations and decelerations are performed during small-sided games than during large-sided games when playing time is controlled for (Gimenés et al., 2018). Observations from Buccheit et al. (2018) indicate this to have been the case, as mechanical work divided by training duration was higher on MD-4 than on MD-3. Lopategui et al. (2021) did not report values relative to training duration but did report longer training durations on MD-3 compared to MD-4. These observations likely explain some of the observed discrepancies compared to our findings, as not only was ACC/DEC·min^{-1} observed to be higher on MD-4 in our study, but training duration was also slightly longer on MD-4 than on MD-3. Lastly, supporting the findings in our study, Moraleda et al. (2021) observed total distances to be highest on MD-3 and acceleration counts to be highest on MD-4 despite not stating to use a tactical periodization model. Based on these findings, it seems that teams are successful in differentiating specific training loads on MD-4 and MD-3 from each other and other training days, at least to some extent, and the possibility that more pronounced differences could be observed through better measuring methods and equipment exists.

Since HSR and sprint distance values were observed to be highest on MD-3 in this study, this meant that values were also higher than those on MD-2 (speed day). Similarly, Lopategui et al (2021) observed the highest HSR and sprint values on MD-3, but contrary Buchheit et al (2018) observed the highest values on MD-2. The HSR and sprint values reported by Buchheit et al. (2018) were very low on both MD-4 and MD-3, and the pitch sizes used on MD-3 were, despite being larger than those presented on

MD-4, relatively small. On MD-3 the team were reported to play 4 vs 4 on a 40 x 35 m pitch, which is close to pitch sizes and player numbers reported for small-sided games (Hill-Haas et al., 2011), and might be considered medium- to small-sided rather than the large-sided games and high player numbers proposed for MD-3 (Lopategui et al., 2021; Tee et al., 2018). Whether or not the largest sprint volumes should be allocated for MD-3 or MD-2 is, however, open to interpretation. Considering the designation given to the different training days it might seem logical to facilitate the largest sprint volumes on MD-2 (speed day). However, the shorter sequences played in medium to large spaces and lower work/rest ratios often applied for MD-2 might allow players to conduct sprints at a higher intensity relative to their max, which is a potent and important stimuli to develop maximal sprinting ability (Haugen et al., 2019; Haugen, Tønnessen, Hisdal, et al., 2014). In fact, Lopategui et al. (2021) observed that there were more repeated high-intensity efforts and more accelerations above the highest threshold ($3\ m{\cdot}s^{-2}$) on MD-2 compared to MD-3, despite more HSR and sprint distance being observed on MD-3. Furthermore, despite MD-2 being referred to as one of the three acquisition days, it is typically depicted as containing lower training loads than MD-4 and MD-3 (figure 2.3) (Delgado-Bordonau & Mendez-Villanueva, 2012; Tee et al., 2018). The approach just described (i.e., lowering volume and maintaining intensity) can therefore be considered in line with the concept of tactical periodization, and moreover follows the principles observed to be successful for tapering in other sports (Haugen et al., 2019). Evidence of a begun taper on MD-2 was evident in our study through the observed decrease in training load across all parameters from MD-3 to MD-2. Despite average session intensity values also decreasing between these days it is possible that the intensity within specific exercises and game-play sequences were maintained considering the differences in work/rest ratios and durations (appendix V). More studies should, however, investigate the effect of work/rest ratios and durations on the intensity of different game formats. Irrespective, $TDC{\cdot}min^{-1}$ on MD-2 showed no difference compared to MD-4, and $HSR{\cdot}min^{-1}$ and $sprint{\cdot}min^{-1}$ was observed to be higher on MD-2 than on MD-4, indicating that for at least these parameters the average sessions density on MD-2 was maintained or increased from MD-4. Allocating the highest training loads to MD-4 and MD-3 before starting the tapering process on MD-2 is also in line with other studies reporting on training loads in both elite women's (Moraleda et al., 2021) and men's football (Martin-Garcia et al., 2018; Stevens et al., 2017).

In summary, similar to observations in this study, it seems that teams following a tactical periodization approach (Buchheit et al., 2018; Lopategui et al., 2021) are successful in differentiating training loads between the different training days. Observations by Buchheit et al. (2018) also indicate that different physiological responses could arise from these differences, but further studies are needed to establish this with certainty.

5.1.2 Microcycle training load pattern

In addition to the horizontal alternation of physical qualities that aims to allow for a more potent stimuli on specific training days, the overall load pattern of the microcycle aims to not only facilitate high intensity during sessions in the middle of the week, but also aims to assure readiness to compete on matchdays (Delgado-Bordonau & Mendez-Villanueva, 2012; Lopategui et al., 2021). The results from this study showed that MD had significantly higher training load than all training days across all parameters investigated, which confirms previous findings (Lopategui et al 2021, Moraleda et al. 2021). Training loads on MD-1 were, oppositely, observed to be the lowest of all days across all parameters investigated, which reflects the intended physical objective of this being a recovery/tapering day following the three acquisition days.

Despite Lopategui et al (2021) being the only other study, in addition to ours, to investigate training loads on MD-1 in a team utilizing a tactical periodization model, it seems that teams are successful in reducing training loads from the acquisition days to the recovery/tapering day (MD-1). Another question that then naturally arises in this context is to what degree this microcycle load pattern is successful in achieving readiness on match day. Furthermore, even though neither our study nor Lopategui et al. (2021) reported training loads from the two recovery days after MD, whether readiness is achieved on MD-4 is also of interest, as both are aims of this periodization model (Delgado-Bordonau & Mendez-Villanueva, 2012; Lopategui et al., 2021). Several studies have investigated recovery timelines of different recovery markers following match play for both male and female football players, and results show that different recovery markers typically return to baseline either before or around 72 hours after a match (Silva et al., 2018). This means that teams aiming to train in a near fully recovered state on the third day following a match can do so with a relatively high level of certainty. Regarding the reduction in training load on MD-1, this is not unique to the model of tactical periodization, and many studies have observed such an approach regardless of the microcycle load structure used (Malone et al., 2015; Martin-Garcia et al., 2018; Moraleda et al., 2021; Stevens et al., 2017). However, to what extent this approach is successful in dissipating fatigue and optimizing readiness has not been established (Malone et al., 2015). Lopategui et al. (2021) tried to establish this within the context of tactical periodization through wellness questionnaires of soreness and fatigue. The lowest values were observed on MD-4 and on MD, which is in line with the rational of the tactical periodization model. At a minimum, this seems to indicate that readiness is higher than on the remaining training days. To what extent this improves the physical performance of players on MD and whether higher levels of readiness can be attained through improved methods, are, however, still open questions. Such investigations should also be conducted in the elite female population.

5.2 Differences in training load between periods

The second aim of this study was to investigate changes in training loads and intensities between two different periods of the season. A key principle to the concept of tactical periodization is the aim of performance stabilization through maintenance of the standard weekly cycle, which should remain almost invariable over the course of the season (Delgado-Bordonau & Mendez-Villanueva, 2012). Despite this, significant reductions in training load were observed across all parameters on the hardest training days (MD-4 and MD-3) from the first to the second period. Reductions were also observed for several parameters on MD-2 despite total distance and ACC/DEC remaining unchanged.

Results from other studies that have quantified training loads from different periods seem to indicate that reductions in training load are not uncommon towards the end of the season (Malone et al., 2015; Mara et al., 2015). Planned reductions in training load and players not being able to sustain training loads are both possible explanations. Training loads from different in-season periods have not been investigated in other teams utilizing a tactical periodization model. Lopategui et al. (2021) did, however, report large variations in training loads within specific acquisition days across the season, but whether this was due to periodic changes or weekly fluctuations was not elaborated on. In our study, the observed reduction in training duration on each training day, except from MD-4, could indicate, at least for MD-3 and MD-2, that the observed reductions were due to a decline in overall training duration, and not the intensity within sessions. This is supported by the fact that both MD-3 and MD-2 showed increases in TDC$\cdot$min^{-1}, and MD-2 also showed an increase in ACC/DEC$\cdot$min^{-1}, whereas this was maintained on MD-3. There were, however, decreases in HSR$\cdot$min^{-1} and sprint$\cdot$min^{-1} on both days. This could be related to the reduction in high-intensity endurance capacity observed at the end of the period but could also be due to drills facilitating HSR and sprinting constituting smaller parts of the sessions. Similar questions arise around the decreased intensity observed for all parameters on MD-4. For example, reductions in endurance, COD ability and leg press power observed at the end of the season could have left players unable to perform the same amount of TDC$\cdot$min^{-1} and ACC/DEC$\cdot$min^{-1} on MD-4. It is, however, more likely that reduced training loads led to declines in physical performance levels, and not the other way around. The players either maintained or improved their physical qualities from pre- to in-season, meaning it is unlikely that they were not able to sustain training intensities going into the second period. Furthermore, considering relationships between internal and external measures of training load, it would seem logical for the players' exertion to remain similar between periods if the observed decrease in session intensity was brought on by reduced physical performance levels (i.e., if they still worked at a similar percentage of their, now reduced, maximal intensity) (Impellizzeri, Marcora, et al., 2019). However, the perceived exertion (RPE) was also observed to significantly decrease on all training days. Such relationships are not perfect, and exact relationships between internal and external loads were not investigated in this study, but this nonetheless supports that the reductions in training load were brought on by changes in training duration and contents rather than declines in physical performance levels. Reduced physical performance levels could have influenced training intensities as they became gradually more pronounced, but if these reductions were due to reduced training loads, then this would still be indirectly caused by the changes in training contents and durations. Lastly, on MD-1 reductions were also observed between periods, and this was evident for all measures of training load and intensity, except for TDC$\cdot$min^{-1}. MD-1 showed the largest decrease in training duration, despite being the day with lowest duration in both periods. Consequently, reductions in training load were seemingly brought on by the combined decrease in both duration and average session intensity. The reductions in training load on MD-1 were, however, likely of little importance to the physical adaptions of the players, as the goal of this day is recovery and not adaption. It should be mentioned that allowing for recovery is an important part of the process of physical adaptions (Kellmann, 2010), but the training loads and intensities observed on MD-1 are likely not large enough to provide stimuluses for adaption by themselves. It is possible that the training loads in period 2 were better suited to promote recovery and subsequent readiness on matchday than those in period 1, but this was not investigated.

In summary, it seems that teams often reduce their weekly training load towards the latter parts of the season. Results from our study indicate that these reductions were caused by changes in training contents and durations, and not reduced physical performance levels. This is supported by findings by Mara et al. (2015), who observed reductions in training load across the season even though physical performance levels were maintained. The observed reductions in training load disagree with the proposed mechanisms for performance stabilization, which could indicate that coaches do not adhere strictly to the concept of tactical periodization.

5.3 Physical performance level of the team

The third and last aim of this study was to investigate the physical performance levels and changes that are associated with, and accompany, the training loads observed using this model. The team average from the physical performance tests investigated at different timepoints of the season (table 4.3) showed that the CMJ and sprinting abilities of the team were similar to those previously reported for the elite female population (Castagna & Castellini, 2013; Haugen et al., 2012; D. Scott et al., 2020). Endurance test results from in-season were, however, higher than those previously reported for domestic league teams in the elite population and at the highest end of those reported for national teams (Castagna et al., 2020; Doyle et al., 2021; Krustrup et al., 2005; Mujika et al., 2009; Ramos, Nakamura, Penna, Mendes, et al., 2019). Limited evidence exists for direct comparisons of COD ability and leg press strength and power in this population.

The superior YYIR1 performance observed in-season compared to previous studies might, to some extent, be the result of the higher training loads observed in this study compared to previous studies on the elite female population (Costa et al., 2019; Mara et al., 2015; Moraleda et al., 2021). Total distances and sRPE on training days ranged from

4826-6845 m, and from 369-634 arbitrary units, respectively, in our study. The lowest values of total distance in our study were 5-119% higher than the lowest values reported in-season from other studies in this population, and the highest values were 26-42% higher than the highest values of total distance reported (Costa et al., 2019; Mara et al., 2015; Moraleda et al., 2021). Similar comparisons for sRPE showed 66-182% and 10-76% higher values than the lowest and highest values reported from other studies, respectively (Costa et al., 2019; Moraleda et al., 2021). Training load data from Costa et al. (2019) were, however, gathered from a national team, and the fact that few studies have reported training loads from elite domestic teams makes it difficult to conclude whether the observed training loads in this study truly are higher than those typically applied in this population. Additionally, neither of the studies that reported YYIR1 results from elite female players reported accompanying training loads, thus it is impossible to say whether training loads in our study were higher than those experienced by players in those studies. Test results should, however, be comparable, as Castagna et al. (2020) conducted their testing at the same timepoint of the season (i.e., after the mid-season break).

If superior endurance performance can be attributed to higher training loads, one could question why we do not observe the same for sprint or CMJ results. However, training load metrics that one could expect to influence these abilities, such as ACC/DEC, HSR and sprint distance, are not as comparable with results from other studies due to the different collection methods used. The limited amount of studies investigating relationships between on-field training loads and improvements in these qualities also means it is uncertain to what extent such qualities can be improved through on-field football sessions (Younesi et al., 2021). Genetic factors influence sprinting ability to a large degree (Beneke & Taylor, 2010), and female players struggle to improve their sprinting abilities after their teens (Haugen, Tønnessen, Hisdal, et al., 2014). Moreover, small magnitudes of change are typically observed following training interventions specifically targeting sprinting abilities in football players, and despite vertical jumping abilities seemingly being a more plastic (Bolger et al., 2015; Markovic & Newton, 2007; Petrakos et al., 2016), it is uncertain to what degree the on-field training loads in this study would improve the overall team average of these abilities in comparison to genetic factors and specific sprint, strength, and plyometric training not accounted for. It should be mentioned that the team average CMJ results observed post-season were at the higher end of those previously reported, and higher than the 34.4 cm Castagna and Castellini (2013) concluded were a sign of superior CMJ ability. It is therefore possible that the on-field training loads could have influenced these results to some degree.

5.4 Changes in physical qualities and associations with training load

Recommendations from the recent systematic review on tactical periodization stated that studies should investigate the impact of training load on some variables of performance for players using this model (Afonso et al., 2020). As per these recommendations, the objective was not only to report on the accompanying physical performance levels, but also changes in these physical performance levels and their association with the observed training loads.

The fact that no significant correlations were observed between changes in neither endurance, sprinting ability, COD ability, power, nor CMJ and any of the different metrics used to quantify training load might seem surprising. The limited number of studies that have investigated correlations between training loads quantified through single metrics and changes in different physical qualities have, however, shown varying results (Younesi et al., 2021). Consequently, the lack of such relationships is not necessarily surprising. This does not mean that the observed training loads in this study did not affect the observed changes in physical qualities. Despite dose-response relationships typically being observed between specific stimuluses and their targeted qualities, such as between strength training volume and increases in strength and muscle mass (Grgic et al., 2018; Ralston et al., 2017), individuals display variation in training responses based on factors such as age, training history, genetics and many other factors (Bonafiglia et al., 2016; Meyler et al., 2021). Therefore, it is possible that specific training loads affected relevant qualities without showing significant correlations. To specify, differences in training load between players does not have to result in similar differences in the magnitude of change in physical qualities for them to be related. Moreover, the complex nature of training load in football makes it difficult to quantify through single metrics, which is also why multi-mechanical models have been developed to help better depict on-field training loads by combining different metrics (Owen et al., 2017). It is possible that the combination of different training loads affected the observed changes in physical qualities, but whether such models are better suited to predict training outcomes still needs to be investigated. The extent to which these on-field training loads affected relevant qualities compared to isolated strength and conditioning training not accounted for is also uncertain. Due to these factors, the lack of associations between physical qualities and specific metrics will not be elaborated upon in great detail in the upcoming chapters and discussions will rather be focused on factors that could have affected the observed results based on the data gathered in this study.

5.4.1 Endurance

The observed fluctuations in endurance over the course of the season could be explained by several factors. For instance, the higher weekly HSR values that were evident between tests 1 and 2, where a trend for improved endurance was observed, and the lower weekly HSR values that were evident between tests 2 and 3, where a significant decline in endurance was observed, might have influenced these changes. The HSR threshold used in this study is very similar to MAS results reported for elite female football players (Trewin et al., 2018), and time/distance above MAS thresholds is observed to be significantly correlated to changes in aerobic fitness (Fitzpatrick et al., 2018) that correlate strongly with YYIR1 performance (Krustrup et al., 2005). Similarly, the observed decrease in training load across all parameters on MD-4 indicate that there were changes to the training contents within these sessions, such as the small-sided games performed on this day (appendix V). The use of small-sided games is an effective method for improving several measures of endurance, such as YYIR1 performance (Iaia et al., 2009), and reductions on this day could potentially have influenced the players' endurance levels. The observed decline in endurance performance in this study is, however, contrary to the findings by Mara et al. (2015). Mara et al. (2015) observed no changes in endurance performance between any periods of the season, despite observing simultaneous reductions in training load. Still, Mara et al. (2015) measured endurance through YYIR2, and the sensitivity of this test for measures of endurance in the female population can be questioned. Across the season (from test 1 to 3), endurance seems to have been largely maintained in our study, which confirms findings by Lopategui (2021) using a tactical periodization model. However, we did observe a trend towards a slight decline in endurance between these timepoints.

Considering that there was a trend for improved endurance from test 1 to 2, followed by a significant reduction from test 2 to 3, this trend was likely due to the decline observed during the second period.

In summary, despite of no significant correlations with any training load metrics, the fact that trends and significant changes in endurance followed the observed changes in training load seem to indicate that the on-field training loads observed in this study likely influenced this capacity to some degree.

5.4.2 Sprinting ability

The significant improvements in sprinting ability observed from test 1 to 2 are harder to discuss in their relation to the observed training loads. All physical performance tests, except from endurance, were tested 20 weeks before the start of the season due to the challenges following the COVID-19 outbreak. As a result, it is impossible to say whether linear sprinting ability was improved during the COVID-19 lockdown period and then maintained during the first part of the season, or the opposite. Observations from another female football team in Norway during this period did, however, show that physical performance was maintained during the COVID-19 lockdown period (Pedersen et al., 2021). This observation speaks to the latter of the two scenarios, meaning that the higher training loads observed during period 1 could help explain the observed improvements from test 1 to 2. Specifically, training load measures that one might expect to influence sprinting ability, such as HSR and especially sprint loads, were highest in period 1, whereas they showed significant reductions across all training days in period 2, where no further improvements were observed. Thus, changes in sprinting ability followed the changes observed in training loads. Since direct associations with these metrics only were investigated in the second period, where no significant changes in sprinting ability were observed, the small magnitudes of change and the relatively low number of players included in these analyses could have led to the lack of such correlations. Isolated sprint and technique work not accounted for in this study could also have influenced these relationships.

The changes observed in this study are similar to previous findings in the elite female population, where sprinting ability has been seen to improve from pre-season to mid-season, before being maintained towards the end of the season (Mara et al., 2015). The fact that Mara et al. (2015) observed that this ability was maintained despite of reduced training loads between the early and late season, as we observed in our study, indicate that higher training loads are needed to improve sprinting ability than to maintain it, which is not surprising. Such trends in sprinting ability are also typically observed in the male population (Caldwell & Peters, 2009; Fessi et al., 2016). However, sprint testing conducted during pre-season can likely also be negatively affected short-term by the higher training volumes typically observed during this period. Sprint results are observed to be affected by both total distance covered during matches (Wiig et al., 2019) and exercise duration (Doeven et al., 2018). As such, it is likely that the reduced training loads typically observed during the in-season phase could facilitate higher and lower levels of freshness and fatigue, respectively, offering further explanations. This is also somewhat supported by the observed tendency towards a significant positive correlation between sRPE and change in 40 m sprint time in our study (i.e., higher sRPE values correlating with less improvement/more deterioration in sprint results).

From test 1 to 3 there were no significant changes in sprinting ability, contrary to findings by Lopategui et al. (2021) in a male team utilizing a tactical periodization model. An average improvement of 1.1% was also evident in our study across the season, but this was non-significant, possibly due to the low statistical strength of this specific analysis (n=4). However, despite Lopategui et al. (2021) observing such improvements in a team utilizing this model in the male population, observations from the elite female population have shown either maintained or reduced sprinting abilities from the start to the end of the season (Mara et al., 2015). As a result, it is hard to conclude whether the utilization of a tactical periodization model in the elite female population could result in improvements in sprint performance across the season based on the available evidence. At a minimum, it seems that the training loads experienced during both periods in our study were high enough to maintain sprinting ability during the season, with the higher training loads during the first part of the season also possibly being high enough to improve sprinting ability.

5.4.3 Change of direction ability

No changes were observed in COD ability from test 1 to 2, but a decline was observed from in- to post-season (from test 2 to 3). This might not be surprising, considering that the training day that aims to develop this specific quality to the largest extent (MD-4) was the only day to show reductions across all parameters of both training load and intensity between periods. Since training duration was unchanged on this day, less time was likely allocated to the most intensive exercises and drills, such as the small-sided games. The small-sided games aim to facilitate a high density of accelerations, decelerations, and changes of direction, and are hypothesized to facilitate the development of such qualities (Buchheit et al., 2018; Gimenés et al., 2018; Tee et al., 2018). Changes in COD ability were not seen to significantly correlate with neither ACC/DEC nor any other variables of training load, but as described, it is still possible that ACC/DEC loads affected players' COD ability despite not showing significant correlations. The same is true for strength training not accounted for, as strength is seen influence COD ability in female football players through a range of factors (Emmonds et al., 2019; P. Jones et al., 2017). Additional strength work, or lack of, could therefore have influenced these results, but no changes were observed in maximal strength measured in the leg press. However, it is possible that specific changes in eccentric knee extensor and/or hip abduction/adduction strength levels occurred, as this was not measured. Stronger female athletes are seen to apply larger hip abduction angles during COD movements, and high eccentric knee extensor strength allows female players to break later and reduce the time needed to decelerate (P. Jones et al., 2017; Spiteri et al., 2013). Interestingly, the observed decline in COD ability was only evident on the dominant side, but why this was the case is uncertain. Seeing as little or no difference is observed in the biomechanical characteristics of 180-degree COD turns between the dominant and non-dominant leg for female football players, it seems unlikely that this was due to deterioration in technique specific the dominant side (Thomas et al., 2020). This is only speculation, but if players perform more ACC/DEC on their dominant leg during training, then the observed reduction in ACC/DEC loads between periods would likely impact COD abilities on the dominant side more. Larger inter-limb differences in strength after the period could also explain this, but this was not investigated.

Despite of the decline in COD ability from in- to post-season, COD ability was maintained across the season (from test 1 to 3). This confirms findings by Lopategui et al. (2021), who also observed that COD ability was maintained across the season in a male team utilizing a tactical periodization model. Few studies have investigated seasonal changes in COD ability across the whole season in other elite female football teams, but Stepinski et al. (2020) investigated this from the start of the season to the in-season period. Results from Stepinski et al. (2020) also support the findings in our study, that COD ability is maintained from the pre-season period to the in-season period, but whether a decline between the middle and end of the season is typical for other elite female football teams or teams utilizing this periodization model is uncertain.

5.4.4 Strength and power

Maximal strength measurements were the only measurements seen to correlate significantly with any of the measured training load parameters. These measurements were observed to show strong correlations with both HSR and sprint loads, but to what extent these loads can bring about improvements in leg press maximal force generating abilities is unclear. Training loads experienced during football sessions are likely able to bring about adaptions in untrained individuals that may transfer (Krustrup, Christensen, et al., 2010), but whether these stimuluses are potent enough to develop maximal force generating abilities in elite female football players is uncertain considering that high-level athletes often need specific and potent stimuluses to develop such qualities (Issurin, 2010; Silva et al., 2015). Specifically, their importance compared to the team's ability to maintain a good frequency of strength work throughout the in-season period, which has been observed to influence such qualities, can be questioned (Silva et al., 2015). However, HSR load has previously been observed to be the best predictor of muscle damage following football matches, where muscle damage of a mild magnitude has been observed (Wiig et al., 2019). Mild muscle damage is still large enough to bring about muscular adaptions (Damas et al., 2018; Paulsen et al., 2012), but no significant changes in maximal strength were observed in this study. This was despite clear reductions in HSR and sprint loads across all days, meaning that regardless of the observed co-variation, it is uncertain to what extent changes in leg press maximal force generating abilities occur based on changes to these training loads.

Considering that power is the product of force and velocity, and that maximal force in the leg press was unchanged between tests 1 and 2, it seems that improvements in leg press power relative to bodyweight from test 1 to 2 was linked to the players' ability to (if one imagines a leg press force-velocity and power profile) produce higher velocities and more force at a given velocity as velocity progresses, in relation to their bodyweight (Bobbert, 2012; Morin & Samozino, 2016). The observed improvements in running speed across all distances seem to support this fact, and even though this a different movement it seems that the overall speed generating abilities of the lower extremities were improved relative to bodyweight. Force relative to body mass determines the body’s acceleration during sprinting, and considering that female players increase their speed up to around 30 m (Haugen et al., 2012; Vescovi, 2012), this is of importance across the measured distances in this study. Specifically, the force that can be applied during the contact phase (impulse) determines the change in running speed and subsequent resultant speed. Considering the short contact times observed during sprinting (roughly 100 to 300 milliseconds) (Weyand et al., 2010), and thus the time available to produce force, several of the same neuromuscular mechanisms related to improved sprinting ability might also transfer to improved mechanical power in the leg press (Cormie et al., 2011; Miller et al., 2012; Morin et al., 2012). Oppositely, reductions were observed in both absolute and relative power from test 2 to 3, but between these timepoints no significant changes were observed in neither sprinting nor maximal force generating abilities. The observed decrease in relative power was, however, smaller in magnitude than the improvement from test 1 to 2. It is possible that the sensitivity of this test, which is the product of both factors, might be higher than either factor in isolation and that potential reductions in force and velocity producing abilities were not of a large enough magnitude to reveal significant changes. Despite not being significantly correlated with any training load parameters, changes in power followed the changes in training loads, but strength and power training not accounted for could also have influenced these changes.

5.4.5 Countermovement jump

Interestingly, no changes were observed in CMJ performance between any of the testing timepoints despite of the measured changes in relative power from both test 1 to 2 and from test 2 to 3. CMJ height is often used as a measure of the lower extremities ability to generate mechanical power (T. Jones et al., 2016), and one might expect to observe similar changes in CMJ performance as in the ability to generate power relative to bodyweight in the leg press. The correlation between peak power and jump height during the CMJ is, however, somewhat artificially inflated (Linthorne, 2021). The fact that peak power during the CMJ occurs at almost the same time as take-off means that velocity at peak power is very similar to velocity at take-off. Since take-off velocity is what determines jump height, this correlation can be said to be artificially inflated.

Demonstrating this, Linthorne (2021) observed that velocity at peak power correlated very strongly with jump height (r = 0.83-0.94), whereas instantaneous ground reaction force at peak power did not (r = -0.20-0.18). Since leg press power was assessed over a range of different loads, and the changes here not reflected in the CMJ results, it is possible that *true* peak power is not reached from the load asserted on the lower limbs by a players' body mass during a CMJ. However, when CMJ is tested across a range of loads, peak power is still typically observed during jumps without additional weight (Cormie et al., 2007). For some player the optimal load to attain peak power will, however, be slightly lower or higher than their own body mass (Morin et al., 2019). Additionally, the take-off distance used during the CMJ, which was different from the push distance during the leg press, also influences peak power (Morin et al., 2019). Moreover, the resulting power during the leg press and CMJ are not direct measurements of the muscular power produced (Bobbert, 2012; Linthorne, 2021). Musculotendinous units have the ability to store and utilize muscle energy for power amplification (Roberts & Azizi, 2011), and players with a superior ability to store and utilize elastic energy will benefit more from this during the CMJ than they will during the stationary start of the leg press. Indeed, athletes are typically observed to jump higher during CMJs than during squat jumps from a stationary start in the bottom position due to CMJs containing a stretch-shortening cycle (Bobbert et al., 1996). This is also related to the history dependent properties of force production in skeletal muscle, whereby force enhancement occurs following muscle stretch through pre-activation and residual force enhancement (Fukutani et al., 2017). All the above-mentioned factors could help explain the observed discrepancies. Lastly, the lack of change in maximal strength could also help explain that no improvements were observed in CMJ performance, seeing as these qualities correlate strongly in both male and female players (Andersen et al., 2018; Wisloff, 2004). Improvements in strength are, however, not necessarily seen to transfer into improved jumping ability in high-level female football players (Pedersen et al., 2019). It should be mentioned that despite ground reaction forces at peak power not being significantly correlated to jump height, the force produced up until the point of take-off (the impulse) is of high importance for the obtained velocity at take-off and the resulting jump height (Kirby et al., 2011). This is, however, related to more factors than just the ability to produce maximal force.

5.5 Methodological limitations

Several factors limited the degree to which the research questions could be answered conclusively. Training load data was only included from the main types of sessions described in the tactical periodization model, which meant that training load data from two weeks in each period were excluded due to alterations to the contents of the microcycle caused by the competitive schedule. This also meant that isolated strength and conditioning work that happened off-field and additional training for non-starters were excluded. Furthermore, due to the mentioned challenges that arose from the COVID-19 outbreak, pre-season testing was conducted 20 weeks before the start of season. All these factors likely influenced investigations into the associations between training loads and physical qualities. Moreover, the low number of players available for analyses between testing timepoints, particularly for comparisons of sprinting and COD ability between tests 1 and 3, will have made significant changes harder to detect. Lastly, despite not being discussed or elaborated on in great detail, the concept of tactical periodization aims to develop the relevant physical qualities mainly through tactical (football) training, and not isolated strength and conditioning training (Tee et al., 2018). The team investigated in this study did perform on-field strength and conditioning work accounted for in the sessions (appendix V), but also additional work outside of football sessions. This was also the case in the two other studies on tactical periodization (Buchheit et al., 2018; Lopategui et al., 2021), and considering the importance of top-ups in maintaining full squad fitness it seems unrealistic to think that elite football teams will not provide additional individualized training as part of a holistic approach (Anderson et al., 2016; Hills et al., 2020).

5.6 Practical applications

Considering the limited number of studies describing training loads in elite women’s football, this study has provided novel insights and reference values regarding training loads at the elite level. This study has provided evidence to show that elite female football teams can be successful in differentiating training loads between training days when implementing a tactical periodization approach. Additionally, elite female football teams can successfully maintain their physical performance levels across the season using this approach but should be aware that significant changes to training loads within the season likely will bring about changes in physical performance levels. Practitioners should be careful in assuming that absolute magnitudes of load within specific metrics will bring about similar physical performance changes between individual players but should monitor potential changes in training loads to avoid reductions in physical performance levels. Despite providing a methodological framework, appropriate training loads and intensities have not been proposed as part of the tactical periodization model for neither the male nor female population. Until such values are established in the literature it is up to the coaches deploying this model to determine suitable training loads, but this study has provided training loads and contents (appendix V) that accompany physical performance levels and can provide guidance for teams aiming to acquire or maintain a given level of physical performance.

5.6.1 Directions for future studies

Several questions and issues presented themselves during this study that are largely unanswered in the literature. First and foremost, since the team in this study did not maintain training loads between the different periods of the season, future studies should investigate whether teams utilizing a tactical periodization model are successful in maintaining physical performance levels throughout the season by maintaining these loads. In addition, the relationship between specific metrics or the combination of metrics and subsequent adaptions in physical qualities should be investigated further in both the male and female population. To what extent isolated strength and conditioning work influences these changes in relation to the on-field training loads should also be investigated. Since teams utilizing a tactical periodization model in both male and female populations are able to differentiate training loads between different days, more studies should investigate the physiological response to these specific sessions. A better understanding of how work/rest ratios and durations affect training loads and intensities within different game-play formats will likely also help to better differentiate these loads. Improved methods to quantify the mechanical load experienced by players are also needed. Lastly, future studies should investigate to what degree elite female football teams are successful in dissipating fatigue and achieving readiness on matchday through the mechanisms utilized in a tactical periodization model.

6. Conclusion

This study demonstrated that an elite female football team utilizing a tactical periodization model were successful in differentiating specific training loads between the different training days within a tactical periodization microcycle, as per intentions. Similarly, the training load pattern across the week was observed to follow recommendations, and the lowest training loads were observed on MD-1 for all parameters investigated. Training loads were observed to decrease from the first to the second part of the season, which is contrary to the recommended mechanisms for attaining performance stabilization throughout the season using a tactical periodization model. Despite of this, all physical qualities were maintained from pre-season to the end of the season, but changes were observed within the season. No significant correlations were observed between the physical qualities that showed significant changes and any of the training load metrics investigated. Such comparisons should, however, not be attributed unwarranted significance considering the complex nature of training load quantification in football and the inability of single metrics to depict this accurately. The changes in physical qualities seemed to follow the same trends and changes observed in training loads, and physical qualities were either improved or maintained during the first period, whereas they were either maintained or declined during the second period. Consequently, the observed changes in physical qualities seemed to be linked to the observed training loads, but additional training not accounted for in the study likely also influenced these changes.

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Table summary

Figure summary

Abbreviations

A	Attacker
ACC/DEC	Combined number of accelerations and decelerations
ACC/DEC·min$^{\cdot 1}$	Combined number of accelerations and decelerations per minute
CAM	Central attacking midfielder
CD	Central defender
CDM	Central defensive midfielder
CI	Confidence interval
CM	Central midfielder
CMJ	Countermovement jump
COD	Change of direction
CV	Coefficient of variation
D	Defender
ES	Effect size
GNSS	Global navigation satellite system
GPS	Global positioning system
HSR	High-speed running
HSR·min$^{\cdot 1}$	High-speed running distance per minute
ICC	Intraclass correlation coefficient
M	Midfielder
MAS	Maximal aerobic speed
MD	Match Day
NSD	Norwegian Centre for Research Data
RPE	Rate of perceived exertion
SD	Standard deviation
Sprint	Sprint distance

Sprint·min^{-1}	Sprint distance covered per minute
sRPE	Session rating of perceived exertion
SSG	Small-sided games
TDC	Total distance covered
TDC·min^{-1}	Total distance covered per minute
VHSR	Very high-speed running
VO^2_{max}	Maximal oxygen uptake
WD	Wide defender
WM	Wide midfielder
YYIR1	Yo-Yo Intermittent Recovery Test Level 1
YYIR2	Yo-Yo Intermittent Recovery Test Level 2

Appendix

I. Literature search conducted for an overview of training and match load in elite women’s football
II. Position specific match load during full matches in elite women’s football
III. Modified CR10 RPE scale
IV. Training load expressed as a percentage of match load
V. Training contents within the microcycle
VI. Letter of consent
VII. NSD’s approval letter
VIII. Approval from the Norwegian School of Sports Sciences’ ethics committee

Appendix I: Literature search conducted for an overview of training and match load in elite women’s football

To provide the readers with an overview of the existing literature on the training and match load of outfield players in elite women’s football, an extensive literature search through NCIB PubMed and Google Scholar was conducted. The terms: “Female*”, “Women*”, “Football”, “Soccer”, “Training”, “Match”, “Load”, “Time-motion”, “Video”, and “GPS” were used in different combinations. In addition, a manual secondary search was conducted on the reference lists of the articles found to be relevant. Studies were included if the participants were elite female outfield players playing at the senior level. Goalkeepers were not included in this overview. A total of 18 articles were included. The articles included were published in the period from 2005-2021 and were conducted on players from the highest domestic leagues and national teams of several countries.

Appendix II: Position specific match load during full matches in elite women's football.

Appendix II: *Position specific match load during full matches in elite women's football (literature search described in appendix I).*

Reference	Year	n	Competition level	Nationality/ region	Position	Total distance (m)	HSR (m)	VHSR (m)	Sprint (m)	HSR bouts	VHSR bouts	Sprint bouts	ACC (n)	DEC (n)
D. Scott et al.	2020	13	Highest division	USA	CD*	9398	1969	350	98					
		29			CD$^{\#}$	9408	1936	382	96					
		12			WD*	9892	2520	589	192					
		24			WD$^{\#}$	10 076	2430	512	154					
		8			CDM*	10 228	2264	384	82					
		11			CDM$^{\#}$	10 244	2345	316	59					
		14			CAM*	10 644	2749	487	129					
		15			CAM$^{\#}$	10 619	2548	375	59					
		7			WM*	10 375	2659	666	248					
		16			WM$^{\#}$	10 338	2651	541	152					
		16			A*	9738	2312	564	209					
		34			A$^{\#}$	9867	2423	585	187					
Datson et al.	2017/2019	25	International	Several teams (13)	CD	9489 ± 562	1901 ± 268	534 ± 113	111 ± 42		119 ± 22	22 ± 7		
		28			WD	10 250 ± 661	2540 ± 500	796 ± 237	163 ± 79		170 ± 45	32 ± 14		
		31			CM	10 985 ± 706	2882 ± 500	853 ± 229	170 ± 69		190 ± 46	35 ± 12		
		17			WM	10 623 ± 665	2785 ± 510	920 ± 260	220 ±116		197 ± 46	40 ± 14		
		16			A	10 262 ± 798	2586 ± 463	872 ± 161	221 ± 53		189 ± 36	42 ± 8		
Ramos et al.	2019	13	International	Brazil	CD	10 003 ± 954	590 ± 104	199 ± 91					218 ± 22	161 ± 19
		8			WD	10 238 ± 665	840 ± 137	379 ± 119					214 ± 35	182 ± 23
		9			M	10 377 ± 981	811 ± 207	299 ± 142					214 ± 17	178 ± 19
		17			A	9825 ± 894	783 ± 251	352 ± 125					210 ± 29	176 ± 27
Trewin et al.	2018	44	International	Top 10	CD	9533 ± 650	661 ± 221			44 ± 14	14 ± 6		187 ± 33	
		24			WD	10 496 ± 822	1191 ± 314			74 ± 16	26 ± 9		185 ± 27	
		56			M	10 962 ± 750	973 ± 334			67 ± 19	20 ± 9		158 ± 33	

Reference	Year	n	Competition level	Nationality/ region	Position	Total distance (m)	HSR (m)	VHSR (m)	Sprint (m)	HSR bouts	VHSR bouts	Sprint bouts	ACC (n)	DEC (n)
		30			A	10 380 ± 893	1037 ± 305			67 ± 17	25 ± 9		174 ± 27	
Mara et al.	2017	3	Highest division	Australia	CD	9220 ± 590	1772 ± 439	417 ± 116						
		2			WD	10 203 ± 568	2569 ± 612	680 ± 278						
		2			CM	10 581 ± 221	2761 ± 417	484 ± 169						
		3			WM	10 472 ± 878	2917 ± 545	850 ± 178						
		1			A	9661 ± 602	2420 ± 405	841 ± 238						
Hewitt et al.	2014	13	International	Australia	D	8759 ± 284	1744 ± 138	188 ± 31						
		30			M	10 150 ± 227	2797 ± 174	392 ± 46						
		15			A	9442 ± 356	392 ± 46	388 ± 56						
Bradley et al.	2014	15	Champions league	Europe	CD		2715 ± 128	602 ± 41	17 ± 6					
		13			WD		3171 ± 231	756 ± 86	7 ± 3					
		17			CM		3402 ± 159	778 ± 46	11 ± 3					
		8			WM		3301 ± 221	931 ± 78	31 ± 11					
		6			A		3283 ± 108	1051 ± 78	69 ± 14					
Andersson et al.	2010	9	International	Scandinavia	D	9500 ± 900°			221 ± 32					
		5			M	10 600 ± 300°			316 ± 51					
		3			A	9800 ± 200°			262 ± 46					
		9	Highest division	Scandinavia	D	9500 ± 100°			230 ± 33					
		5			M	10 100 ± 300°			221 ± 39					
		3			A	9500 ± 599°			191 ± 42					
Gabbett & Mulvey	2008		International	Australia	D	9621 ± 1202		820 ± 327						
					M	10672 ± 1338		981 ± 317						
					A	9609 ± 359		1184 ± 146						

*Data are presented as mean ± SD. HSR = high-speed running, VHSR = very high-speed running, ACC = accelerations, DEC = decelerations, CD = central defender, WD = wide defender, D = defender, CDM = central defensive midfielder, CM = central midfielder, CAM = central attacking midfielder, WM = wide midfielder, M = midfielder, A = attacker, * = national team players,* $^{\#}$ *= non-national team players, ° = data converted from kilometers to meters.*

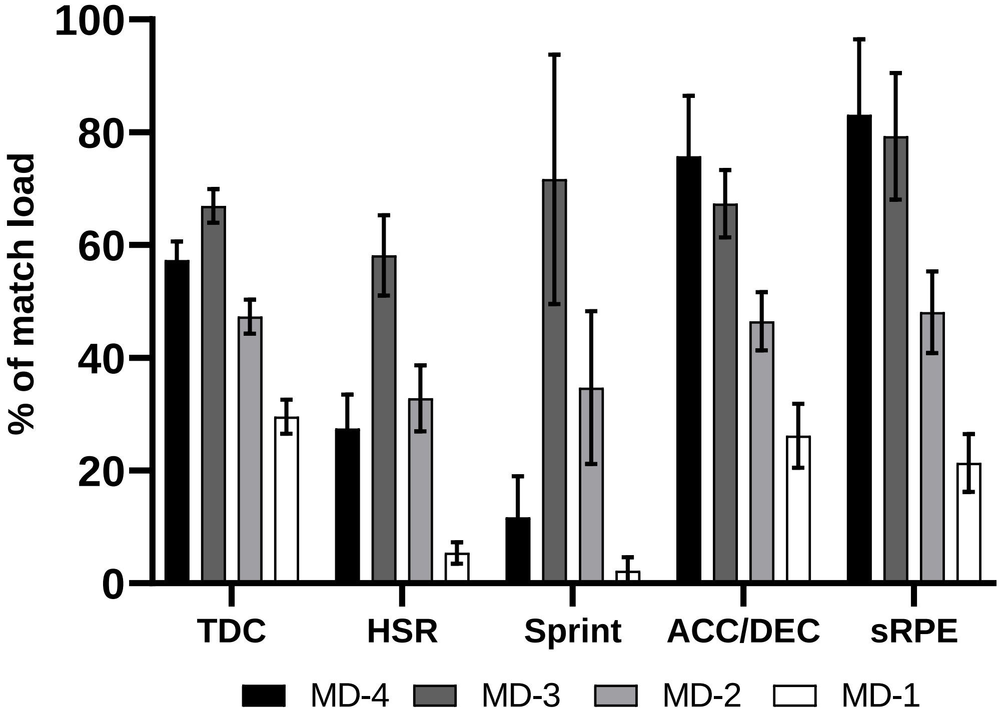
Appendix III: Modified CR10 RPE scale

Appendix III: *Modified CR10 RPE scale (Foster et al. 2001).*

Rating	**Descriptor**
0	Rest
1	Very, very easy
2	Easy
3	Moderate
4	Somewhat hard
5	Hard
6	-
7	Very hard
8	-
9	-
10	Maximal

Appendix IV: Training load expressed as a percentage of match load

To calculate training load as a percentage of match load, individual averages in training load were divided by their individual average match load and used to calculate a team average in training load relative to match load.



Appendix IV: *Training load expressed as a percentage of match load. Data are presented as mean ± SD. TDC = total distance covered, HSR = high-speed running distance, Sprint = sprint distance, ACC/DEC = combined number of accelerations and decelerations, sRPE = session rating of perceived exertion, MD = match day.*

Appendix V: Training contents within the microcycle

***Appendix V**: Training contents on the different days within the microcycle*

MD-4 Strength	MD-3 Endurance	MD-2 Speed	MD-1
General warm-up & mobility/dynamic stretching (5 min) Workstations (lateral jumps, accelerations & decelerations with elastic bands, single- & double-legged hurdle jumps with controlled landings after last hurdle) (5-10 min) Intensified warm-up with extra focus on change of direction, accelerations, and decelerations (3-5 min) Technical warm-up/passing drill (10 min) Small possession (15-20 min) Position specific 1v1s (10-15 min) SSGs 4v4/5v5 (length x width: 25-40m x 20-25m, 6-10 games of 90-120s, rest = 60-120s) (30-40 min)	General warm-up & mobility/dynamic stretching (5 min) * Workstations (banded hip flexions, isometric hamstring holds, core work) (5-10 min) Intensified warm-up finished with progressions runs and/or sprints (5 min) Large possession or shadow play (20 min) Situational drills building from a segmented to holistic focus (30 min) 11v11 games (full pitch, 3-4 games of 8-12 min, r=2-4 min) (40 min) * Conditioning on either a group or individual level (10s on/20s off runs, 30m sprints)	General warm-up & mobility/dynamic stretching (5 min) Progressive plyometric and power exercises (hurdle jumps, resisted broad jumps) (5-10 min) Intensified warm-up with focus on running technique drills, finished with progressions runs and/or sprints (5 min) Technical warm-up/passing drill (10 min) High-intensity pressure drills with short work periods and sufficient rest (15-20 min) Transitions & counterattacks (3v1, 3v2, 4v2, 4v3) (15-20 min) * 7v7/8v8 games (70-80m x 40-45m, 2-4 games of 3-5 min, rest = 3 min) (15-25 min)	Warm-up of gradually increased intensity with included mobility/dynamic stretching (10 min) Fun competition (10 min) Small-sided possession competition (10-15 min) Finishing drills (10 min) Set pieces (10-15 min)

MD = match day, SSG = small-sided games, ******* *= Only featured on occasion.*

Appendix VI: Letter of consent

Vil du delta i forskningsprosjektet

«ReadyToPlay:
Protecting the health of Norwegian elite football players»

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å *beskrive forekomsten av skader og sykdom i Toppserien, og undersøke risikofaktorer for skader i sammenheng med belastning og fysisk form*. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål

Kvinnefotball er i rask utvikling, og nivået og kravene som stilles på trening og i kamp er høyere enn noen gang. Dette kan påvirke risikoen for skader og sykdom, noe som er viktig å kartlegge siden det vil påvirke prestasjon og utvikling for både lag og spiller. Informasjon om faktorer som gjør at spillere har økt risiko for skader er viktig for å kunne forebygge skader, men dette er lite kartlagt i kvinnefotball. Hensikten med denne studien er derfor *å kartlegge alle helseproblemer i Toppserien og undersøke risikofaktorer for skader og sammenheng med treningsbelastning og fysisk form*. Dette vil være med å danne grunnlaget for hvordan vi kan forebygge skader og bedre prestasjon i fremtiden.

Prosjektet er del av flere doktorgradsprosjekter og involverer etablerte forskere og medisinere innen fotball. Anonymiserte resultater fra studien vil bli presentert på nasjonale og internasjonale konferanser, brukt i undervisningsformål, inkludert i trenerutdanningen.

Hvem er ansvarlig for forskningsprosjektet?

Norges idrettshøgskole og Senter for idrettsskadeforskning er ansvarlig for prosjektet. *Norges fotballforbund* og *Toppfotball Kvinner* er også med som samarbeidspartnere for prosjektet.

Hvorfor får du spørsmål om å delta?

Vi kontakter deg med denne forespørselen fordi ditt lag har sagt seg villig til å delta i prosjektet.

Vi ønsker å kartlegge samtlige lag og spillere i Toppserien, derfor får du som spiller på et toppserielag forespørselen om å delta.

Hva innebærer det for deg å delta?

Metoden som brukes i prosjektet er en prospektiv kohortstudie, dette innebærer at vi ønsker å følge en spesifikk gruppe over tid, i dette tilfellet alle spillerne i Toppserien. Du vil trene som normalt med ditt lag hele sesongen, men vi vil samle data om din fysiske prestasjonsevne, sykdom og skader du blir utsatt for, samt intensiteten og varigheten av både trening og kamp du deltar i.

Hvis du velger å delta i prosjektet;

- Vil du i løpet av uken få påminnelser om å rapportere sykdom/skader, intensitet og varighet via mobilappen «AthleteMonitoring». Daglig for treningsbelastning og ukentlig for sykdom/skade registrering. Her må du svare på et kort spørreskjema, «OSTRC Questionnaire on Health Problems», og registrere treningsmengden for uken som har gått. Dette tar fra 30 sekunder til 4 minutter å svare på, avhengig av om du har hatt skade/sykdom eller ikke.
- Ditt lags fysioterapeut vil varsles umiddelbart om du rapporterer noe nytt, for å raskt kunne undersøke deg og sette i gang tiltak. Fysioterapeuten vil registre hvilken skade/sykdom som har oppstått og hvor mange dager du er borte fra trening/kamp.
- Toppfotball Kvinner gjennomfører i samarbeid med lagene i Toppserien testing av fysisk prestasjonsevne ved Idrettens Helsesenter. Her testes muskelstyrken i beina i tillegg til prestasjonstester i spenst, agility og hurtighet. Du vil også svare på et spørreskjema hvor andre potensielle risikofaktorer for skader blir undersøkt. Vi vil lagre data fra disse testene og bruke resultatene til å se etter sammenhenger med skader.

- Anonyme data om skader og sykdom vil også knyttes opp mot data på trenings- og kampbelastning for å undersøke sammenhengen mellom belastning, skader og fysisk prestasjonsevne.
- TV-opptak vil brukes for å undersøke skader som oppstår i kamp nærmere.

Prosjektet vil starte etter at laget ditt har gjennomført testing på Idrettens Helsesenter (i februar/mars) og vare hele sesongen.

Det er frivillig å delta

Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke ditt samtykke tilbake, uten å måtte oppgi noen grunn. Alle opplysninger om deg vil da bli anonymisert. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Det vil ikke få noen konsekvenser for deg eller ditt lag dersom du ønsker å trekke deg i fra studien.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger

Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket.

- Alle som får innsyn i dine data vil ha taushetsplikt. Kun forskere som deltar i prosjektgruppen vil ha tilgang til dine data. I tillegg vil klubbens fysioterapeut og lege ha innsyn i dine data.
- Når dine data benyttes til forskningsformål, vil de avidentifiseres ved at navn og personnummer fjernes. Dataene vil bli behandlet konfidensielt.
- Applikasjonen som brukes heter «Athlete monitoring» og er utviklet av et kanadisk selskap ved samme navn. Applikasjonen er godkjent etter de nye personvernreglene, GDPR.

Alle resultater som omtales i publikasjonene etter prosjektet vil være anonymiserte og det vil ikke være mulig å gjenkjenne deg i resultatene som publiseres.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?

Prosjektet skal etter planen avsluttes 31.12.2029. Alle opplysninger som kan knytte deg til materialet vil bli anonymisert og opplysninger vi har lagret om deg vil slettes.

Alle data om skader og fysisk prestasjonsevne som hentes ut for forskningsformål vil bli lagret, i anonymisert form, i en database for å kunne kartlegge hvordan omfang og utvikling endrer seg i Toppserien over tid. Materialet vil være viktig kunnskap for å forstå hvordan vi skal arbeide med forebygging av skader og sykdom, samt tilrettelegging av belastning med tanke på forebygging og utvikling av fysisk prestasjonsevne. Dataene vil kunne danne et viktig grunnlag for utarbeidelse av blant annet arbeidskrav i Toppserien.

Styret ved Norges idrettshøgskole har bestemt at forskningsdata skal lagres i fem år etter prosjektslutt for etterprøvbarhet og kontroll. Dette innebærer at alle data, utenom personopplysninger, vil bli lagret i sin helhet i fem år hos Norges idrettshøgskole. Dette er meldt til Norsk senter for forskningsdata (NSD).

Dine rettigheter

Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke personopplysninger som er registrert om deg,
- å få rettet personopplysninger om deg,
- få slettet personopplysninger om deg,
- få utlevert en kopi av dine personopplysninger (dataportabilitet), og
- å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?

Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra Norges idrettshøgskole har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hvor kan jeg finne ut mer?

Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:

- Norges idrettshøgskole ved Solveig Thorarinsdottir, *solveig.thorarinsdottir@nih.no*, tlf. 405 22 930, Roar Amundsen, *roar.amundsen@nih.no*, tlf. 482 97 832, eller Markus Vagle, *markus.vagle@nih.no*, tlf. 992 74 982.
- Vårt personvernombud: Rolf Haavik, *rolf.haavik@habberstad.no*, tlf. 90 73 37 60.
- NSD – Norsk senter for forskningsdata AS, *personverntjenester@nsd.no*) eller tlf. 555 82 117.

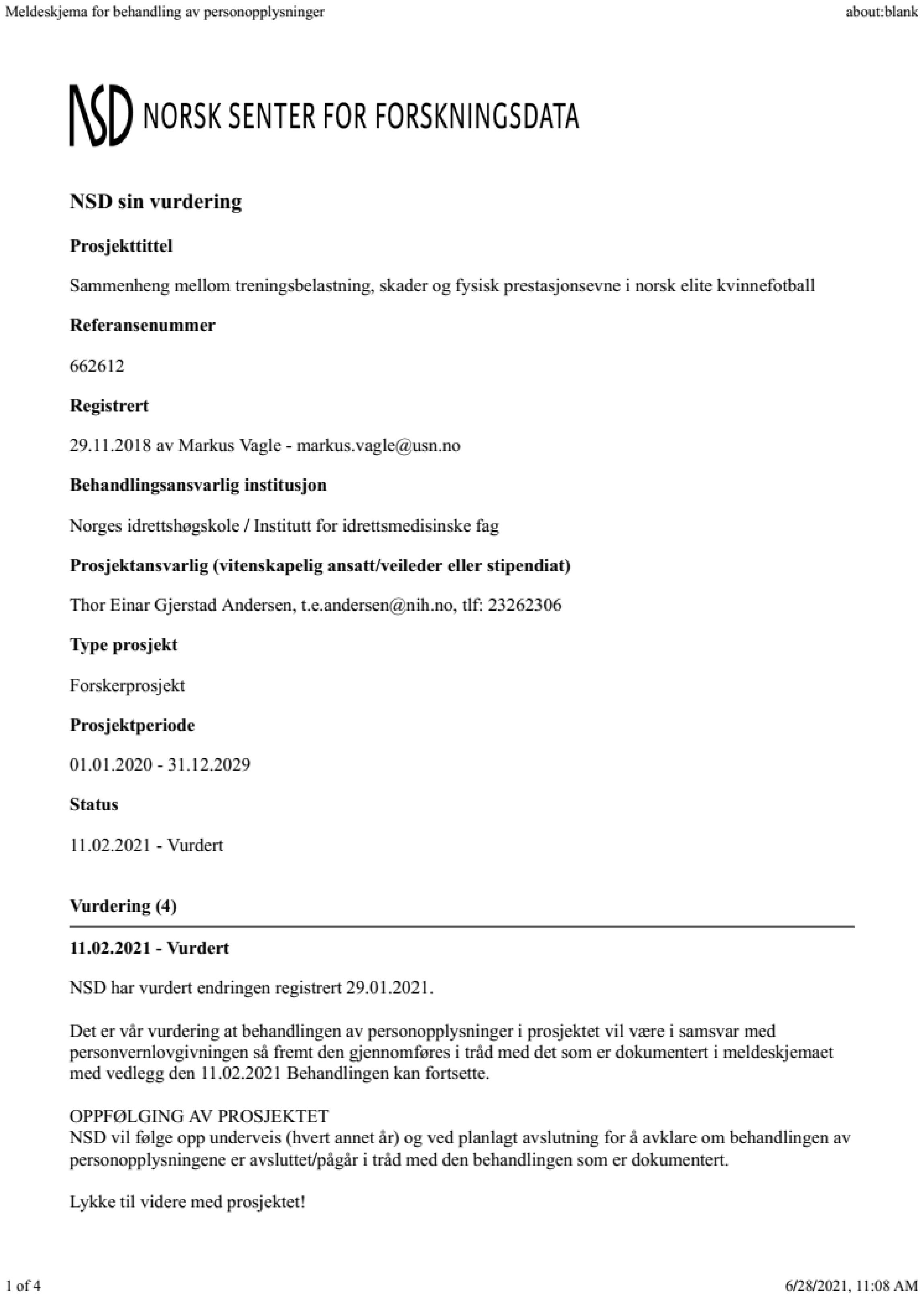
Med vennlig hilsen

Roar Amundsen (PhD-stipendiat)
Solveig Thorarinsdottir (PhD-stipendiat)
Markus Vagle (PhD-stipendiat)
Professor dr. med. Roald Bahr (Veileder og leder for Senter for idrettsskadeforskning)

Samtykkeerklæring

Dersom du ønsker å delta i forskningsprosjektet vil du kunne gi ditt samtykke elektronisk ved å godkjenne informasjonen når du logger inn i appen som brukes for å registrere skader, sykdom og treningsmengde. Informasjonen er også gjengitt i dette skrivet. Du og ditt lag vil få tilgang til appen uavhengig av om du gir ditt samtykke til at dataene dine brukes i forskningsprosjektet.

Appendix VII: NSD’s approval letter



Meldeskjema for behandling av personopplysninger about:blank

NSD NORSK SENTER FOR FORSKNINGSDATA

NSD sin vurdering

Prosjekttittel

Sammenheng mellom treningsbelastning, skader og fysisk prestasjonsevne i norsk elite kvinnefotball

Referansenummer

662612

Registrert

29.11.2018 av Markus Vagle - markus.vagle@usn.no

Behandlingsansvarlig institusjon

Norges idrettshøgskole / Institutt for idrettsmedisinske fag

Prosjektansvarlig (vitenskapelig ansatt/veileder eller stipendiat)

Thor Einar Gjerstad Andersen, t.e.andersen@nih.no, tlf: 23262306

Type prosjekt

Forskerprosjekt

Prosjektperiode

01.01.2020 - 31.12.2029

Status

11.02.2021 - Vurdert

Vurdering (4)

11.02.2021 - Vurdert

NSD har vurdert endringen registrert 29.01.2021.

Det er vår vurdering at behandlingen av personopplysninger i prosjektet vil være i samsvar med personvernlovgivningen så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet med vedlegg den 11.02.2021 Behandlingen kan fortsette.

OPPFØLGING AV PROSJEKTET
NSD vil følge opp underveis (hvert annet år) og ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet/pågår i tråd med den behandlingen som er dokumentert.

Lykke til videre med prosjektet!

1 of 4 6/28/2021, 11:08 AM

Tlf. Personverntjenester: 55 58 21 17 (tast 1)

17.06.2020 - Vurdert

NSD har vurdert endringen registrert 02.06.20.

Det er vår vurdering at behandlingen av personopplysninger i prosjektet vil være i samsvar med personvernlovgivningen så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet med vedlegg den 17.06.20. Behandlingen kan fortsette.

Prosjektet er nå utvidet i forbindelse med Covid-19 og de nye retningslinjene som fotballspillerne er underlagt. Det er lagt til et utvalg 2 som er spillernes støtteapparat. I tillegg er det ønskelig å innhente opplysninger om blant annet symptomer på Covid-19, herunder biologisk materiale i form av blodprøver. Prosjektet har i den forbindelse søkt til REK.

REK sør-øst D (deres ref: 152409) i vedtak datert (15.06.2020) godkjent prosjektet etter helseforskningsloven § 10.

NSD forstår det slik at forskningsprosjektet ikke skal innhente opplysninger om symptomer fra andre i husstanden til utvalget. Videre vil vi poengtere at det fremgår av vedtaket til REK at prosjektet skal avsluttes 31.12.2021, og at data deretter skal oppbevares i fem år av dokumentasjonshensyn. NSD sin vurdering gjelder frem til 2029. Vi minner om at det må søkes om forlengelse hos REK dersom data skal oppbevares frem til 2029.

OPPFØLGING AV PROSJEKTET
NSD vil følge opp underveis (hvert annet år) og ved planlagt avslutning for å avklare om behandlingen av personopplysningene pågår i tråd med den behandlingen som er dokumentert.

Lykke til med prosjektet!

Kontaktperson hos NSD: Belinda Gloppen Helle

Tlf. Personverntjenester: 55 58 21 17 (tast 1)

31.01.2020 - Vurdert

NSD har vurdert endringen registrert 16.12.2019.

Det er vår vurdering at behandlingen av personopplysninger i prosjektet vil være i samsvar med personvernlovgivningen så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet med vedlegg den 31.01.2020. Behandlingen kan fortsette.

OPPFØLGING AV PROSJEKTET
NSD vil følge opp underveis (hvert annet år) og ved planlagt avslutning for å avklare om behandlingen av personopplysningene pågår i tråd med den behandlingen som er dokumentert.

Lykke til med prosjektet!

Kontaktperson hos NSD: Belinda Gloppen Helle

Tlf. Personverntjenester: 55 58 21 17 (tast 1)

25.01.2019 - Vurdert

Det er vår vurdering at behandlingen vil være i samsvar med personvernlovgivningen, så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet 25.01.2019 med vedlegg, samt i meldingsdialogen mellom innmelder og NSD. Behandlingen kan starte.

MELD ENDRINGER
Dersom behandlingen av personopplysninger endrer seg, kan det være nødvendig å melde dette til NSD ved å oppdatere meldeskjemaet. På våre nettsider informerer vi om hvilke endringer som må meldes. Vent på svar før endringen gjennomføres.

TYPE OPPLYSNINGER OG VARIGHET
Prosjektet vil behandle særlige kategorier av personopplysninger om helseforhold og alminnelige personopplysninger frem til 31.12.2021. Denne datoen må fremgå i informasjonsskrivet, nå står det 31.12.2019.

LOVLIG GRUNNLAG
Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 nr. 11 og art. 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse, som kan dokumenteres, og som den registrerte kan trekke tilbake.

Lovlig grunnlag for behandlingen vil dermed være den registrertes uttrykkelige samtykke, jf. personvernforordningen art. 6 nr. 1 a), jf. art. 9 nr. 2 bokstav a, jf. personopplysningsloven § 10, jf. § 9 (2).

PERSONVERNPRINSIPPER
NSD vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen:

- om lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen
- formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke viderebehandles til nye uforenlige formål
- dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet med prosjektet
- lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet

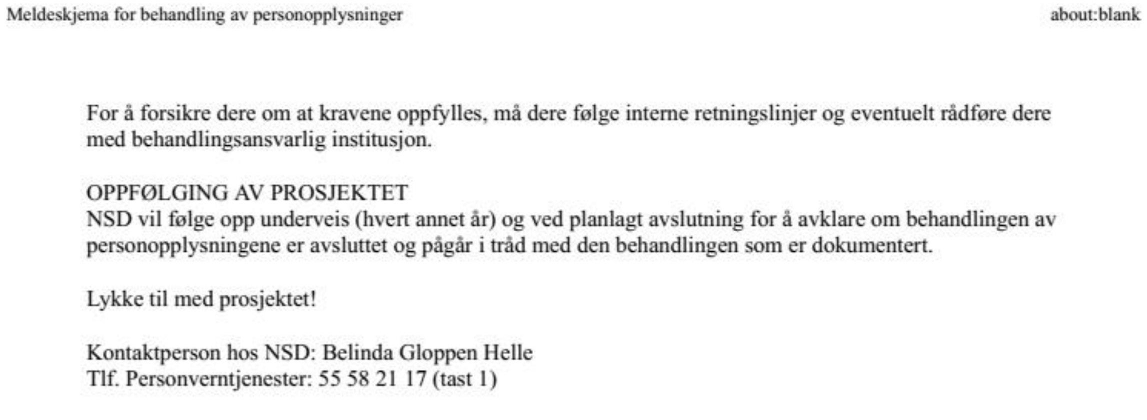
DE REGISTRERTES RETTIGHETER
Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: åpenhet (art. 12), informasjon (art. 13), innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18), underretning (art. 19), dataportabilitet (art. 20).

NSD vurderer at informasjonen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER
NSD legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

Athlete Monitoring er databehandler i prosjektet. NSD legger til grunn at behandlingen oppfyller kravene til bruk av databehandler, jf. art 28 og 29.



For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og eventuelt rådføre dere med behandlingsansvarlig institusjon.

OPPFØLGING AV PROSJEKTET
NSD vil følge opp underveis (hvert annet år) og ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet og pågår i tråd med den behandlingen som er dokumentert.

Lykke til med prosjektet!

Kontaktperson hos NSD: Belinda Gloppen Helle
Tlf. Personverntjenester: 55 58 21 17 (tast 1)

Appendix VIII: Approval from the Norwegian School of Sport Sciences' ethics committee

Thor Einar Andersen
Seksjon for idrettsmedisin

OSLO 16. desember 2018

Søknad 86 -131218 – Sammenhengen mellom treningsbelastning, skader og fysisk prestasjonsevne i norsk elite kvinnefotball

Vi viser til søknad, prosjektbeskrivelse, informasjonsskriv, samtykkeskjema og innsendt melding til NSD.

I henhold til retningslinjer for behandling av søknad til etisk komite for idrettsvitenskapelig forskning på mennesker, ble det i komiteens møte av 13. desember 2018 konkludert med følgende:

Vedtak

Komiteen finner at prosjektet er forsvarlig under forutsetning av:

- *At vilkår fra NSD følges*

Komiteen gjør oppmerksom på at vedtaket er avgrenset i tråd med fremlagte dokumentasjon.

Dersom det gjøres vesentlige endringer i prosjektet som kan ha betydning for deltakernes helse og sikkerhet, skal dette legges fram for komiteen før eventuelle endringer kan iverksettes.

Med vennlig hilsen

Professor Sigmund Loland
Leder, Etisk komite, Norges idrettshøgskole