LITHUANIAN SPORTS UNIVERSITY

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MONITORING WORKLOAD AND READINESS TO PERFORM DURING INTENSIFIED PERIODS IN BASKETBALL

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DEDICATION

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In memory of
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CONTENTS

ABBREVIATIONS

AU	–	Arbitrary Units
CMJ	–	Countermovement jump
CR	–	Category ratio
EC	–	European Championship
ES	–	Effect size
HR	–	Heart Rate
HRmax	–	Maximum Heart Rate
HRmean	–	Mean Heart Rate
HRV	–	Heart Rate Variability
YYIR1	–	Yo-Yo intermittent recovery 1 test
Ln_rMSSD	–	Natural logarithm of the rMMSD
LSKL	–	Lithuanian student league game (Lietuvos studentų krepšinio lyga)
NBA	–	National Basketball Association
NCAA	–	National Collegiate Athletic Association
NKL	–	Second-tier Lithuanian league (Nacionalinė krepšinio lyga)
PL	–	PlayerLoad
rMSSD	–	Square root of the mean sum of squared differences between adjacent normal RR intervals
SHRZ	–	Summated heart rate zones
sRPE	–	Session Rating Perceived Exertion
TRIMP	–	Training Impulse
U18	–	National under 18 basketball team (i.e., younger or 18 years old)
U20	–	National under 20 basketball team (i.e., younger or 20 years old)
WB	–	Well-being
%HRmax	–	Percentage of Heart Rate maximum

INTRODUCTION

Team sports athletes are regularly exposed to high training and match workloads aimed at improving their physical capacities and on-court skills (Kelly, Strudwick, Atkinson, Drust, & Gregson, 2020; Marrier et al., 2019; Nakamura et al., 2017; Pliauga et al., 2018). An appropriate workload typology and magnitude leads to various physiological adaptations over the course of season, enhancing both neuromuscular and cardiovascular fitness components (Mohr & Krustrup, 2014; Oliveira, Leicht, Bishop, Barbero-Alvarez, & Nakamura, 2013). During some periods of the season, athletes are intentionally exposed to high training and match workloads, which represent intensified periods (i.e., preparation camps and congested match schedules). These intensified periods of training and competition are sometimes unavoidable, and in some case necessary for athletes' progression and physiological adaptation towards higher levels of performance (Cunanan et al., 2018). Nevertheless, in case of inadequate recovery, athletes might enter the non-functional overreaching or overtraining state, which leads to decreased performance and increased risk of injuries (Bosquet, Papelier, Leger, & Legros, 2003; Edwards et al., 2018; Kiely, 2018; Meeusen et al., 2013). Therefore, the use of an optimal workload and recovery management is one of the most important objectives during intensified periods (Bompa & Buzzichelli, 2018; Cunanan et al., 2018; Issurin, 2010; Nunes et al., 2014; Taylor, Chapman, Cronin, Newton, & Gill, 2012).

Basketball is characterized by high physical and physiological demands (Conte et al., 2015; Fox, Stanton, & Scanlan, 2018; Sansone et al., 2019; Scanlan et al., 2015a; Stojanović et al., 2018) particularly during intensified training and match periods. Indeed, during the season, athletes are exposed to congested match schedules in various basketball leagues, which involve multiple matches played in close succession (e.g. 2–3 per week) (Conte, Kolb, Scanlan, & Santolamazza, 2018; Fox, O'Grady, & Scanlan, 2020). Moreover, national basketball athletes are usually involved in international tournaments such as European Championships (EC), which are one of the most prestigious competitions characterized by multiple matches played in short timeframe (Conte & Lukonaitiene, 2018). Furthermore, the preparation for these events encompasses short, intensified preparation periods. Thus, it is fundamental to monitor these periods aiming to help coaches to increase or maintain player performance capacities and maintaining a good well-being status (Edwards et al., 2018; Russell, McLean, Impellizzeri, Strack, & Coutts, 2020). Overall, monitoring objective and subjective workload and readiness measures can provide an accurate global picture of how players are responding to intensified training and match demands providing useful information for basketball practitioners (Aoki, Arruda et al., 2017; Edwards et al., 2018; Fox, Scanlan, & Stanton, 2017; Nunes et al., 2014; Sansone, Tschan, Foster, & Tessitore, 2018).

The current body of literature mainly focused on the comparison of the workload experienced during intensified preparation periods (i.e., preseason phase lasting 5–7 weeks) in male, club, adult players (Ferioli, Bosio, Bilsborough et al., 2018a; Ferioli, Bosio, La Torre et al., 2018b; Pliauga et al., 2018), typically using periodization strategies including periods of high physical loads followed by taper periods (Bompa & Buzzichelli, 2018; Nunes et al., 2014; Pliauga et al., 2018). However, national teams start their preparation and compete in EC during summer, which in basketball periodization, traditionally represents a period of transition and rest after the regular club season, therefore the post-season and off-season periods are shortened and national team players have less time to recover between seasons (Bompa & Buzzichelli, 2018). However, these studies are specific for these basketball populations (i.e., adult, male, club players) limiting the generalizability of the results to female basketball. A previous investigation monitoring the Brazilian national female basketball team for a 12-week preparation period characterized by 2 overload and taper periods in preparation for an international tournament revealed that this periodization approach induced an enhancement of strength, power, agility and endurance because of an adequate workload distribution (Nunes et al., 2014). However, the manipulation of overload and tapering periods might result more difficult in shorter preparation periods, which are usually adopted in preparation of ECs. Moreover, there is a lack of information on workload experienced in short-preparation periods prior international tournament. Therefore, it is not clear whether training methodologies adopted by coaches during short time preparation periods could be either sufficient to elicit positive adaptations or have no positive effect on players' performance (Anderson, Triplett-Mcbride, Foster, Doberstein, & Brice, 2003; Ferioli et al., 2018a, b; Halson, 2014). Hence, studies assessing the optimal workload during short intensified training periods in basketball teams are warranted.

Ideally, following the preparation periods, peak performance should be achieved and maintained during the competition periods (Cunanan et al., 2018). However, the maintainance of the peak performance and readiness to play during intensified congested match schedules present a challenging task for basketball coaches and practitioners (Fox et al., 2020; Klusemann, Pyne, Hopkins, &

Drinkwater, 2013; Pino-Ortega et al., 2019). Previous investigations have indicated decrements in external (i.e., game stimuli imposed) and internal (i.e., the physiological or perceptual reactions to the imposed stimuli) workload across games played in close succession (Fox et al., 2020; Klusemann et al., 2013; Pino-Ortega et al., 2019). One of these studies focused on the analysis of players' individual workload changes during 1-to-3 games played on close succession during the in-season phase and revealed trivial-to-small differences in external and internal load (Fox et al., 2020). However, data are representative only of a single league (i.e., second-tier Australian basketball league), while other leagues might be characterized by a different schedule, with different periodization strategies and game workloads, moreover no information on players' readiness was provided calling for further studies. Provision of match workload data and player readiness across matches during different congested schedules seems essential to provide a comprehensive evaluation of potential fatigue level encountered by players.

Hypothesis: high workload during intensified periods in basketball negatively effects players' readiness to perform.

The aim of the research was to evaluate the workload and readiness to perform during short intensified training and match periods in basketball.

Research objectives:

1. To investigate workload and readiness in basketball players to perform during a 3-week intensified preparation period for European Championships.
2. To investigate workload and readiness in basketball players to perform during congested match schedules at European Championship.
3. To quantify and compare workload and well-being across games played on consecutive days during the in-season phase in basketball players.

Practical significance of the research

The new findings of our studies could provide information for basketball coaches and practitioners with useful insights to adopt adequate workloads during short intensified preparation periods prior international tournaments. Moreover, assessing match-to-match changes during different congested match schedules potentially allows to manipulate between-match recovery strategies. Overall, these studies will provide workload and readiness to perform magnitudes, which could later serve as reference values when planning the training process and making informed player rotation decisions during matches.

1. LITERATURE REVIEW

1.1. Intensified training periods within training periodization

Periodization is a term that describes the macromanagement of the training process with respect to time (Bompa & Buzzichelli, 2018; Cunanan et al., 2018; Issurin, 2010; Pliauga et al., 2018). The use of a periodized program is proven to be advantageous for athletes in different sports due to practice and competitions throughout the season (Clemente, Martins, & Mendes, 2014; Ferioli et al., 2018a; Issurin, 2010; Marrier et al., 2019; Pliauga et al., 2018). In contrast, it is suggested that the proposed benefits of periodization for those only interested in increasing muscle size and strength are largely founded in conjecture and that there is little compelling evidence that periodization is a superior method of training for these sports (Mattocks et al., 2016). Despite that, periodized programs enable athletes to achieve their peak performance in the timely manner (Bompa & Buzzichelli, 2018). Therefore, the need to prioritize ***planning*** based on attaining the optimal athletic fitness level, specifically, creating a level of competitive readiness characterized by a complex of physiological, medical-control, and psychological indices was developed by Matveyev (Matveyev, 1977). Specifically, Matveyev (1977) noted that sporting form is a "harmonious unity of all the components of the athlete's optimal readiness: physical, psychic, technical, and tactical."

Performance in most sports is determined by the athlete's technical, tactical, physiological and psychological/social characteristics (Bangsbo, 2015). Athletes within different sports require sport specific ***adaptations*** to boost their performance, which is the ultimate goal of every training program (Halson & Jeukendrup, 2004; Viru & Viru, 2000). While individual sport might relay more on specific physical capacity (e.g., 100-m sprint, marathon, rowing, etc.) others require a range of unique skills such as technical and tactical components in ball-games (Bangsbo, 2015). For the most successful scenario, player within a variety of sports calls for a highly developed fitness to cope with the physical demands during the competitions to allow for their appropriate technical and tactical performace. Bangsbo (2015) created a holistic representation of various components affecting the ultimate performance of an athlete (Figure 1.1). This model reveals, that under optimal conditions, the demands in sport are closely related to the athlete's physical capacity, which can be divided into the following categories: (a) the ability to perform prolonged exercise (endurance); (b) the ability to exercise at high-intensity for a prolonged period;

(c) the ability to sprint; and (d) the ability to develop a high power output (force) in single actions such as jumping in basketball (Figure 1.1) (Bangsbo, 2015). The capacity within these categories is based on the characteristics of the respiratory, cardiovascular and neuromuscular systems (Bangsbo, 2015).

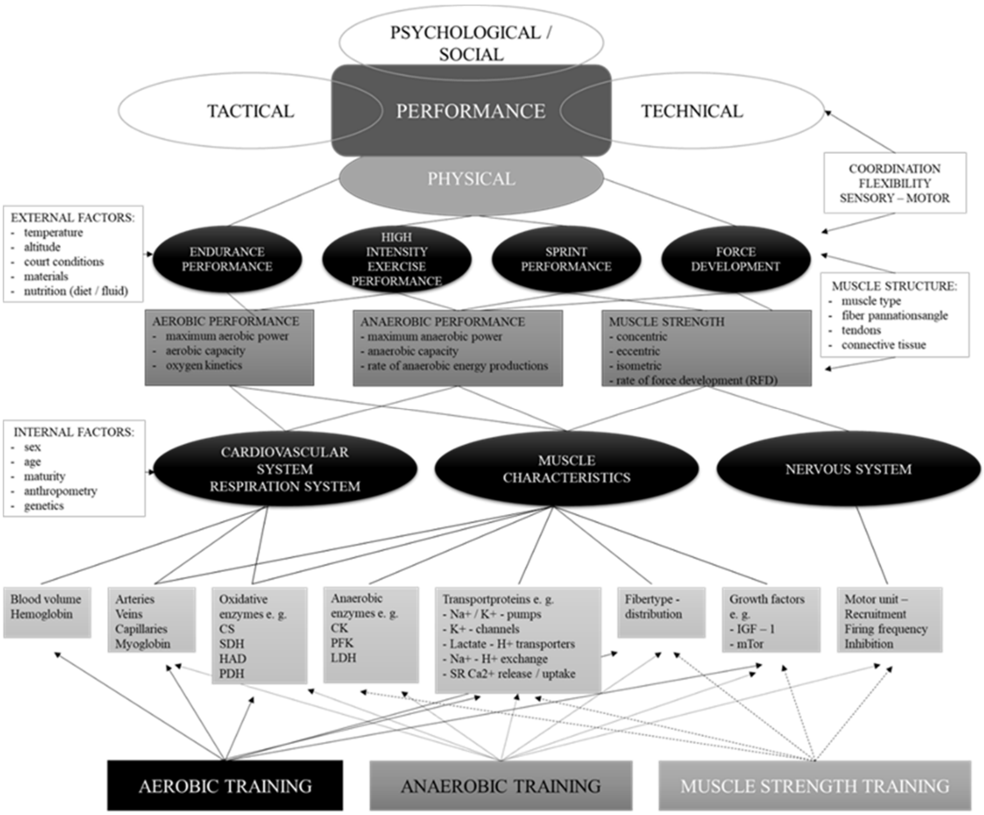


Figure 1.1. A holistic model of the determinants of sports performance (Figure adopted from Bangsbo, 2015)

Applying periodized planning to team sports poses unique challenges due to the variety of training goals, volume of concurrent training and practices as well as extended season of competition (Gamble, 2006). Therefore, there is a need for planned variations in the training program to systematically shift the emphasis on different training effects at different phases promotion (Gamble, 2006). The most common periodization models adopted in sports include traditional periodization (Matveyev, 1965; Olivera, Sequeiros, & Dantas, 2005) and block periodization (Issurin; Olivera et al., 2005; Pliauga et al., 2018). In the traditional periodization

(TP) model proposed by Matveev (1965), macrocycles and mesocycles are arranged for transition from high-volume and low-intensity workloads to high-intensity and low-volume workloads. Moreover, this model is based on the simultaneous development of many fitness components (e.g. aerobic capacity, strength, power) within a regular workload distribution (Matveyev, 1965). The block periodization (BP) model is characterized by concentrated training stimuli focused on specific aspects of fitness or performance components (Bondarchuk, 1988; Issurin, 2008; Pliauga et al., 2018). More precisely, the block periodization model contains mesocycles with a specific training goal whereby athlete progression is performed in a logical order to prepare for the subsequent training block (Bondarchuk, 1988; Issurin, 2008; Pliauga et al., 2018). Previous research that compared the effects of traditional and block periodization models on athletic performance showed that block periodization is more effective in improving anaerobic qualities in elite kayakers (García-Pallarés, Garcia-Fernández, Sánchez-Medina, & Izquierdo, 2010), experienced resistance-trained athletes (Bartolomei, Hoffman, Merni, & Stout, 2014) and basketball players (Pliauga et al., 2018).

Both traditional and block periodization models are based on the assumption that an athlete needs to receive an optimal exercise or training stimulus balanced with appropriate unloading to elicit favorable long-term training effects (Cunanan et al., 2018). In turn, the programming variations, including oscillations in volume and intensity, would serve to promote adaptation, leading to the realization of enhanced fitness characteristics (Bompa & Buzzichelli, 2018; Cunanan et al., 2018; Issurin, 2010; Pliauga et al., 2018). Periodization is a framework that enables the coach to forecast and assign periods of time toward the acquisition and realization of specific fitness characteristics (e.g., endurance, strength-endurance, strength, power, speed) (Cunanan et al., 2018). In contrast, programming can be considered the micromanagement of those outlined stages of training (Figure 1.2). ***Training programs*** aim to firstly increase the athlete's physiological potential, and the secondly is to maximize sport-specific biomotor abilities as well as reducing the risk of injuries (Bompa & Buzzichelli, 2018). On that basis, practitioners have attempted to establish programming methodologies that are in accordance with the founding principles of periodization (Aoki, Arruda et al., 2017; Aoki, Ronda et al., 2017; Clemente et al., 2014; Marrier et al., 2019; Nunes et al., 2014; Pliauga et al., 2018).

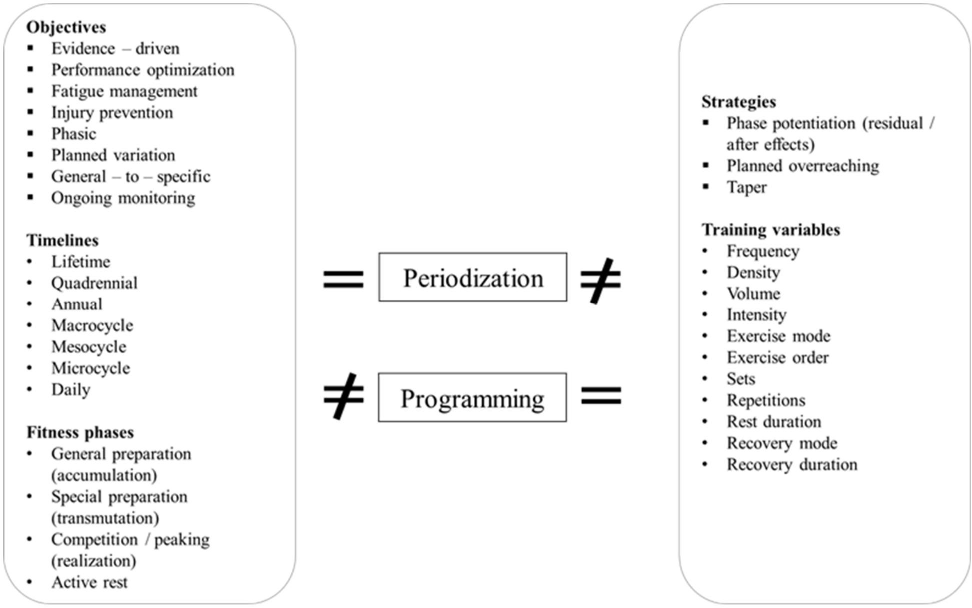


Figure 1.2. The distinction and relationship between periodization and programming (Figure adopted from Cunanan et al., 2018)

One of the most important objectives within periodization framework is the management of ***fatigue*** (Cunanan et al., 2018; Taylor et al., 2012). It is well known that fatigue inhibits performance (Edwards et al., 2018; McGuigan, 2017; Taylor et al., 2012). In contrast, appropriate fatigue management potentially enhances player readiness to perform (Drew, Cook, & Finch, 2016; Edwards et al., 2018). Athlete fatigue is a difficult concept to define, making its measurement equally problematical (Abiss & Laursen, 2007; Enoka & Duchateau, 2008, 2016). Fatigue is generated by the interaction of two main attributes: performance and perceived fatigability (Figure 1.3) (Edwards et al., 2018). Performance fatigability is defined as a decline in objective performance measures derived from reduced capacity of the nervous system and contractile properties of muscles over time, while perceived fatigability is described as the maintenance of homeostasis and subjective psychological state (Enoka & Duchateau, 2016; Lidor, Blumenstein, & Tenenbaum, 2007). In addition, muscle physiologists often describe fatigue simply as an acute exercise-induced decline in muscle force (Kamandulis et al., 2012), while within applied exercise science research, fatigue is most commonly referred to as a reduced capacity for maximal performance (Khlifa et al., 2013; Moreira et al., 2018; Pliauga et al., 2018).

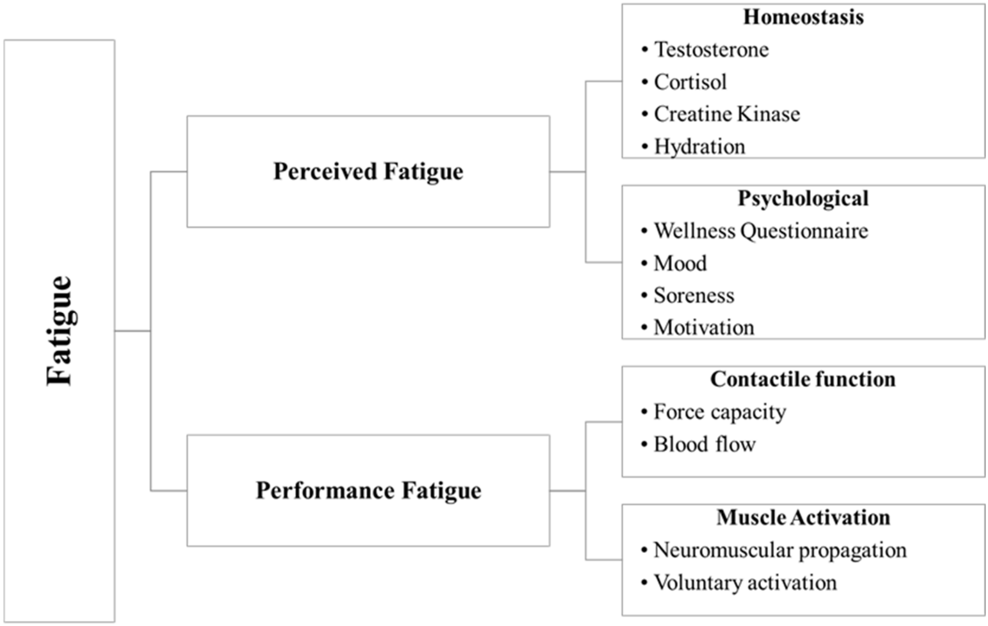


Figure 1.3. Modulating factors of perceived and performance fatigability
(Figure adopted from Edwards et al., 2018; Enoka & Duchateau, 2016)

All manipulations of workload and subsequent management of fatigue aims to provide a stimulus that leads to increase of performance (Bompa & Buzzichelli, 2018; Fox et al., 2017; Impellizzeri, Marcora, & Coutts, 2019; McGuigan, 2017; Pliauga et al., 2018). To achieve this desired goal, practitioners must understand the ***general adaptation model***, since it provides with the information about physiological changes that body undergoes throughout the process of training (i.e., following applied stimulus) (Cunanan et al., 2018; McGuigan, 2017). The general adaptation model is presented in Figure 1.4.

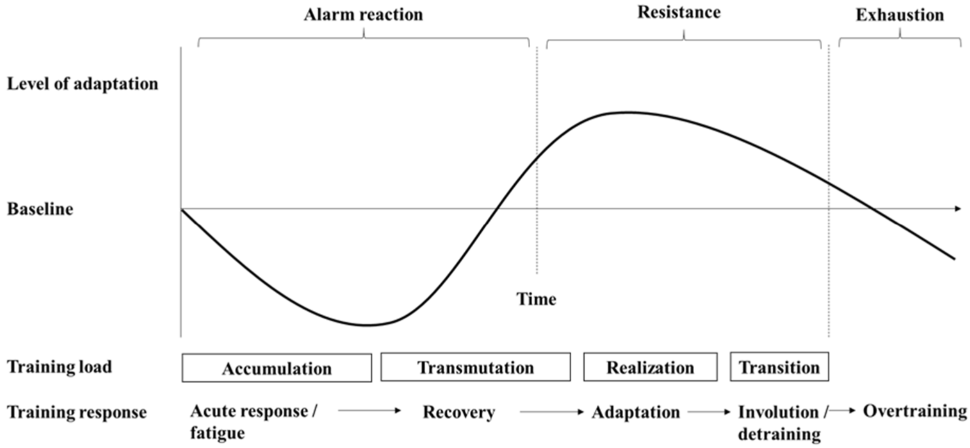


Figure 1.4. General adaptation model (Figure adopted from Cunanan et al., 2018)

Within the ***general adaptation model*** 3 phases are explained (Figure 1.4). Upon the application of a stimulus (i.e. stress) athlete's body enters the alarm phase, which presents with fatigue. The decline due to fatigue is then followed by increase in the organism's level of adaptation during resistance phase, if an appropriate recovery is applied (Cunanan et al., 2018; Issurin, 2010; Jentjens & Jeukendrup, 2003; McGuigan, 2017; Selye, 1950). This phenomenon is better known as a ***supercompensation*** (Figure 1.5) (Issurin, 2010). To ensure the further increase in performance the next training stimulus should be applied during the supercompensation phase (McGuigan, 2017). However, if the recovery is inadequate athlete might enter the third phase of exhaustion within the general adaptation model, which represents the decreased performance and eventually could lead to overtraining (see Figure 1.4 and Figure 1.6) (Cunanan et al., 2018; McGuigan, 2017). Based on the supercompensation theory, Matveyev (1965) proposed a general scheme of several-load summation. According to this scheme a number of workouts can be performed while the athlete is still fatigued, and the supercompensation effect can be induced following a specific training cycle but not a single workout (Issurin, 2010). This position formed the foundation for compiling ***intensified periods***.

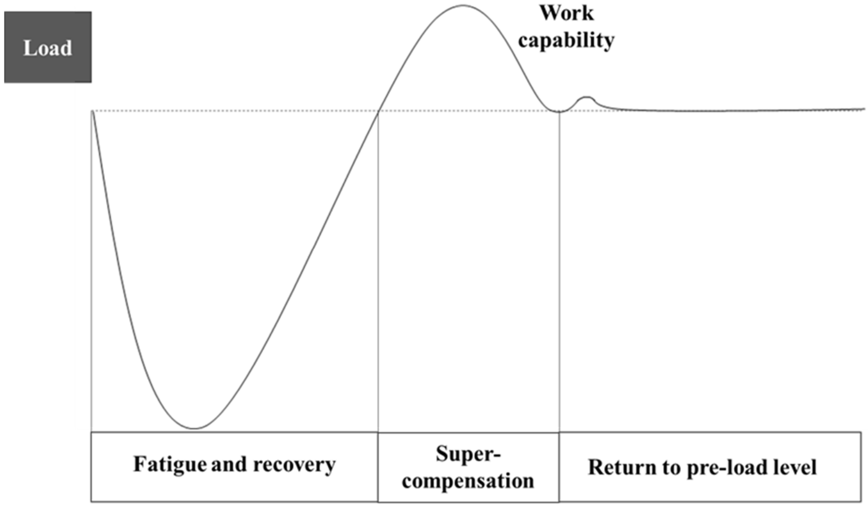


Figure 1.5. The supercompensation cycle, showing the trend of work capability following a single load (Figure adopted from Issurin, 2010)

In a periodized training plan, physical training is developed in a structured, sequential pattern divided into ***preparation*** phase followed by ***competition*** periods (Figure 1.2) (Bompa & Buzzichelli, 2018; Cunanan et al., 2018). During the preparation phase it is advised to separate general physical training and sports-specific physical training (Bompa & Buzzichelli, 2018; Cunanan et al., 2018) (Figure 1.2). Following the competition phase, the transition phase which separates seasons is applied to achieve the complete physical and psychological recovery before the new preparation period starts (Bompa & Buzzichelli, 2018).

The phasic and cyclical nature of periodized training is proposed in order to both predict the athlete's individual tolerance to exercise and fatigue-managing recovery, which in turn helps to prevent overreaching, overtraining or stress-induced injury (Figure 1.4) (McGuigan, 2017; Weiss, Allen, McGuigan, & Whatman, 2017). During some periods, athletes are exposed to excessive training and match workload which represents ***intensified periods*** (i.e., preparation periods, congested match schedules in seasons or in tournaments). These ***intensified periods*** of training and competition are unavoidable and necessary for athletes to progress to higher levels of performance (Cunanan et al., 2018; Impellizzeri et al., 2019). However, if the balance between workload and readiness to perform (i.e., management of fatigue) is disturbed for prolonged time these periods might cause negative workload effect (Figure 1.5). Therefore, ***intensified periods*** (i.e., overloading in preparation;

competing in congested match schedules) and recovery (i.e., taper, transition, rest) must be interchanged within periodized training programs (Impellizzeri et al., 2019; Lyakh et al., 2016; Plews et al., 2017).

Fatigue	Increasing state of fatigue →			
Training	Continual intensified training with inappropriate recovery →			
Symptoms	Increasing severity of symptoms →			
Outcome	**Acute fatigue**	**Overreaching**		**Overtraining**
		Functional	**Nonfunctional**	
Recovery	Day(s)	Days → weeks	Weeks → months	Months → ?
Performance	Increase	Temporary decrease	Decrease or no change	Decrease

Figure 1.6. Overreaching and overtraining theoretical continuum (Figure adopted from Bompa & Buzzichelli, 2018; Cunanan et al., 2018; McGuigan, 2017; Meeusen et al., 2013)

Intensified periods are regularly used to elicit greater physiological (Fernandez-Fernandez, Sanz-Rivas, Sarabia, & Moya, 2015; Wahl et al., 2013; Wahl, Güldner, & Mester, 2014) and sport specific technical-tactical (Kalén, Pérez-Ferreirós, Rey, & Padrón-Cabo, 2017) adaptations. In fact, it was found that basketball players need to gain competitive experience from a few intensified tournaments with congested match schedule before they become able to perform well with their respective national team (Cuzzolin, 2020; Kalén et al., 2017). Aiming for ***intensified periods*** to elicit superior physiological adaptations, unloading periods can allow for supercompensation. Athletes who reduce their training load the most during the taper/recovery typically improve the most in performance (Bosquet, Montpetit, Arvisais, & Mujika, 2007). Additionally, a large body of evidence has emerged suggesting that inappropriately prescribed training load may increase injury risk (Bacon & Mauger, 2017; Bittencourt et al., 2016; Huxley, O'Connor, & Healey, 2014; Martínez-Silván, Díaz-Ocejo, & Murray, 2017).

Understanding training periodization and planning methodologies is a key to achieve optimal performance level. However, coaches should carefully consider intensified periods within annual periodization.

1.1.1. Intensified periods in basketball periodization

Basketball is one of the most popular team sports worldwide, with high participation among both genders competing in different age groups (Moreira, McGuigan, Arruda, Freitas, & Aoki, 2012; Spiteri et al., 2019). Basketball is intermittent, court-based team sport in which the outcome of the match is determined by a variety of performance indicators (Abdelkrim, El Fazaa, & El Ati, 2007; McInnes, Carlson, Jones, & McKenna, 1995). Indeed, the final match outcome depends on tactical (Courel-Ibáñez, McRobert, Toro, & Vélez, 2017; Sampaio et al., 2016), technical (Conte & Lukonaitienė, 2018; Maimón, Courel-Ibáñez, & Ruiz, 2020; Nunes et al., 2016) and physical (Montgomery, Pyne, & Minahan, 2010; Russell et al., 2020) performances of the match (Padulo et al., 2015). Moreover, psychological state of well-being is highly important for successful basketball player performance (Kiely, 2018). It is known, that during both training sessions and matches, the technical and tactical skills depend on physical performance level (Padulo et al., 2015). When considering any specific technical skill, a fatigue has negative effect on passing accuracy (Ahmed, 2013; Lyons, Al-Nakeeb, & Nevill, 2006) while free-throw accuracy is lowered at high intensities (Padulo et al., 2015). Therefore, training methods should imitate the real match demands, aiming to develop both sport-specific skills and improve physical fitness performance aiming to prepare fatigue-resilient successful basketball player (Smith, 2003; Ziv & Lidor, 2009).

During the match basketball players are exposed to repeated high intensity movements interspersed with periods of low to moderate intensity activity (Conte et al., 2015; Stojanovic et al., 2018; Taylor et al., 2020). Specifically, highly developed ***power capabilities*** in basketball are particularly important, because this sport includes high-intensity game elements, such as changes of direction, dribble, sprints, jumps, shots, passes, accelerations and decelerations (Abdelkrim et al., 2010; Conte et al., 2015; Scanlan, Wen, Tucker, & Dalbo, 2014). The external load of players per game consists of up to 1,000 different activity types (Conte, Tessitore, Smiley, Thomas, & Favero, 2016; Taylor, Wright, Dischiavi, Townsend, & Marmon, 2017), including 40 to 65 jumps, approximately 100 short sprints of 1.7 seconds every 20 seconds and around 60 changes of direction (Conte et al., 2016; Ostojic, Mazic, & Dikic, 2006). Average duration for different activities in both male and female basketball players during the match are presented in Figure 1.6. While the positional demands of a basketball player differ, specific physical capacities should be developed in order to meet sport demands (Pehar et al., 2017). Therefore, ***anaerobic performance*** is the most important actions for basketball players during the match (i.e. sprints, jumps etc.) (Figure 1.7) that must be incorporated into the basketball periodization programs. The most important biomotor abilities ***speed, power, and agility***, have been demonstrated to predict playing time in elite male college basketball players (Hoffman et al., 1996; Hoffman, 2020) as well as discriminate between the league standing of top and bottom teams (Gomez, Lorenzo, Sampaio, Ibanez, & Ortega, 2008). Therefore, basketball practitioner and players should concentrate on enhancing and maintaining these fitness components (Pliauga et al., 2018; Ronda & Cuzzolin, 2020).

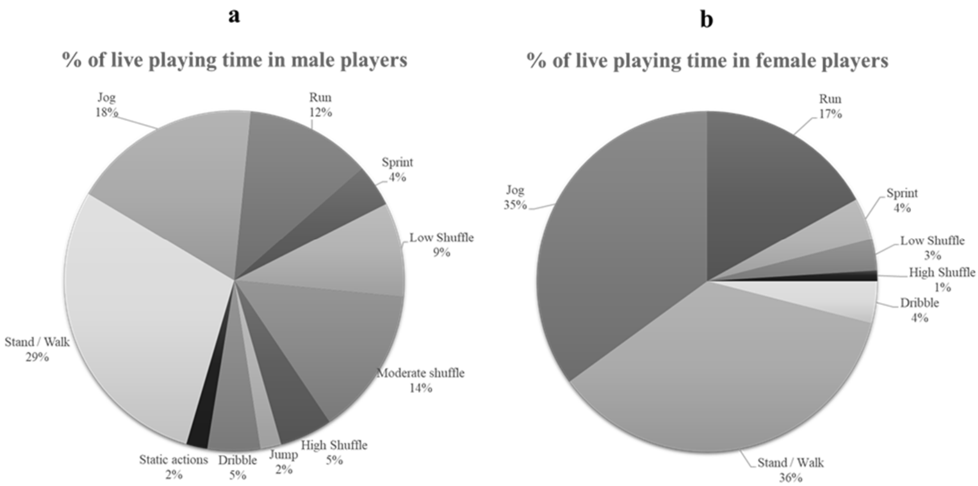


Figure 1.7. Average activity duration (%) for various types of activities in male (a) and female (b) players during total game in basketball (Figure adapted from Milanović, Stojanović, & Scanlan, 2020; Stojanović et al., 2018)

Most of the match time basketball players spend standing, walking or running slowly (Figure 1.6). Basketball cover a distance from 4.4 to 7.5 km per match, with mean HR ranging from 87.0 % to 94.4 % of HR peak for these reasons they do need to have good ***aerobic capacity*** (Abdelkrim et al., 2010; Delextrat, Hippocrate, Leddington-Wright, & Clarke, 2014; Montgomery et al., 2010; Narazaki, Berg, Stergiou, & Chen, 2009; Puente, Abián-Vicén, Areces, López, & Del Coso, 2017; Stojanovic et al., 2018). Moreover, aerobic capacity is strongly correlated with high-intensity running during matches, and has been identified as one of the determinants of repeated sprint ability (Abdelkrim et al., 2010; Castagna, Impellizzeri, Rampinini, D'Ottavio, & Manzi, 2007). Aerobic capacity is considered to improve the ability to recovery from the anaerobic efforts during the game (Tomlin & Wenger, 2001). The reported values of maximal oxygen consumption of male basketball players range from 49.8 mL/kg/min to 63.4 mL/kg/min (Abdelkrim et al., 2010; Boone & Bourgois, 2013; Cormery, Marcil, & Bouvard, 2008; Narazaki et al., 2009; Ostojic et al., 2006) while for female players range from 41.4 mL/kg/min to 54.1 mL/kg/min (Häkkinen, 1993; Hosseini, Hamid, & Karimi, 2017). Players with greater level of physical fitness are likely to perform a higher workload without inducing higher stress levels (Valvassori, Aoki, Conte, Drago, & Moreira, 2020). Despite the required aerobic capacity during the match, previous studies have suggested that aerobic capacity does not stand as a predictor of playing time nore performance during elite male basketball match (Hoffman, Tenenbaum, Maresh, & Kraemer, 1996; Hoffman, 2020). In contrast, aerobic capacity has been suggested to be associated with basketball performance in female (Apostolidis, Nassis, Bolatoglou, & Geladas, 2004; Hoffman, 2020; Riezebos, Paterson, Hall, & Yuhasz, 1983).

Successful basketball players, independent on their gender, undergo a complex training process due to the variety of performance components required. Therefore, the volume of concurrent training and extended competitive season as well as congested match schedules poses challenges for periodized training programs (Gamble, 2006). Typically, three main phases of periodized programs are planned in basketball: pre-season, in-season and off-season (Bompa & Buzzichelli, 2018; Schelling & Torres-Ronda, 2013) (Table 1.1). An example of annual basketball conditioning was proposed by Schelling and Torres-Ronda (2013) suggests that the generic aerobic power (level I) should be developed during off-season or in early pre-season (Table 1.1). Authors then suggest improving the ability to repeat high-intensity actions (level II and III) combining small sided games (SSG) or actual basketball game (levels IV and V) in pre-season aiming to prepare the players for the high demands of the competition (Shelling & Torres-Ronda, 2013) (Table 1.1). Following the preparation phase, during the competitive season, specific skill-based conditioning and SSG should predominate (levels IV and V), however, sessions based on level II or level III should be performed occasionally (i.e., once a week or every 2–3 weeks) (Schelling & Torres-Ronda, 2013) (Table 1.1). This proposed periodization model clearly guides the coaching staff on how and when to shift the training workload typology throughout the season.

Table 1.1. Annual basketball periodization for conditioning
(adapted from Shelling & Torres-Ronda, 2013)

	Phase			
	Off-season		Preseason	In-season
Duration	1–4 wk	2 wk to 5 mo	4–8 wk	6–9 mo
Kind of workouts	–	Individual workouts	Individual and/or team workouts	Individual and team workouts
Main goal	Rest / recovery	Individual needs and aerobic power	Aerobic power and ability to repeat high-intensity efforts	Skill-based conditioning and small-sided games
Secondary goal	–	Ability to repeat high-intensity efforts	Small-sided games and actual basketball	Ability to repeat high-intensity efforts
Levels	0	0^+ and I	I, II and III	IV and V
		II	IV and V	II and III

The most common pre-season preparation strategies adopted in basketball are traditional periodization and block periodization (Pliauga et al., 2018). In TP macrocycles and mesocycles are arranged for transition from high-volume and low-intensity workloads to high-intensity and low-volume workloads with the simultaneous development of many fitness components (e.g., aerobic capacity, strength, power) within a regular workload distribution (Matveev, 1965). In contrast, BP is characterized by concentrated training stimuli focused on specific aspects of fitness or performance components (Bondarchuk, 1988; Issurin, 2008). Recent study, comparing the effect of TP and BP periodization models on athletic performance in basketball showed that BP is more effective in improving vertical jumping performance in male basketball players (Pliauga et al., 2018). Indeed, this study showed that BP training approaches with a proper balance between training and recovery should be used by basketball coaches and practitioners to enhance jumping performance in players (Pliauga et al., 2018).

Examples discussed above gives clear guidelines how periodization of the workload throughout the basketball season and pre-season specifically should be done (Pliauga et al., 2018; Shelling & Torres-Ronda, 2013). However, it is difficult to make informed decision if the basketball players are also involved in their national teams preparation and international competitions which are usually held during the summer time, which in basketball periodization, traditionally represents a period of transition and rest after the regular club season (Bompa & Buzzichelli, 2018; Shelling & Torres-Ronda, 2013) (Table 1.1). Indeed, the current body of literature mainly focused on the comparison of the workload experienced due to different periodization strategies during preparation periods (i.e., preseason phase lasting 5–7 weeks) in male, club, adult players (Ferioli et al., 2018a, b; Pliauga et al., 2018), typically interchanging of overload and taper (i.e., recovery) periods (Bompa & Buzzichelli, 2018; Pliauga et al., 2018). In a previous study by Nunes et al. (2014), the Brazilian female national basketball team was monitored for a 12-week preparation period characterized by 2 overload and taper periods in preparation for an international tournament. Results revealed that this periodization approach induced an enhancement in strength, power, agility and endurance thanks to an adequate workload distribution (Nunes et al., 2014).

The discussed manipulation of overload and taper periods might result more difficult in shorter preparation periods. Indeed, players preparing for international tournaments during off-season phase need to optimize their physical and basketball specific performance components in short period of time (Cuzzolin, 2020) while preventing reduction of these adaptations prior to competition (Halson, 2014; Impellizzeri et al., 2019). Intensive, camp-based training has been associated with very high-injury incidence (Drew et al., 2015, 2016). Moreover, players are coming from different clubs and coaches which possibly means, that the level of readiness to play are also affected by their previous experiences (Lyakh et al., 2016; MacKnight & Sridhar, 2020). Taking these factors into account, Cuzzolin (2020) suggests considering the following factors, when planning the periodized programs for national basketball teams (an example of EC in brackets): a) amount and density of games already planned for the competition; b) length of the competition; c) how much time and the number of practices that can be used before the beginning of the competition; d) players' trainability (i.e., readiness to perform); e) team history; player's experience with each other, experience of the coaching staff, and team's experience in the competition.

Ideally, following the preparation periods peak performance should be achieved and maintained during the periods of competitions (Cunanan et al., 2018). Following demanding intensified preparation periods, basketball players are exposed to intensified competition periods like congested match schedule during international tournament or in-season. Understanding the workload imposed during both intensified preparations and matches across congested schedules seems fundamental for basketball coaches and practitioners to optimally adjust the prescribed workloads given to players during these congested weeks (Clemente et al., 2019; Conte et al., 2018). Indeed, it is the most challenging task to maintain peak match-to-match readiness to perform during intensified congested match schedules (Fox et al., 2020; Klusemann et al., 2013; Pino-Ortega et al., 2019). Previous investigations have presented decrements in external (i.e., game stimuli imposed) and internal (i.e., the physiological or perceptual reactions to the imposed stimuli) workload across games played in close succession (Fox et al., 2020; Klusemann et al., 2013; Pino-Ortega et al., 2019). Analysis of players' individual workload changes during 1-to-3 games played on close succession during the in-season phase revealed trivial-to-small differences in external and internal load (Fox et al., 2020). It was also found that intensified basketball tournament of 3 day play elicited small to moderate impairments in physical test performance (Montgomery et al., 2008). Therefore, the periodization of workload throughout the year, including preparation, competition and recovery should be planed carefully placing special attention to ***intensified periods in basketball*** *(i.e., preparation, congested match schedules).*

Basketball training requires understanding of the demands of the game and methodological approach is essential for combining all subcomponents of the basketball training program to prepare players for demanding matches throughout the annual periodization of the whole season (Pliauga et al., 2018; Shelling & Torres-Ronda, 2013). Specifically, taking into the account the complexity of basketball players performance it is of a great importance to obtain information how to prepare national team players during short duration preparation periods for instance. 3-week while obtaining optimal match-to match readiness to play during different intensified competition periods. Moreover, the systematic monitoring of the physiological and psychological variables related to performance, enables practitioners to manage and control training process imposed (Edwards et al., 2018; Impellizzeri et al., 2019; McGuigan, 2017; Russell et al., 2020) while ensuring overall athlete health. The problem or better phrase it as an open question is "HOW to control, manage and individualize intensified periods in basketball".

1.2. Monitoring workload

Monitoring has become an integral component of a total athlete preparation (Foster, Rodriguez-Marroyo, & Koning, 2017; Impellizzeri et al., 2019; McGuigan, 2017; Russell et al., 2020; West et al., 2020). Specifically, monitoring the workload is crucial in order to understand the training process as exercise is a stressor that induces various psychophysiological responses, which mediate cellular adaptations in many organ systems (Impellizzeri et al., 2019; Viru, Viru, & Bosco, 2003). ***Workload*** can be defined as "the cumulative amount of stress placed on an individual from multiple sessions and games over a period of time" (Gabbett et al., 2014). The athlete's response to the stimulus and the stimulus itself is specific to the nature, intensity, and duration of the exercise task (Halson, 2014; Viru et al., 2003). To obtain specific performance adaptations, training needs to target the systems that determine performance (Figure 1.8) (Impeellizzeri et al., 2019). Athlete workloads are typically expressed using external and internal metrics (Edwards et al., 2018; Fox et al., 2020; Impellizzeri et al., 2019; McGuigan, 2017; Russel et al., 2020). ***External workload*** reflects the training and competition stimuli imposed, while ***internal workload*** reflects the actual load physiological or perceptual responses that the body initiates to cope with the requirements elicited by the external workload (Fox et al., 2017, 2018; Gabbett, 2020; Impellizzeri et al., 2019).

The relationship between training doses (e.g., external workload) and the individual responses to it (e.g., internal workload) largely determines the adaptation and performance-related outcomes to the training program as the training sessions accumulate over time (Akubat, Barrett, & Abt, 2014; Halson, 2014; McGuigan, 2017). In the theoretical framework of the training process (Figure 1.8) it is proposed that monitoring both external and internal workload enables coaches and scientists to better control and optimize the training process aiming to improve player performance and/or manage injury risk (Brorsson, Jónsdóttir, & Karlsson, 2020; Impellizzeri et al., 2019; McGuigan, 2017; West et al., 2020).

Figure 1.8. Theoretical framework of the training process
(Figure adopted from Impellizzeri et al., 2019)

Currently the tools available to monitor athletes evolve with new technologies (e.g., microsensors, smartphone apps, portable biochemical analysis devices) being introduced and developed (Edwards et al., 2018; Fox et al., 2017; Russell et al., 2020). However, the availability of excess variety of methods and technologies for monitoring makes it challenging to understand and create an optimal monitoring strategy (Russell et al., 2020; West et al., 2020). In Table 1.2, the overview of existing monitoring tools in basketball is presented (Scanlan, Fox, Conte, & Milanović, 2020). Monitoring systems should be intuitive, provide efficient data analysis and interpretation, and enable efficient reporting of simple, yet scientifically valid, feedback (Halson, 2014; Russell et al., 2020; West et al., 2020). Moreover, during training or competition periods it is important to implement monitoring tools that are minimally invasive and not time consuming (McGuigan, 2017). Therefore, the most used methods to monitor workload in competitive basketball are microsensors based objective external load (Berkelmans et al., 2018; Fox et al., 2017; Svilar, Castellano, & Jukic, 2018), heart-rate based objective internal load (Berkelmans et al., 2018; Daniel, Montagner, Padovani, & Borin, 2017; Gavaldà, Ródenas, Colás, & Soler, 2018; Manzi et al., 2010; Montgomery & Maloney, 2018; Sansone et al., 2018; Scanlan et al., 2018) and questionnaires based on subjective internal load (Aoki et al., 2017; Conte et al., 2015; Moraes et al., 2017; Moreira et al., 2018; Svilar et al., 2018; Vaquera et al., 2018).

Table 1.2. A comparison of common workload metrics in basketball (adapted from Scanlan et al., 2020)

	Non-invasive to players?	Valid?	Reliable?	Hardware cost	Software cost	Data processing time	Ease of interpretation
External workload							
Time–motion analysis	✓	✓	✓	$$–$$$	$–$$$	🕐🕐🕐	✓✓✓
Accelerometers	✓	✓	✓	$$–$$$	$$–$$$	🕐🕐	✓
Inertial sensors	✓	-	✓	$$–$$$	$$–$$$	🕐🕐	✓✓
Local positioning systems	✓	-	-	$$$	$$–$$$	🕐🕐	✓✓✓
Internal workload							
Heart rate	✓	✓	✓	$–$$	$–$$	🕐	✓✓
Banister's training impulse	✓	✓	✓	$–$$	$	🕐	✓
Lucia's training impulse	✗	✓	✓	$–$$$	$–$$	🕐🕐	✓
SHRZ	✓	✓	✓	$–$$	$–$$	🕐	✓
sRPE	✓	✓	✓	$	$	🕐	✓

Note: "–" indicates that validity/reliability has not been assessed; reliable is defined as coefficient of variation ≤ % (moderate); hardware cost, software cost, data processing time, and ease of interpretation on a 1–3 scale with 1 indicating the lowest rating and 3 indicating the highest rating; SHRZ Summated-Heart-Rate-Zones, sRPE session rating of perceived exertion.

1.2.1. External workload in basketball

The physical demands of basketball expressed as the external workload may help to inform physical preparation process leading to optimized performance throughout the periodized programs (Nunes et al., 2014; Russel et al., 2020; Shelling et al., 2013). A standard international level basketball court is 28 meters long and 15 meters wide covering 420 m^2, therefore athletes travel significant distances while competing (Taylor et al., 2017). Moreover, basketball match-play is administered across 4 by 10-minute duration quarters in FIBA and 4 by 12-minute duration quarters in NBA (Cuzzolin, 2020; Taylor, 2020). The main positions in basketball are forward, guard and center players (Puente et al., 2017; Taylor, 2020). Although position-specific variations in game tasks exist, all players experience extensive intermittent activity during training and match-play, performing high-intensity movements interspersed throughout low-intensity activity (Conte et al., 2015; Puente et al., 2017; Scanlan et al., 2014). In addition, the injury risk increases when the workload applied is higher than the capacity of the player (Brorsson et al., 2020), therefore monitoring these demands is necessary.

External load can be measured using variety of different parameters like duration, weight lifted, distance covered, number of sprints and jumps (McGuigan, 2017; Schwellnus et al., 2016; Soligard et al., 2016). However, some of these measures might be difficult to implement in basketball specific activities (McGuigan, 2017). In this regard, the video-based **time-motion analysis** was extensively used previously (Arede, Ferreira, Esteves, Gonzalo-Skok, & Leite, 2020; Conte, Favero, Niederhausen, Capranica, & Tessitore, 2017; Klusemann et al., 2013; McCormick et al., 2012). However, using this method to obtain information takes a lot of time (Table 1.2), therefore it is not very convenient to use on a daily basis (Scanlan et al., 2020). The recent development of more sophisticated wearable technology allows for increasingly detailed information about external load (Russell et al., 2020; Scanlan et al., 2020). For example, the use of local positioning systems (LPS) inside together with accelerometers and gyroscopes, it is now relatively simple to quantify accelerations, decelerations, speed, and power during both sessions and matches (Russel et al., 2020; Scanlan et al., 2020) (Table 1.2). The most frequently analyzed variables include straight-line running (distance, speeds, frequencies), non-sagittal plane movements (lateral movement demands, accelerations, decelerations), and vertical demands (jump frequency, height) which together represent PlayerLoad

(PL) (Scanlan et al., 2020; Taylor et al., 2017). These methods are accurate and provide real time information (Fox et al., 2018), which overcomes previously mentioned time-motion analysis disadvantages and helps coaches to make informed decisions timely (Edwards et al., 2018; McGuigan, 2017; Scanlan et al., 2020).

The wearable technology seems to be optimal to use, however it is very expensive and typically requires skilled practitioners to interpret and apply the information (Gabbett, 2020; Scanlan et al., 2020). Practitioners without access to this type of technology should register what players do in the training session (e.g., sets, repetitions, load, number of intervals, distance, time, length and number of recovery periods) (McGuigan, 2017). However, these measures do not provide information on how the athlete is responding to the training load. This is why measures of internal load are also important to monitor (Russel et al., 2020).

1.2.2. Internal workload

The internal workload experienced from a specific external workload may vary depending on specific contextual factors either between or within athletes (Figure 1.8) (Bouchard, Rankinen, & Timmons, 2011; Impellizzeri et al., 2019; Kiely, 2018; Mann, Lamberts, & Lambert, 2014; Matthew & Delextrat, 2009; Rodriguez-Alonso, Fernandez-Garcia, Perez-Landaluce, & Terrados, 2003; Smith, 2003). Even if external workload can be planned in advance to each session (Arede, Vaz, Franceschi, Gonzalo-Skok, & Leite, 2018; Pliauga et al., 2018; Schelling et al., 2013) it is difficult to precisely estimate the individual's actual internal load prior to exercise (Edwards, 2018; Impellizzeri et al., 2019; Kiely, 2018). Both external and especially internal workloads are specifically difficult to plan in advance during exercise bouts in basketball that are characterized by spontaneous activities such as small sided games, basketball specific drills or the actual match play (Conte et al., 2016; O'Grady, Fox, Dalbo, & Scanlan, 2020; Moreira et al., 2012; Sansone et al., 2019; Stojanovic et al., 2019). Due to these factors, it is recommended to incorporate internal together with external workload monitoring tools so that the intended psychophysiological response would be achieved (Impellizzeri et al., 2019; Scanlan et al., 2014; Svilar et al., 2018). Moreover, measures of internal workload derived from perceived exertion and heart rate show consistently positive associations with accelerometer-derived external loads and intensity during team-sport training and competition (McLaren et al., 2018) especially in basketball (Scanlan et al., 2014; Svilar et al., 2018). Although significant relationships were found between internal and external workloads it is still suggested that these methods measure different constructs of the training process in basketball, therefore should be used in combination to obtain full picture of the athlete's workload experienced (Scanlan et al., 2014; Svilar et al., 2018).

Objective internal workload is most frequently quantified using ***heart rate (HR)*** monitoring (Edwards, 2018; McGuigan, 2017; Milanovic et al., 2020; Russell et al., 2020; Sansone et al., 2019) (Table 1.3). HR monitors indicate the frequency of electrical heart activity (Alexandre et al., 2012) and this method is non-invasive and efficient in terms of data processing using proprietary software or customised spreadsheets (Fox et al., 2017). These measurements of player HR responses can serve multiple purposes including training prescription, identifying adaptations in fitness and detecting signs of nonfunctional overreaching (Edwards et al., 2018; Vaquera et al., 2008). Previous literature supports HR as a measure of exercise intensity as a valid (Leger & Thivierge, 1988; Terbizan, Dolezal, & Albano, 2002) and reliable (Leger & Thivierge, 1988; Schönfelder, Hinterseher, Peter, & Spitzenpfeil, 2011) tool. Moreover, linear relationship between HR and oxygen uptake ($\dot{V}O_2$) was established (Achten & Jeukendrup, 2003). Later, HR monitors can provide insight regarding oxidative metabolic recruitment during exercise (Berkelmans et al., 2018; Denadai, Gomide, & Greco, 2005).

The application of HR monitoring during basketball matches provides information for coaches about intensities experienced by players which later can be used to develop the precise training approaches in order to meet the match demands (Abdelkrim et al., 2007; Berkelmans et al., 2018; McInnes et al., 1995) or to make tactical decision. For instance, substitution or time-out call when player is working at maximum intensity for prolonged period of time (Scanlan et al., 2015). It was previously found that the greatest proportion of the playing time during basketball match (~75 %) players, independently on gender, are performing activities which elicit their HR ≥85 % of HRmax (Milanovic et al., 2020; Stojanovic et al., 2018). Average HR varies between 132 and 165 beats/min during total game time and between 161 and 186 beats/min during live game time in male and female basketball players (Stojanovic et al., 2018). Substitutions, deliberate fouling and timeouts may be effectively used to increase stoppage time in the later key stages of games for the maintenance of high-intensity activities (Milanovic et al., 2020). The HR differ between players as HR responses to external workload are affected by various factors such as performance level or the players, match-related factors (i.e., team tactics, position, game intensity, playing time and etc.) (Stojanovic et al., 2018; Vencúrik et al., 2014). Afforementioned in Figure 1.8, internal load might also be exaggerated by indirect factors such as health, nutrition, genetics, psychological state of players and other individual factors etc. (Bouchard et al., 2011; Impellizzeri et al., 2019; Mann et al., 2014; Rodriguez-Alonso et al., 2003; Smith, 2003).

Even a simple analysis of HR is minimally invasive, valid and reliable, heart rate reported simply as beats/min, or %HRmax may underestimate the intensity of the training session or match in basketball (Narazaki et al., 2009). Indeed, the HR-based models are more frequently used in basketball to easen the interpretation (Table 1) (Manzi et al., 2010; Nunes et al., 2014; Sansone et al., 2019; Scanlan, Fox, Borges, Dascombe, & Dalbo, 2017; Scanlan et al., 2014, 2020). In recent systematic review by Berkelmans et al. (2018) 3 most common approaches of HR based internal workload in basketball settings were identified: a) Banister's Training Impulse (TRIMP) (Manzi et al., 2010; Scanlan et al., 2014, 2017), b) Lucia's TRIMP (Scanlan et al., 2017), and c) Edwards' Summated-Heart-Rate-Zones (SHRZ) (Manzi et al., 2010; Scanlan et al., 2014, 2017) (Table 1.3). Banister's TRIMP uses mean HR (Aoki et al., 2017; Banister, Macdougall, & Wenger, 1991; Heishman et al., 2018; Scanlan et al., 2014), while in Lucia's TRIMP (Lucía, Hoyos, Pérez Ruiz, & López Chicharro, 2000) and Edwards SHRZ (Edwards, Edwards, Edwards, & Edwards, 1993) the HR responses are divided into intensity zones, with each zone arbitrarily weighted for calculating internal workload in accordance to different metabolic cost in lower or and higher intensities (Edwards et al., 1993; Lucía, Hoyos, Santalla, Earnest, & Chicharro, 2003; Russell et al., 2020; Stagno, Thatcher, & Van Someren, 2007). These HR-based workload models provide practical and efficient data collection and processing procedures thus provides internal workload values, which capture the responses of players to the external workload imposed (Scanlan et al., 2020).

Table 1.3. Heart rate based objective internal workload monitoring models

Banister's TRIMP (AU) = D × (Δ heart rate ratio) × $e^{b(\Delta \text{ heart rate ratio})}$	where D is session duration (min), b is the sex factor (1.67 for females and 1.92 for males); e = base of the natural logarithm (constant of 2.712); ΔHR ratio = (HRex − HRrest) / (HRmax − HRrest), with HRex indicating mean HR during the training session, HRrest indicating HR measured during pre-exercise rest, and HRmax indicating maximal HR achieved during a maximal exercise test
Lucia's TRIMP (AU) = (D in zone 1 × 1) + (D in zone 2 × 2) + (D in zone 3 3 × 3)	where D is session duration (min), zone 1 = HR corresponding with blood lactate < 2.5 $mmol \cdot L^{-1}$; zone 2 = HR corresponding with blood lactate between 2.5 $mmol \cdot L^{-1}$ and 4.0 $mmol \cdot L^{-1}$; zone 3 = HR corresponding with blood lactate > 4 $mmol \cdot L^{-1}$
Edwards' SHRZ (AU) = (D in zone 1 × 1) + (D in zone 2 × 2) + (D in zone 3 3 × 3) + (D in zone 4 × 4) + (D in zone 5 × 5)	where D is session duration (min), zone 1 = 50–59 %HRmax; zone 2 = 60–69 %HRmax; zone 3 = 70–79 %HRmax; zone 4 = 80–89 %HRmax; zone 5 = 90–100 %HRmax

Subjective internal workload in basketball is typically assessed via the ***session rating of perceived exertion (sRPE)*** method (Conte et al., 2018; Paulauskas et al., 2019; Scanlan et al., 2020). Perception of effort is defined as "the conscious sensation of how hard, heavy, and strenuous a physical task is" (Marcora, 2010). This method is low cost, valid and reliable to quantify subjective internal workload (Table 1.2) (Brosson, 2020; Ferioli et al., 2018; Foster, 1998; Foster et al., 2001; Gabbett, 2020; Scanlan et al., 2020; Scott, Black, Quinn, & Coutts, 2013; Sweet, Foster, McGuigan, & Brice, 2004). Even though, this method is assigned to internal workload, it is calculated from both external metric (session duration) and subjective metric using self-reported rating of perceived exertion, commonly using the 0–10 Category Ratio scale (Borg et al., 1998; Foster et al., 2001; Scanlan et al., 2020). About 15–30 min after the training session or match, the players are asked: "How was your training?" and the individual answers using a numerical score between 1 and 10 according to the RPE scale. This score is then multiplied by the session duration to calculate the workload, which serves the understanding whether the workload is getting too high with regard to the exercises performed (Turner, Bishop, Marshall, & Read, 2015).

In contrast to the objective measures discussed above which measure physiological responses to exercise, sRPE is more sensitive to a range of different stimuli including external and internal workloads, as well as psychological inputs such as stress, arousal and fatigue (Impelizzeri et al., 2019) (Figure 1.8). Due to complex nature of sRPE, using only this method might be challenging for basketball coaches to differentiate between physiological and psychological factors influencing player workloads (Fox et al., 2017). Therefore, a combination of external workload metrics, as well as objective and subjective internal workload metrics, is recommended to attain a complete picture of training and game demands in basketball (Bourdon et al., 2017; McGuigan, 2017; Scanlan et al., 2020) (Table 1.2).

Even with a lot of new information informing practitioner on HOW to select the most appropriate workload monitoring strategy in basketball, it is still unclear which methods would help to make informed decisions during intensified periods in basketball. Moreover, how much workload is optimal for players during these periods would help practitioners to improve their planning of training programs within periodized seasons.

1.3. Monitoring readiness to perform in basketball

How the player ultimately performs is the result of the accumulation of individual workloads. Thus, a key purpose of monitoring is not only to assess the workload, but also to evaluate the stress response to individual training sessions, which would identify ***the readiness to perform***. Together with external and internal workload measures the readiness to perform monitoring tools should be used, since only workload data would not lead to informed decisions of how players are adapting to applied stressors (Coutts & Cormack, 2014; Cuzzolin, 2020; Gabbet, 2020). Systematic monitoring of the physiological and psychological variables related to performance, enables practitioners to manage and control training process imposed (Edwards et al., 2018; Impellizzere et al., 2019; McGuigan, 2017). The efficiency of training and competition depends on the workload as well as on the player's ability to tolerate it, and imbalance between the two may lead to non-functional overreaching, overtraining or injuries (Eliakim & Nemet, 2020). As for the workload, readiness to perform should be measured using various approaches, since no single metric can clearly state the risk of injury or state of preparedness (Bittencourt et al., 2016; West et al., 2020).

Several objectives (i.e., heart rate indices (Nakamura et al., 2017)) and biochemical markers (Pliauga et al., 2015; Valvassori et al., 2020) and subjective (i.e., self-reported exertion and wellness measures (Clemente et al., 2019; Conte et al., 2018) monitoring tools have been implemented in combination to assess player readiness to perform in basketball. Indeed, subjective well-being (WB) questionnaires and objective HR variability (HRV) measures of athlete's readiness are easy-to-use and widely applied tools to understand whether athletes are effectively coping with external demands (Edwards et al., 2018; Fox et al., 2017; McGuigan, 2017; Thorpe, Atkinson, Drust, & Gregson, 2017). Moreover, performance testing is fundamental aiming to evaluate the players progress in response to specific training program (McGuigan, 2017; Nunes et al., 2014; Pliauga et al., 2018).

The accumulation of stress accompanied by insufficient regeneration is one of the main causes of overtraining (Weiss et al., 2017). Stress-recovery balance and proper periodization of loading leads to best results in sports preparation. Previous research demonstrated that basketball players require ~48 hours of rest to maximize performance after highly demanding activities involving intense eccentric basketball activity (Chatzinikolaou et al., 2014). In fact, previous investigations support a proper balance between training and recovery as fundamental process to optimize basketball performance (Moreno, Ramos-Castro, Rodas, Tarragó, & Capdevila, 2015; Nunes et al., 2014). Therefore, the readiness to perform during different types of congested match schedules (2 matches without 24 hours rest in in-season phase and 7 matches in 9 days during European Championship) when suggested recovery time is not applied is of great importance. The use of different recovery strategies depends on the type of activity performed and the time until the next training session or event (Huyghe, Calleja-Gonzalez, & Terrados, 2020).

1.3.1. Heart rate variability (HRV)

HR variability (HRV) method is an effective, safe, easy to apply and use for both athletes and coaches to monitor and improve sport performance while detecting changes in autonomic nervous system in response to exercise (Acharya, Joseph, Kannathal, Lim, & Suri, 2006; Dong, 2016; Makivić, Nikić Djordjević, & Willis, 2013; Morgan & Mora, 2017; Nakamura et al., 2017). This measurement shows the variation of the duration between each heart beat over time (Acharya et al., 2006; Dong, 2016) and is a relevant marker reflecting cardiac health and the state of the autonomic nervous system responsible for regulating cardiac activity (Acharya et al., 2006; Dong, 2016). HRV reflects the heart's ability to adapt to changing circumstances by detecting and quickly responding to unpredictable stimulus (Acharya et al., 2006). The normal HRV is due to autonomic neural regulation of the heart and the circulatory system (Saul, 1990). The balance between sympathetic and parasympathetic nervous systems branches of autonomic nervous system controls the HR (Acharya et al., 2006). For example, cardio-acceleration is the result of increased sympathetic nervous system or diminished parasympathetic nervous system activity (Acharya et al., 2006). Conversely, a low sympathetic nervous system activity or high parasympathetic nervous system activity causes cardio-deceleration (Acharya et al., 2006).

To determine and assess the HRV in athletes mobile phone apps were found to be reliable and easy to use (Esco, Williford, Flatt, Freeborn, & Nakamura, 2018; Holmes et al., 2020; Nakamura et al., 2017; Perrotta, Jeklin, Hives, Meanwell, & Warburton, 2017; Plews et al., 2017). One of the most commonly used parameter in sports science is the square root of the mean sum of squared differences between adjacent normal RR intervals (rMMSD) and natural logarithm of the rMMSD (Ln_rMMSD) (Esco et al., 2018; Plews, Laursen, Kilding, & Buchheit, 2013). Parameter of rMSSD has been proved to be time efficient, since provides accurate measures when recorded in segments of only 1 vs. 5 min (Esco & Flatt, 2014; Flatt & Esco, 2016). Furthermore, it appears to be less influenced by breathing rate, and can be calculated and interpreted with greater ease (Buchheit, 2014). It is because of these features that rMSSD has been utilized by a number of authors for monitoring athletic responses to training (Nakamura et al., 2017; Peterson, 2018; Plews et al., 2013).

In fact, Ln_rMSSD parameter was used as a predictor of the optimal performance for elite sprinters in track and field (Peterson, 2018). It was found that Ln_rMSSD of 4.5 ms predicted best shape for optimal performance (Peterson, 2018). In contrast, lowered values for Ln_rMSSD is an indication of the sympathetic system being in change for heart response, which shows, that athletes are not tolerating the workload imposed (Buchheit, 2014). A study by Buchheit (2015) investigated the usefulness of monthly HRV assessment in professional handball players, which turned to be not sensitive enough to predict changes in physical performance. Instead, in another study it was suggested to use 7-day rolling average to overcome limitations associated with making assumptions based on a single day HRV values (Plews, Laursen, Kilding, & Buchheit, 2012). An increase in chronic HRV is associated with the positive response to training, while decreased HRV indicates a negative response (Plews et al., 2013). Aiming to interpret the data of HRV it is of a great important to establish a baseline of typical values for individual athletes, moreover the conditions for assessing HRV must be standardized (Holmes et al., 2020; Nakamura et al., 2017; Perrotta et al., 2017).

1.3.2. Well-being

Recent surveys on fatigue monitoring in high-performance sport demonstrate that athlete self-report measures are used extensively for assessing the overall well-being of team-sport athletes (McGuigan, 2017; Saw, Main, & Gastin, 2016; Taylor et al., 2012). Indeed, these questionnaires are easy to use and are minimally invasive and time efficient (Edwards et al., 2018; McGuigan, 2017; Thorpe et al., 2017). One of the most popular wellness questionnaires in basketball is well-being questionnaire assessing fatigue, sleep quality, stress, mood, and muscle soreness using a five-point Likert scale (scores of 1 to 5) and the sum of scores across questions indicates well-being status (Conte et al., 2018; Halson, 2014; Sansone et al., 2019). This approach offers a useful method to monitor the players physical and emotional responses to a given workload (Halson, 2014). Using well-being questionnaire together with workload assessment seems to be a sensitive tool to identify the readiness to perform. Indeed, Conte et al. (2018) found, that weekly workload changes results in increased well-being after reduced workload periods.

1.3.3. Performance testing

Basketball coaches and sport scientists often use a battery of sport-specific physical tests to evaluate player's physical performance (Drinkwater, Pyne, & McKenna, 2008; Valvassori et al., 2020). By identifying key physical determinants of performance, it is possible to track player's individual changes to different training plans within periodized programs (Drinkwater et al., 2008). To date, a wide range of tests are available for coaches to construct the performance testing sessions including sprinting, jumping, agility testing (Nunes et al., 2014; Pliauga et al., 2018; Scanlan et al., 2018; Spiteri et al., 2014; Wen, Dalbo, Burgos, Pyne, & Scanlan, 2018), followed by aerobic fitness evaluation (Montgomery et al., 2008; Shelling & Torres-Ronda, 2013; Valvassori et al., 2020). Power performance in basketball players is most often assessed via a vertical jump tests (Pehar et al., 2017; Pliauga et al., 2018). It has been demonstrated that vertical jump performance can differentiate between starters and nonstarters in NBA players (Gonzalez et al., 2013) and NCAA Division I women (Gonzalez, Hoffman, Scallin-Perez, Stout, & Fragala, 2012), and between different levels of play (Köklü, Alemdaroğlu, Koçak, Erol, & Fındıkoğlu, 2011;

Spiteri et al., 2019). The countermovement jump (CMJ) is a commonly used neuromuscular performance test which can serve as an indication of both recovery and changes in performance throughout the basketball season (Huyghe et al., 2020; McGuigan, 2017; Pliauga et al., 2018). Alternatively, a 10-m sprint test may also be used where baseline values have been recorded 48 hours after simulated basketball games (Pliauga et al., 2018). Moreover, it was previously found that physical fitness level tested by Yo-Yo intermittent recovery test level 1 (YYIR1) may play a role on mucosal immunity responses from short-term training stress in youth basketball players (Valvassori et al., 2020). However, despite the value behind performance tests, players may return to baseline performance levels while still not being fully recovered (Huyghe et al., 2020). Therefore, performance tests should be analyzed alongside other readiness to perform parameters such as HRV and well-being questionnaires (McGuigan, 2017).

2. METHODS AND MATERIALS

2.1. Participants

A total of sixty-two basketball players participated in the studies. General descriptive parameters are presented in Table 2.1. Both female and male basketball players were involved in the studies. All players were informed about the study aims and procedures and provided personal and guardian (if younger than 18-year-old) written informed consent. Ethics approval was granted from the Kaunas Regional Ethical Committee Review Board in accordance with the ethical standards of the Helsinki Declaration, approval number BE-2-97.

For **the first study**, twenty-eight female basketball players competing in the national Lithuanian female Under18 and Under20 teams were recruited. From the initial sample, 24 female players were investigated since four players (two per team) did not complete the entire preparation period prior to European Championship (Table 2.1).

For **the second study**, twenty-four female basketball players were recruited. From the initial sample, 21 players were investigated since one player competed in both teams and two players failed to complete full data collection (Table 2.1).

For **the third study**, ten male basketball players competing in the second-tier Lithuanian league [Nacionalinė krepšinio lyga (NKL)] were selected for this study. Only players participating in all games and playing ± 10 min per game (average time = 22.8 ± 8.0 min) and not reporting injuries during the investigated period were involved in the study (Ferioli et al., 2020b). Therefore, seven players met the inclusion criteria (Table 2.1).

Table 2.1. Characteristics of the participants

Study	Participants (n)	Characteristics
1. Investigating the workload, readiness and physical performance changes during intensified 3-week preparation periods in female national Under18 and Under20 basketball teams	National Lithuanian female U–18 (n = 12)	age = 18.0 ± 0.5 y; stature = 180.4 ± 7.5 cm; body mass = 72.7 ± 9.3 kg; training experience = 9.3 ± 2.3 y.
	National Lithuanian female U–20 (n = 12).	age = 19.6 ± 0.8 y; stature = 178.6 ± 6.4 cm; body mass = 68.0 ± 5.9 kg; training experience = 9.1 ± 1.9 y.
2. Investigation of readiness and workload in junior female basketball players during a congested match schedule	National Lithuanian female U–18 (n = 10)	age = 18.0 ± 0.4 y; stature = 179.9 ± 6.6 cm; body mass = 70.2 ± 5.1 kg; training experience = 9.1 ± 1.8 y.
	National Lithuanian female U–20 (n = 11)	age = 20.5 ± 2.9 y; stature = 178.4 ± 8.8 cm; body mass = 73.0 ± 9.7 kg; training experience = 9.6 ± 2.4 y.
3. Workload and well-being across games played on consecutive days during in-season phase in basketball players	NKL (n = 7, male)	age = 20.8 ± 1.6 y; stature = 195.0 ± 5.4 cm.; body mass = 88.3 ± 4.2 kg; training experience = 11.6 ± 3.7 y.

2.2. Procedures

The overview of the procedures used in different studies is presented in Table 2.2.

Table 2.2. Procedures used in different studies

Study	Procedures
1. Investigating the workload, readiness and physical performance changes during intensified 3-week preparation periods in female national Under18 and Under20 basketball teams	• PlayerLoad (PL) • training impulse (TRIMP) • session rate of perceived exertion workload (sRPE-WL) • Monotony and strain • heart rate variability (HRV) • well-being (WB) • 20-m sprint test (including 10-m split time) • countermovement jump (CMJ) • yo-yo intermittent recovery test level 1 (YYIR1)
2. Investigation of readiness and workload in junior female basketball players during a congested match schedule	• session rate of perceived exertion workload (sRPE-WL) • heart rate variability (HRV) • well-being (WB)
3. Workload and well-being across games played on consecutive days during in-season phase in basketball players	• PlayerLoad (PL) • Summated heart rate zones (SHRZ) • session rate of perceived exertion training load (sRPE-WL) • well-being (WB)

2.2.1. Player load (PL)

The external training load was assessed using Catapult OptimEye S5 devices (Catapult Innovations, Melbourne, Australia). Prior to each training session or friendly game, players were individually equipped with microsensors placed in vests to secure the attachment between the scapulae and worn under their sportswear. PlayerLoad (PL) was calculated as the instantaneous change rate in accelerations through tri-axial accelerometer at 100 Hz following previously used formula: PL = [√(Ac1 n-Ac1 n1) 2 + (Ac2 n-Ac2 n-1) 2 – (Ac3 n-Ac3 n-1) 2]/0.01, where Ac1, Ac2, and Ac3 are the orthogonal components measured from the triaxial accelerometer and 0.01 is the scaling factor (Fox et al., 2018).

2.2.2. Training impulse (TRIMP) and summated heart rate zones (SHRZ)

Internal training load was objectively measured using H10 Bluetooth heart-rate (HR) strap (Polar Electro, Kempele, Finland). During every training session and game, HR was continuously monitored together with OptimEye S5 devices and post-exercise PL and HR data were downloaded and stored with the same proprietary software (Catapult Sprint Version 5.1.7, Catapults Innovations, Melbourne, Australia).

TRIMP was calculated according to the following formula: TRIMP (AU) = D × (Δ heart rate ratio) × $e^{b(\Delta \text{ heart rate ratio})}$, where D = session duration, the constant e = 2.718, and the weighting factor b = 1.67 for women (Fox et al., 2018) and where Δ heart rate ratio = (average heart rate during exercise − resting heart rate) ÷ (maximal heart rate during exercise − resting heart rate) (Fox et al., 2017; Morton, Fitz-Clarke, & Banister, 1990).

SHRZ workload was calculated using the following formula: SHRZ (AU) = (duration in zone 1 × 1) + (duration in zone 2 × 2) + (duration in zone 3 × 3) + (duration in zone 4 × 4) + (duration in zone 5 × 5), where zone 1 = 50 %–59.9 %HR_{max}, Zone 2 = 60 %–69.9 %HR_{max}, Zone 3 = 70 %–79.9 %HR_{max}, Zone 4 = 80 %–89.9 %HR_{max}, and Zone 5 = 90 % to 100 %HR_{max}. (Edwards et al., 1993; Scanlan et al., 2018).

2.2.3. Session rating of perceived exertion workload (sRPE-WL)

Internal training load was subjectively assessed using sRPE method (sRPE-WL), which was extensively used in basketball (Conte et al., 2018; Paulauskas et al., 2019; Weiss et al., 2017). Each player was required to provide a global intensity score using the category ratio scale (CR-10 Borg's scale) (Borg, 1998) approximately 30 min after each training session or match answering to the question: "How intensive was your training session/match?" (Foster et al., 2001). To determine sRPE-WL, training duration in minutes was multiplied by the sRPE score (Foster et al., 2001). Each session duration was recorded individually including warm-up and recovery periods and excluding the cool-down (Conte et al., 2018; Paulauskas et al., 2019). The match duration was recorded from the beginning to the end of the game including all stoppages (i.e., fouls, out of bounds, time-outs and inter-quarter breaks) and excluding the warm-up (Conte et al., 2018; Paulauskas et al., 2019). The sRPE scores were collected and stored on cloud-based online survey software (Google Forms, CA, United States of America) (Paulauskas et al., 2019).

2.2.4. Monotony and strain

Training monotony and strain were calculated for both PL and sRPE-WL (Paulauskas et al., 2019). Training monotony-PL and monotony-sRPE-WL were calculated as weekly load divided by standard deviation, while strain-WL and strain-sRPE-WL were calculated multiplying monotony values by total weekly training load (Foster et al., 2001).

2.2.5. Heart rate variability

Every morning upon waking, players were required to measure HRV for 90 s while being in seated position and breathing spontaneously (Williams et al., 2018). The H10 Bluetooth heart-rate (HR) strap (Polar Electro, Kempele, Finland) was paired with a freely available smartphone application (Elite HRV, Ashville, North Carolina, USA), which have been previously used in team sports (Williams et al., 2018) to daily measure players' HRV. Squared root of the mean sum of the squared differences between R-R intervals (rMSSD) and their log-transformed data (Ln-rMSSD) were calculated using the Elite HRV app, which have been shown to be a valid tool to assess athletes' HRV (Williams et al., 2018).

2.2.6. Well-being

Psychological questionnaires were used to assess daily WB status of each player. Questionnaire assessed fatigue, sleep quality, general muscle soreness, stress levels, and mood on a five-point Likert scale (scores of 1 to 5 with 0.5 point increments) (Table2.3) (Conte et al., 2018).

Table 2.3. Well-being questionaire

	5	4	3	2	1
FATIGUE	Very fresh	Fresh	Normal	More tired than normal	Always tired
SLEEP QUALITY	Very restful	Good	Difficulty falling asleep	Restless sleep	Insomnia
GENERAL MUSCLE SORENESS	Feeling great	Feeling good	Normal	Increased soreness/tightness	Very sore
STRESS LEVEL	Very relaxed	Relaxed	Normal	Feeling stressed	Highly stressed
MOOD	Very positive mood	A generally good mood	Less interested in others &/or activities than usual	Snappiness at team-mates, family and co-workers	Highly annoyed/irritable/down

Total WB was calculated by summing the five scores for each item (Conte et al., 2018). Questionnaire data were collected every morning using the previously described online survey software (Google Forms, CA, United States of America) (Paulauskas et al., 2019).

2.2.7. Testing procedures

Players were instructed to maintain regular sleeping patterns, diet and avoid any physically demanding tasks 24 h before each testing session. Firstly, players' body composition (i.e., body mass and fat percentage) was measured using an electronic scale (model TBF 300; Tanita, Tokyo, Japan). Afterwards, players performed a 10-min standardized warm-up consisting of running, dynamic stretching, jumps and sprints. Subsequently, players' sprint, jump and fitness performances were assessed using CMJ test, 20-m sprint test and Yo-yo Intermittent Recovery test level-1 (YYIR1), respectively.

Countermovement jump test

The CMJ free arms test was used to assess players' jump height using Optojump system (Optojump, Microgate, Bolzano, Italy). Players performed the vertical jump starting from an upright standing position with a preliminary downward movement to a knee angle of approximately 90° (Pliauga et al., 2018). Three trials were performed interspersed by 20 s of passive rest between trials (Pliauga et al., 2018). The highest jump height was used for analysis in each testing session. If the best result occurred in the third trial, an additional trial was performed (Pliauga et al., 2018). The test–retest reliability has been previously shown for this procedure (ICC = 0.98) (Attia et al., 2017).

20-m sprint test

The 20-m linear test with 10-m split time was adopted as previously described (Kamandulis et al., 2013; Wen et al., 2018). Running time was recorded using the Power Time Testing System (New Test, Oulu, Finland). Players sprinted from a standing splitstance start position. Three trials were conducted interspersed by approximately 3 min of passive recovery. The fastest sprint time was used for the analysis in each testing session. The test–retest reliability of this procedure has been previously showed in basketball players (ICC = 0.95) (Kamandulis et al., 2013).

Yo-yo intermittent recovery test level 1

The YYIR1 test, which has been shown to be a valid basketball-specific test for the assessment of aerobic fitness and game-specific endurance (Castagna et al., 2007; Krustrup et al., 2003; Sansone et al., 2018) was conducted on a regularsized basketball court to assess players' fitness levels. The YYIR1 test was conducted with 2 × 20-m shuttle runs back-and-forth performed at progressively increased speed controlled by audio beeps from an audio record (Krustrup et al., 2003). Each running bout was separated by 10-s active recovery consisting of 2 × 5-m jogging (Krustrup et al., 2003). The test ended when players were unable to reach the frontline on time twice (objective evaluation) or they were unable to continue the test (subjective evaluation). The distance covered was recorded as test result (Krustrup et al., 2003).

2.3. Experimental designs

2.3.1. Study 1

The investigated teams were monitored during the 3-week (i.e., 22 days) preparation period for the Women's European Basketball Championships 2018 – Division B (Under18: Austria, August 3–12 and Under20: Romania, July 7–15). Players were fully familiarized with all procedures to monitor workload and readiness to perform during the first testing session. The preparation periods for both teams were structured as an intensified training residential camp and each team was separately trained by different coaching staffs. The preparation periods took place from 5 July to 26 July 2018 and between 9 June to 30 June 2018 for Under18 and Under20 teams, respectively. In these timeframes, the Under18 team completed 29 training sessions and 5 friendly games, while the Under20 team completed 23 training sessions and 5 friendly games. Details about training schedules for both teams are provided in Table 2.4. Additionally, during the investigated period no injuries occurred. Players' workload was monitored in each scheduled training session and friendly game. The weekly load was calculated for each player averaging the daily workload experienced. In case more than one training session was completed in the same day, the daily workload was calculated summing the load of each session in that day. Moreover, players' readiness and WB were individually evaluated every morning upon awakening via heartrate variability (HRV) and WB questionnaires. Additionally, players' physical performance was assessed pre- and post-preparation period (i.e., on day 1 and day 22).

Table 2.4. Training schedule in Under18 and Under20 during 3-week intensified preparation periods

Sessions Characteristics		Under 18							Under20						
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Morning	Typology	TEST	S&C	S&C	S&C	–	S&C	S&C	TEST	S&C	S&C	TT	–	–	–
	Duration (min)	104	104	149	70	–	104	117	108	85	128	101	–	–	–
Afternoon	Typology	S&C	S&C	TT	TT	TT	TT	TT	TT	TT	–	TT	FG1	FG2	–
	Duration (min)	57	93	131	128	112	117	123	120	126	–	118	104	103	–
		Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14
Morning	Typology	TT	FG2	TT	S&C	TT	S&C	TT	S&C	S&C	TT	TT	TT	S&C	–
	Duration (min)	91	97	101	120	117	104	120	97	125	66	118	125	95	–
Afternoon	Typology	FG1	–	TT	TT	TT	–	TT	TT	TT	–	TT	TT	–	–
	Duration (min)	98	–	107	123	121	–	114	99	103	–	123	113	–	–
		Day 15	Day 16	Day 17	Day 18	Day 19	Day 20	Day 21	Day 15	Day 16	Day 17	Day 18	Day 19	Day 20	Day 21
Morning	Typology	–	TT	TT	–	–	TT	TT	–	TT	–	S&C	S&C	TT	TT
	Duration (min)	–	58	44	–	–	115	124	–	81	–	99	103	90	117
Afternoon	Typology	TT	FG3	FG4	FG5	–	S&C	–	S&C	FG3	FG4	–	TT	FG5	–
	Duration (min)	129	106	104	105	–	124	–	119	96	100	–	98	110	–

Abbreviations and notes: TEST, pre-testing session (n.b. post-testing session was scheduled on Day 22); S&C, strength and conditioning sessions (i.e. training sessions with the majority of time spent executing S&C exercises); TT, technical–tactical sessions (i.e. training sessions with the majority of time spent executing basketball-specific drills); FG, friendly games.

2.3.2. Study 2

Workload, readiness and match performance of the two national teams were monitored for 10 days during EC division B (U18, Austria, 3–12 August and U20, Romania, 7–15 July) (Figure 2.1) (FIBA.Basketball, 2018a, b). Players were fully familiarized with all procedures to monitor workload and readiness to perform during the preparation phase. The U18 team was exposed to 1 day more of competition because of the greater number of teams in this EC age category. However, both Championships had a pre-EC day (Day 1) and the same distribution of matches (7) within the first 9 days of the tournament, with no matches on two days.

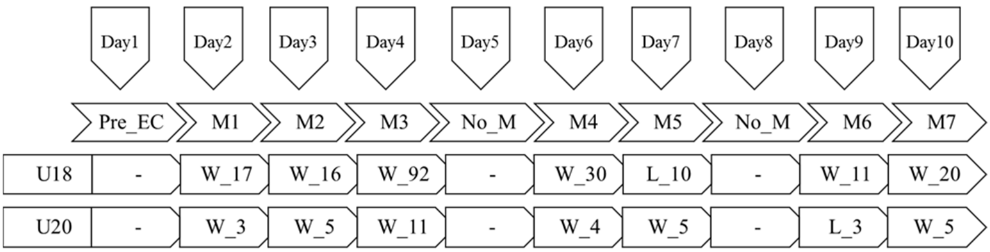


Figure 2.1. The structure and match outcomes of the 10 days studied during the European Championship

Abbreviations: M, match (1 – first; 2 – second; 3 – third; 4 –fourth; 5 –fifth; 6 – sixth; 7 – seventh matches); No_M, no-match day during which teams were training or resting; W, win match (indicating by how many points); L, lost match (indicating by how many points)

2.3.3. Study 3

This observational study was designed to compare the differences in workload and well-being between games played across two consecutive days (<24 h rest between games) during the 2018–2019 in-season phase. Players were fully familiarized with all procedures to monitor workload and well-being during the pre-season and the initial stages of the in-season phase. A total of six NKL games were monitored across three weeks (from 23rd of November to 8th of December 2018) with two games played per week on Friday (Day 1) at 18:00 h and on Saturday (Day 2) at 16:00 h (Figure 2.2). The final analysis included 21 game samples for Day 1 and Day 2, respectively. The weekly training schedule was organized with a similar structure across the three separate investigated weeks encompassing one Lithuanian student league game [Lietuvos studentų krepšinio lyga (LSKL)], three 90-min training sessions, the two investigated NKL games and one rest day (Table 2.5).

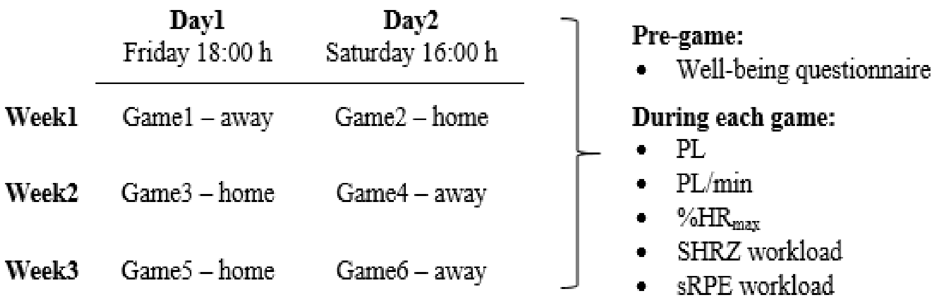


Figure 2.2. The congested monitored games and measurements collected during each game day

Abbreviations: PL, player load; PL/min, player load per minute; $\%HR_{max}$, percentage of maximum heart rate; SHRZ, summated heart rate zones; sRPE, session-rating of perceived exertion.

Table 2.5. Training and game schedule during the investigated 3-week in-season period

Week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	LSKL Game	Technical session	Tactical and conditioning session	Tactical session	NKL Game 1	NKL Game 2	Rest
2	LSKL Game	Technical session	Tactical and conditioning session	Tactical session	NKL Game 3	NKL Game 4	Rest
3	LSKL Game	Technical session	Tactical and conditioning session	Tactical session	NKL Game 5	NKL Game 6	Rest

Abbreviations: LSKL, Lithuanian Student Basketball League [Lietuvos studentų krepšinio lyga (LSKL)]; NKL, second-tier Lithuanian league [Nacionalinė krepšinio lyga (NKL)].

2.4. Statistical analysis

2.4.1. Study 1

Data are presented as mean ± SD for each dependent variable. After checking the normality of data through the Shapiro–Wilk test, data were analysed using linear mixed models, which correctly deal with missing values. Three separate models were constructed to assess the differences (a) between teams, (b) within-team weekly changes, and (c) pre-post differences in testing results, respectively. Team (Under20 vs. Under18), week (Week1, Week2 or Week3) and time (pre vs. post) were used as fixed effects in the three models, respectively. Player and day were used as random effects in model 1 and model 2, while only player was used as random effect in model 3. Measures of workload, monotony, strain, readiness and WB were used in the first two models as dependent variables, while testing performances were used as dependent variables in model 3. Significance was set at $p < 0.05$. In model 2 (i.e., assessing within-team weekly changes), in case of statistically significant differences, Tukey post hoc analyses were run. Linear mixed models and post-hoc analyses were conducted using the "lmerTest" and "emmeans" packages, respectively, in RStudio (R.3.5.2, R Foundation for Statistical Computing). The magnitude of differences for pairwise comparisons was assessed using effect size (ES) with 95 % confidence intervals. ES was calculated using *Microsoft Excel* (Version 15, Microsoft Corporation, Redmond, USA) and interpreted as 2.0 = Very large (Hopkins, Marshall, Batterham, & Hanin, 2009).

2.4.2. Study 2

Data are presented as mean ± SD for each dependent variable. Data distribution was assessed using the Shapiro–Wilk test, which demonstrated a normal distribution for the HRV data and a non-normal distribution for the sRPE workload and WB data. Therefore, a 2 × 10 repeated-measures analysis of variance (ANOVA) was used to test differences in HRV between U18 and U20 teams (between-team) and changes in daily values (within-team). If significant differences were found, an independent *t*-test using the Bonferroni correction was used for post hoc analysis of daily differences. Because sRPE workload and WB were not normally distributed, Friedman and Mann–Whitney *U* tests were used to assess within-day changes and between-team differences, respectively. When the Friedman test showed a significant difference, Connover's post hoc analysis with Bonferroni correction was used. In addition, the same analysis to check the daily changes in each dependent variable was carried out for the entire sample of 21 basketball players (U18 and U20 teams combined) together. For the second aim, players from both teams were grouped based on their average playing time during the tournament via hierarchical cluster analysis using Ward's method and the squared Euclidian distance as interval (Conte & Lukonaitiene, 2018). In this analysis, efficiency statistic was also included in the cluster comparison. Data distribution was assessed using the Shapiro–Wilk test, which revealed normal distribution for all variables except for sRPE workload and sleep and mood from the WB questionnaire. Following the cluster analysis, an independent *t*-test or Mann–Whitney *U* test (sRPE workload, sleep, mood) was used for pairwise comparison. The magnitude of differences for pairwise comparisons was assessed using Cohen's d effect size (ES) with 95 % confidence intervals for parametric statistics. ES were interpreted as < 0.20 = trivial, 0.20–0.59 = small, 0.60–1.19 = moderate, 1.2–1.99 = large, and ≥ 2.0 = very large (Peterson, 2018). For nonparametric pairwise comparisons, ES was calculated as *r* and interpreted as 0.1 = small; 0.3 = moderate; 0.5 = large (Hauer, Tessitore, Knaus, & Tschan, 2020).

2.4.3. Study 3

Data are presented as mean ± standard deviation (SD) for each dependent variable (i.e. workload and well-being measures). After confirming the normality of data through the Shapiro–Wilk test, data were analyzed using linear mixed models with day as a fixed effect (i.e. games played on Day 1 or Day 2) and player, opposition rank, location and score difference as random effects. The magnitude of differences for pairwise comparisons between measures obtained for Day 1 and Day 2 was assessed using effect sizes (ES) with 95 % confidence intervals. ES were interpreted as: trivial = < 0.20, small = 0.20–0.59, moderate = 0.60–1.19, large = 1.20–1.99, very large = ≥ 2.00 (Hopkins et al., 2009). All statistical analyses were conducted using the lmer test package in RStudio (version 3.5.2, Eggshell Igloo, R Foundation for Statistical Computing) and JASP (version 0.11.1). The level of significance was set at $p < 0.05$.

3. RESULTS AND DISCUSSION

3.1. Investigating the workload, readiness and physical performance changes during intensified 3-week preparation periods in female national Under18 and Under20 basketball teams

3.1.1. Between-team analysis of workload readiness and WB

Table 3.1 displays differences between Under18 and Under20 in workload, readiness and WB values during the preparation period. In Under20, significantly lower values were found for PL ($p = 0.010$; ES = Small), TRIMP ($p = 0.004$; ES = Moderate), sRPE-WL ($p < 0.001$; ES = Moderate), strain-PL ($p = 0.023$; ES = Small) and Strain-sRPE-WL ($p < 0.001$; ES = Moderate) (Table 3.1). Furthermore, significantly higher values of Ln_rMSSD ($p = 0.015$; ES = Moderate) and rMSSD ($p = 0.023$; ES = Moderate) were found in Under20 compered to Under18 (Table 3.1). The results of total WB score demonstrated no between-team statistically significant differences, while statistically lower results ($p = 0.023$; ES = Small) were found for stress levels.

3.1.2. Within-team weekly changes workload readiness and WB

Within-team weekly changes in workload, readiness and WB values are displayed in Table 3.2 and Table 3.3 for Under18 and Under20, respectively. Week-by-week differences were found for all workload variables in Under18 ($p < 0.05$) (Table 3.2). Post-hoc analysis showed a lower PL in Week3 compared to Week1 ($p = 0.009$; ES = Moderate) and Week2 ($p = 0.002$; ES = Small). Considering internal load, results revealed a decrease in Week3 compared to Week1 in TRIMP ($p = 0.006$; ES = Small) and sRPE-WL ($p = 0.001$; ES = Moderate) (Table 3.2). Conversely, no statistically significant differences were found between weeks in Under20 for both external and internal load measurements (Table 3.3). The analysis of Monotony-PL showed statistically significant differences in both investigated teams (Under18: $p < 0.001$ and Under20: $p < 0.034$), while Monotony-sRPE-WL revealed statistically significant differences only in Under18 ($p < 0.001$). Post-hoc analysis of Monotony-PL in Under18 demonstrated statistically significant decrease throughout weeks with moderate-to-very large effect sizes (Table 3.2). Conversely, no statistically significant differences were found in post-hoc analysis for Under20. The post-hoc analysis of Monotony-sRPE-WL in Under18 indicated statistically significant differences between weeks except for the Week2 to Week3 comparison

($p = 0.330$) (Table 3.2). The analysis of Strain values demonstrated statistically significant differences only in Under18 team (Strain-PL $p < 0.001$ and Strain-sRPE-WL $p = 0.047$). Post-hoc analysis revealed statistically significant differences between Week1 and Week2 ($p = 0.005$) and Week1 and Week3 ($p < 0.001$) for Strain-PL, while only statistically significant differences were found between Week1 and Week2 ($p = 0.037$) in Strain-sRPE-WL (Table 3.2). The analysis of WB demonstrated significant weekly fluctuations for both investigated teams (Tables 3.2 and 3.3). Post-hoc analysis revealed that Under18 reached the highest value (20.74 ± 1.86 AU) in Week3 with moderate-to-small changes compared to Week1 and Week2 (Table 3.2), while Under20 showed the highest value in Week2 (20.75 ± 2.16 AU) compared to both Week1 and Week3 (Table 3.3).

3.1.3. Between-team and within-team analysis of performance

The analysis of testing results revealed no between-team statistically significant differences in pre-test results. Within-team analysis showed that Under18 team increased only YYIR1 performance ($p < 0.001$; ES = Very Large). Differently, Under20 team showed higher results in 10-m sprint split time ($p = 0.003$; ES = Moderate), CMJ ($p = 0.025$; ES = Moderate) and YYIR1 ($p < 0.001$; ES = Large) performances with a moderately decrease in the HRmax measured during the YYIR1 (Table 3.4).

Table 3.1. Between-team differences in workload, monotony, strain, readiness and well-being during the investigated preparation period

Variable	Under20	Under18	P value	MD	95 % CI for MD		ES	95 % CI for ES		Interpretation
					Lower	Upper		Lower	Upper	
Workload										
PL (AU)	706.37 ± 295.2	816.36 ± 333.19	**0.010**	109.99	53.27	166.70	0.35	0.17	0.53	Small
TRIMP (AU)	214.60 ± 109.42	304.95 ± 171.83	**0.004**	90.35	64.47	116.23	0.63	0.45	0.81	Moderate
sRPE-WL (AU)	617.29 ± 328.24	942.82 ± 436.51	**< 0.001**	325.54	255.92	395.15	0.85	0.66	1.03	Moderate
Monotony and Strain										
Monotony-PL (AU)	4.68 ± 1.26	5.29 ± 1.78	0.083	0.62	-0.09	1.32	0.40	-0.06	0.86	Small
Strain-PL (AU)	965.50 ± 154.82	1064.68 ± 217.66	**0.023**	99.18	12.77	185.59	0.53	0.07	0.99	Small
Monotony-sRPE-WL (AU)	3.77 ± 1.74	3.60 ± 0.98	0.610	-0.17	-0.82	0.49	-0.12	-0.57	0.34	Trivial
Strain-sRPE-WL (AU)	1288.11 ± 715.77	1792.69 ± 365.51	**< 0.001**	504.58	239.67	769.49	0.88	0.40	1.35	Moderate
Readiness										
rMSSD (ms)	100.77 ± 38.03	63.98 ± 49.82	**0.023**	-36.79	-44.83	-28.74	-0.85	-1.04	-0.66	Moderate
Ln_rMSSD (ms)	4.54 ± 0.41	3.83 ± 0.90	**0.023**	-0.70	-0.83	-0.58	-1.07	-1.27	-0.87	Moderate
Well-Being										
Total	19.87 ± 3.02	19.59 ± 2.45	0.410	-0.28	-0.75	0.20	-0.10	-0.27	0.07	Trivial
Fatigue	3.86 ± 0.63	3.75 ± 0.67	0.397	-0.11	-0.22	0.00	-0.17	-0.34	0.01	Trivial
Sleep	3.98 ± 0.72	3.91 ± 0.84	0.635	-0.07	-0.20	0.07	-0.09	-0.26	0.09	Trivial
Soreness	3.84 ± 0.74	3.83 ± 0.74	0.992	0.00	-0.13	0.13	0.00	-0.18	0.17	Trivial
Stress	4.14 ± 0.57	3.87 ± 0.60	**0.023**	-0.27	-0.37	-0.17	-0.46	-0.63	-0.28	Small
Mood	4.29 ± 0.50	4.23 ± 0.48	0.661	-0.06	-0.14	0.03	-0.11	-0.29	0.06	Trivial

Notes: data presented as mean ± standard deviation. *Abbreviations:* PL, PlayerLoad; TRIMP, training impulse; sRPE-WL, training workload calculated from session-rating of perceived exertion; rMSSD, root mean square of the successive differences; Ln_rMSSD, log-transformed data of rMSSD; MD, mean difference; CI, confidence interval; ES, effect size.

Table 3.2. Within-team weekly changes in workload, monotony, strain, readiness and well-being during the investigated preparation period in Under18

	Under18			**ES**					
	Week1	Week2	Week3	Week1 vs. Week2		Week1 vs. Week3		Week2 vs. Week3	
Workload									
PL (AU)	868.20 ± 312.49	855.82 ± 371.97	713.13 ± 290.53*#	0.02	Trivial	0.89	Moderate	0.26	Small
TRIMP (AU)	338.18 ± 178.86	303.45 ± 136.78	267.83 ± 191.43*	0.16	Small	0.35	Small	0.16	Trivial
sRPE-WL (AU)	1045.77 ± 481.74	957.80 ± 449.66	806.90 ± 321.78*	0.14	Trivial	0.90	Moderate	0.23	Small
Monotony and Strain									
Monotony-PL (AU)	6.84 ± 0.88	5.31 ± 1.82*	3.64 ± 0.38*#	0.78	Moderate	3.50	Very large	0.87	Moderate
Strain-PL (AU)	906.71 ± 103.05	1124.54 ± 266.72*	1182.14 ± 125.4*	-0.89	Moderate	-2.27	Very large	-0.19	Trivial
Monotony-sRPE-WL (AU)	4.61 ± 0.58	3.31 ± 0.96*	2.96 ± 0.55*	1.17	Moderate	2.13	Very large	0.40	Small
Strain-sRPE-WL (AU)	1634.38 ± 397.77	1937.81 ± 418.35*	1791.82 ± 214.88	-0.84	Moderate	-0.37	Small	0.32	Small
Readiness									
rMSSD (ms)	55.68 ± 43.16	72.71 ± 55.26*	62.91 ± 48.91*	-0.37	Small	-0.48	Small	0.06	Trivial
Ln_rMSSD (ms)	3.65 ± 0.97	3.99 ± 0.83*	3.88 ± 0.76*	-0.62	Moderate	-0.68	Moderate	-0.06	Trivial
Well-Being									
Total	18.85 ± 2.57	19.18 ± 2.46	20.74 ± 1.86*#	-0.13	Trivial	-0.61	Moderate	-0.56	Small
Fatigue	3.63 ± 0.74	3.60 ± 0.68	4.01 ± 0.5*#	0.05	Trivial	-0.49	Small	-0.58	Small
Sleep	3.71 ± 0.87	3.86 ± 0.87	4.15 ± 0.74*#	-0.12	Trivial	-0.40	Small	-0.29	Small
Soreness	3.55 ± 0.90	3.81 ± 0.67*	4.14 ± 0.47*#	-0.26	Small	-0.58	Small	-0.45	Small
Stress	3.70 ± 0.60	3.77 ± 0.65	4.13 ± 0.46*#	-0.09	Trivial	-0.56	Small	-0.45	Small
Mood	4.25 ± 0.49	4.14 ± 0.47	4.30 ± 0.46#	0.24	Small	-0.08	Trivial	-0.25	Small

Notes: data presented as mean ± standard deviation, * statistically significant ($p < 0.05$) difference compared to Week1; # statistically significant ($p < 0.05$) difference compared to Week2. *Abbreviations:* PL, PlayerLoad; TRIMP, training impulse; sRPE-WL, training workload calculated from session-rating of perceived exertion; rMSSD, root mean square of the successive differences; Ln_rMSSD, log-transformed data of rMSSD; WB, well-being; ES, effect size.

Table 3.3. Within-team weekly changes in workload, monotony, strain, readiness and well-being during the investigated preparation period in Under20

	Under20			ES					
	Week1	Week2	Week3	Week1 vs. Week2		Week1 vs. Week3		Week2 vs. Week3	
Workload									
PL (AU)	680.90 ± 256.99	695.48 ± 340.01	744.16 ± 275.85	-0.09	Trivial	0.08	Trivial	0.18	Trivial
TRIMP (AU)	214.37 ± 101.18	228.90 ± 122.87	198.68 ± 100.00	-0.12	Trivial	0.21	Small	0.48	Small
sRPE-WL (AU)	679.92 ± 332.16	586.80 ± 364.38	589.09 ± 271.69	0.16	Trivial	0.41	Small	0.26	Small
Monotony and Strain									
Monotony-PL (AU)	4.33 ± 0.85	4.33 ± 0.85	5.32 ± 1.50	-0.02	Trivial	-0.54	Small	-0.64	Moderate
Strain-PL (AU)	978.39 ± 128.07	978.39 ± 128.07	947.80 ± 211.25	0.04	Trivial	0.11	Trivial	0.10	Trivial
Monotony-sRPE-WL (AU)	3.89 ± 2.58	3.89 ± 2.58	3.82 ± 1.28	0.09	Trivial	0.02	Trivial	-0.12	Trivial
Strain-sRPE-WL (AU)	1637.02 ± 1083.93	1637.02 ± 1083.93	1147.66 ± 363.73	0.49	Small	0.42	Small	-0.12	Trivial
Readiness									
rMSSD (ms)	92.25 ± 36.89	106.49 ± 38.75*	102.63 ± 37.09*	-0.39	Small	-0.28	Small	0.12	Trivial
Ln_rMSSD (ms)	4.44 ± 0.45	4.61 ± 0.39*	4.48 ± 0.51*	-0.39	Small	-0.24	Small	0.14	Trivial
Well-Being									
WB total	18.88 ± 4.36	20.75 ± 2.16*	19.74 ± 1.57$^{*\#}$	-0.38	Small	-0.28	Small	0.05	Trivial
Fatigue	3.80 ± 0.68	3.97 ± 0.58	3.76 ± 0.61$^{\#}$	-0.10	Trivial	-0.06	Trivial	0.03	Trivial
Sleep	3.98 ± 0.69	3.98 ± 0.81	3.97 ± 0.62	0.10	Trivial	-0.11	Trivial	-0.24	Small
Soreness	3.44 ± 0.96	4.15 ± 0.52*	3.82 ± 0.48$^{*\#}$	-0.71	Moderate	-0.46	Small	0.24	Small
Stress	4.09 ± 0.57	4.27 ± 0.56*	4.01 ± 0.55$^{\#}$	-0.24	Small	-0.02	Trivial	0.13	Trivial
Mood	4.27 ± 0.50	4.38 ± 0.52	4.18 ± 0.45$^{\#}$	-0.15	Trivial	0.05	Trivial	0.13	Trivial

Notes: data presented as mean ± standard deviation, * statistically significant ($p < 0.05$) difference compared to Week1; # statistically significant ($p < 0.05$) difference compared to Week2. *Abbreviations:* PL, PlayerLoad; TRIMP, training impulse; sRPE-WL, training workload calculated from session-rating of perceived exertion; rMSSD, root mean square of the successive differences; Ln_rMSSD, log-transformed data of rMSSD; WB, well-being; ES, effect size.

Table 3.4. Pre- post-preparation changes in physical performance and body composition in Under18 and Under20

Variable	Pre	Post	P value	MD	95 % CI for MD		ES	95 % CI for ES		Interpretation
					Lower	Upper		Lower	Upper	
Under18										
10-m split time (s)	1.93 ± 0.08	1.91 ± 0.08	0.311	0.02	-0.03	0.07	0.29	-0.29	0.87	Small
20-m (s)	3.35 ± 0.15	3.31 ± 0.13	0.152	0.04	-0.02	0.10	0.42	-0.18	1.01	Small
CMJ (cm)	37.97 ± 4.45	39.06 ± 4.84	0.128	-1.09	-2.63	0.44	-0.45	-1.04	0.15	Small
YYIR1 (level)	15.14 ± 0.68	16.08 ± 0.82	**< 0.001**	-0.94	-1.34	-0.54	-1.49	-2.31	-0.64	Large
HR_{max} (bpm)	197.58 ± 8.64	193.42 ± 8.54	**0.043**	4.17	-0.06	8.40	0.63	-0.01	1.24	Moderate
Body mass (kg)	68.03 ± 5.87	69.48 ± 5.61	**< 0.001**	-1.46	-2.15	-0.76	-1.34	-2.11	-0.53	Large
Body fat (%)	19.79 ± 4.01	18.51 ± 2.51	0.081	1.28	-0.27	2.83	0.53	-0.09	1.12	Small
Under20										
10-m split time (s)	1.93 ± 0.08	1.90 ± 0.07	**0.003**	0.03	0.01	0.05	1.09	0.32	1.83	Moderate
20-m (s)	3.34 ± 0.13	3.21 ± 0.31	0.150	0.13	-0.07	0.33	0.45	-0.19	1.06	Small
CMJ (cm)	39.48 ± 5.48	42.67 ± 6.21	**0.025**	-3.19	-6.06	-0.32	-0.75	-1.41	-0.06	Moderate
YYIR1 (level)	15.06 ± 0.58	16.33 ± 1.1	**< 0.001**	-1.21	-1.82	-0.61	-1.43	-2.31	-0.52	Large
HR_{max} (bpm)	195.64 ± 6.47	192.30 ± 5.79	**0.013**	4.00	0.95	7.05	0.94	0.17	1.67	Moderate
Body mass (kg)	72.65 ± 9.25	74.00 ± 9.98	**0.004**	-1.36	-2.22	-0.49	-1.05	-1.78	-0.29	Moderate
Body fat (%)	21.13 ± 2.36	22.08 ± 3.32	0.072	-0.96	-2.08	0.17	-0.57	-1.20	0.08	Small

Notes: data presented as mean ± standard deviation. *Abbreviations:* Pre, pre-preparation period; Post, post-preparation period; CMJ, countermovement vertical jump, YYIR1, yo-yo intermittent recovery test level 1; HR_{max}, maximum heart rate; MD, mean difference; CI, confidence interval; ES, effect size.

3.1.4. Discussion

This study aimed to investigate the differences in workload, training readiness, WB and pre-post preparation period changes in physical performance between two female, youth national basketball teams during a short preparation period (i.e., 3 weeks) for an international competition. The main results indicate between-team statistically significant differences in training volume and intensity across the three investigated weeks and the use of different periodization strategies. Additionally, within-team pre- post-preparation period differences in physical performance showed the players accumulating lower workload resulting in moderate-to-very large increase in post-preparation anaerobic and aerobic performances, while the team experiencing higher workload largely increased the aerobic performance, with no statistically significant changes on anaerobic performance.

The adoption of short intensified preparation periods in basketball has been deemed important to positively benefit players' performances (Aoki et al., 2017). Moreover, the comparison of workloads experienced by different teams during preparation periods was considered important to provide basketball coaches useful indications about the adoption of optimal training strategies (Ferioli et al., 2018a; Ferioli et al., 2018b; Pliauga et al., 2018). A previous study comparing the training strategies adopted during a 5–7-week preparation period in professional and semi-professional male basketball teams documented the professional players accumulating approximately twice as much workload as semi-professional players (Ferioli et al., 2018a). This difference in workload would be expected since high-level teams are usually training more professionally, with more appropriate coaching staffs, facilities and equipment availability compared to lower level teams. Conversely, no differences would be expected in youth national teams involved in a similar duration preparation period (i.e., 3-weeks) for the same championship level (i.e., Women's European Basketball Championships 2018 – Division B). To the best of our knowledge, the current study is the first investigation assessing the differences in workload during short intensified preparation period between two national, youth, female basketball teams (i.e., Lithuanian national teams Under18 and Under20) preparing for their age-category European championships. Although the preparation period for the two investigated teams was scheduled with the same duration (i.e., 22 days) and at the same time of the season (i.e., end of club season), coaching staffs adopted two different periodization strategies. Indeed, the Under18 team was exposed to a higher number of training sessions, resulting in small-to-moderate higher volume and intensity (i.e., PL, TRIMP and sRPE-WL) compared to Under20 team underlining the different coaching strategies adopted.

When considering the within-team weekly changes, the different coaching strategies are more evident. Indeed, the Under20 team reported trivial-to-small changes in the workload across the three investigated weeks, while the Under18 team showed a higher load in the first 2 weeks followed by a taper week. While the adoption of a periodization approach lasting 12 weeks encompassing overload and tapering periods has been shown to positively benefit players' performance and stress-recovery state in elite female basketball players (Nunes et al., 2014), these results were not evident in the current investigation. The possible reason for this dissimilarity might be that longer periodization periods can allow the manipulation of more than one overload and taper phases and with longer length allowing a proper adaptation (Nunes et al., 2014). Differently, the use of short overloading and taper periods might not be the most appropriate approach during short intensified preparation periods, while the use of a constant workload might induce better training adaptations as highlighted in the Under20 team. Therefore, future studies comparing periodization approaches encompassing different lengths and different periodization strategies (i.e., using overloading and taper periods and constant volume) are warranted.

The HRV has been indicated as a non-invasive tool to assess autonomic nervous system activity and specifically the interaction between sympathetic (HR increase) and parasympathetic (HR decrease) responses (McGuigan, 2017). When the athlete is not tolerating training load, a low HRV value is registered indicating a predominance of the sympathetic nervous system on heart-rate responses. Therefore, HRV has been considered as a good physiological marker to monitor players' readiness and recovery status (McGuigan, 2017). In the current investigation, the registered readiness scores showed to be sensitive to the different workload experienced by the two teams. Indeed, the team reporting a lower workload (i.e., Under20) across the three investigated weeks registered moderately higher readiness scores compared to the team accumulating higher workload. Specifically, the Under20 and Under18 teams reported average Ln_rMSSD values of 4.5 ms and 3.8 ms, respectively. Although no previous investigation reported the optimal HRV values for female, youth basketball players during an intensified preparation period, a previous research documented that Ln_RMSSD values around 4.5 ms indicates a physiological status possibly promoting optimal sprint performance in collegiate male sprinters (Peterson, 2018). Therefore, Under20 players seemed to reach a more suitable readiness value in the last week before the beginning of the European championship (Ln_rMSSD = 4.5 ms) compared to Under18 players (Ln_rMSSD = 3.9 ms). Future studies are warranted to assess the optimal HRV values for female, youth basketball players.

Subjective WB values typically worsen in response to higher training load and increase following reduced workload periods (Saw et al., 2016). This pattern was shown when considering within-team weekly overall WB changes. Indeed, the Under18 players showed the highest WB value during the taper week (i.e., Week3) and the Under20 players revealed weekly trivial-to-small differences in both workload and WB values. However, inconsistent results were found in overall WB values compared to HRV values and workload when considering between-team differences. In fact, while a moderate between-team difference was found in HRV values, and statistically significant differences were found in workload, no statistically significant differences were found for overall WB values. Actually, it has been previously shown no consistent association between objective and subjective measures of readiness and workload (Rabbani, Baseri, Reisi, Clemente, & Kargarfard, 2018; Saw et al., 2016), suggesting the adoption of subjective WB measures into a mixed methods approach to athlete monitoring (McGuigan, 2017; Rabbani et al., 2018).

The analysis of pre-post differences in physical performance underlined similar responses in fitness levels changes with large-to-very large increase in YYIR1 test in both Under20 and Under18 players. Conversely, only players experiencing a lower workload (i.e., Under20) documented moderate increases in anaerobic performances (i.e., 10-m sprint and CMJ). These results are in line with previous investigations showing that achieving high training load volume during preparation period might negatively affect anaerobic performances (Ferioli et al., 2018a, b; Pliauga et al., 2018). Therefore, it seems fundamental the adoption of an adequate workload during short intensified training periods. In the current investigation, the Under20 team averaged PL = 706 AU, TRIMP = 215 AU, sRPE-WL = 617 AU, which might be considered as indicative values for female, youth basketball players during short intensified preparation periods. Future studies are necessary to confirm whether these values can provide positive adaptations on both aerobic and anaerobic performances in female, youth basketball players.

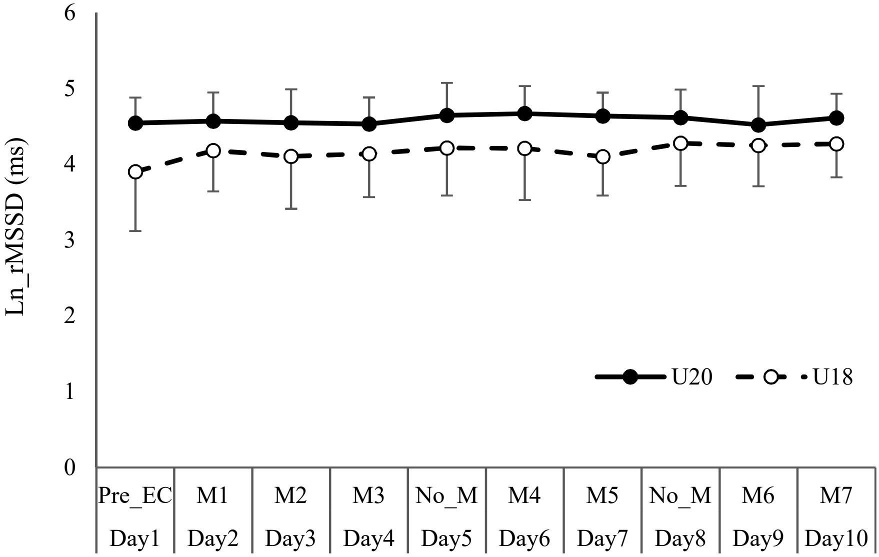
Although this study provides interesting insight for youth female basketball coaches and practitioners, some limitations should be acknowledged. Firstly, the tests adopted in this study were limited to physical qualities, while future studies assessing the effect of short intensified preparation periods on technical skills performance should be conducted. Secondly, the investigated players underwent to different time-laps between the end of the club season and the beginning of the studied preparation periods, which started with approximately 4-week difference (i.e., Under 20 and Under 18 starting on 9th of June and 5th July, respectively). Thus, further studies monitoring also players' load in this timeframe are warranted.

Female, youth basketball coaches, sport scientists and practitioners should consider implementing workload monitoring strategies during short intensified preparation periods to prescribe adequate training stimuli. Moreover, basketball coaches and practitioners should consider adopting a constant adequate workload (i.e. PL = 706 AU, TRIMP = 215 AU, sRPE-WL = 617 AU) during short intensified training periods in order to improve players' physical qualities rather than short overloading and taper periods averaging higher workloads. Finally, basketball practitioners should consider monitor workload, readiness, WB and physical performances in combination since each of these components might be independent of each other.

3.2. Investigation of readiness and workload in junior female basketball players during a congested match schedule

3.2.1. Between-team and within-team analysis

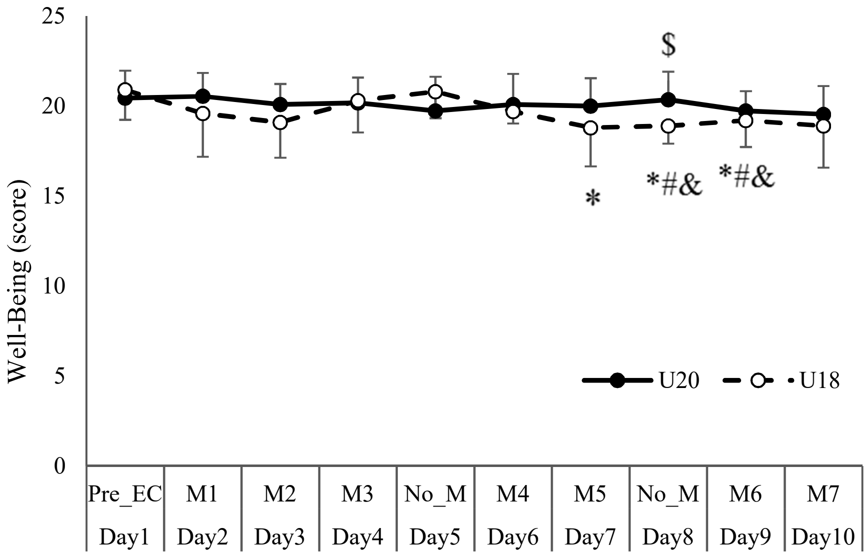
Analysis of workload during the EC showed no between-team differences for any day except Day 6 (no match), although the U18 team was exposed to significantly higher sRPE workload ($p = 0.04$; ES = 0.56, large, 95 % CI = –0.82, –0.11) compared with the U20 team. HRV changes across the 10 days of the EC within and between groups (U18 and U20) are displayed in Figure 3.2. No significant differences were observed across EC days (within-subject analysis [$p = 0.09$, ES = 0.48, small]) and no interaction ($p = 0.45$) was found with Ln_rMSSD, although a significant difference was observed between teams ($p = 0.04$, ES = 0.48, small). However, post hoc analysis revealed no differences between teams for each day ($p > 0.05$) (Figure 3.2).



Abbreviations: Ln_rMSSD, log-transformed data of root mean square of the successive differences; M, match.

Figure 3.1. Heart rate variability changes in U18 and U20 teams during the European Championships

The total within- and between-group (U18 and U20) changes in WB during the EC are presented in Figure 3.3. Significant differences between days were found for the U18 team (within-subject analysis $p < 0.001$); post hoc analysis showed a significantly lower WB total score on Day 7 ($p = 0.004$; $p = 0.03$; $p = 0.006$) and Day 8 ($p = 0.002$; $p = 0.02$; $p = 0.003$) compared with Day 1, Day 4 and Day 5, respectively and for Day 9 ($p = 0.04$) compared with Day 1. No significant differences between days were found for the U20 team ($p = 0.30$). Between-group analysis found that the U18 team demonstrated significantly lower total WB on Day 8 after 2 consecutive match days (M4 and M5) ($p = 0.03$; ES = 0.56, large).

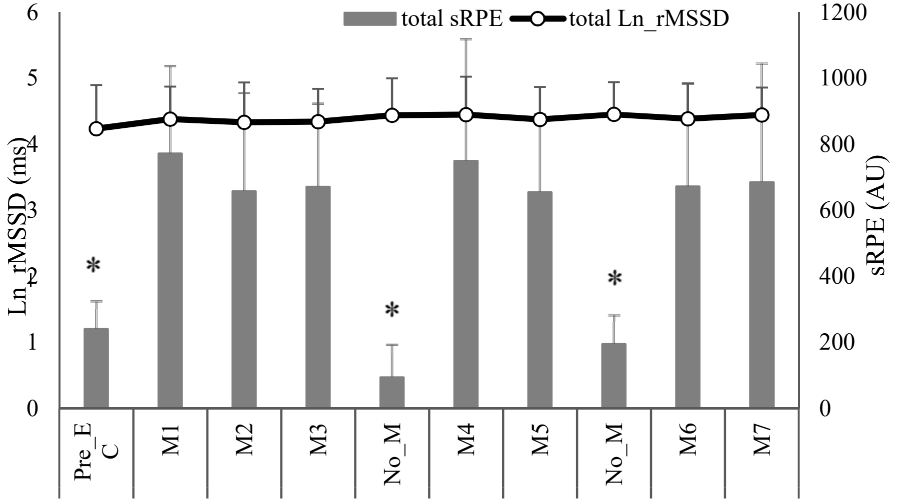


Note: * significant ($p < 0.05$) difference compared with Day 1; # significant ($p < 0.05$) difference compared with Day 4; & significant ($p < 0.05$) difference compared with Day 5; $ significant ($p < 0.05$) difference compared with U18. *Abbreviations:* M, match.

Figure 3.2. Well-being changes in U18 and U20 teams during the European Championships

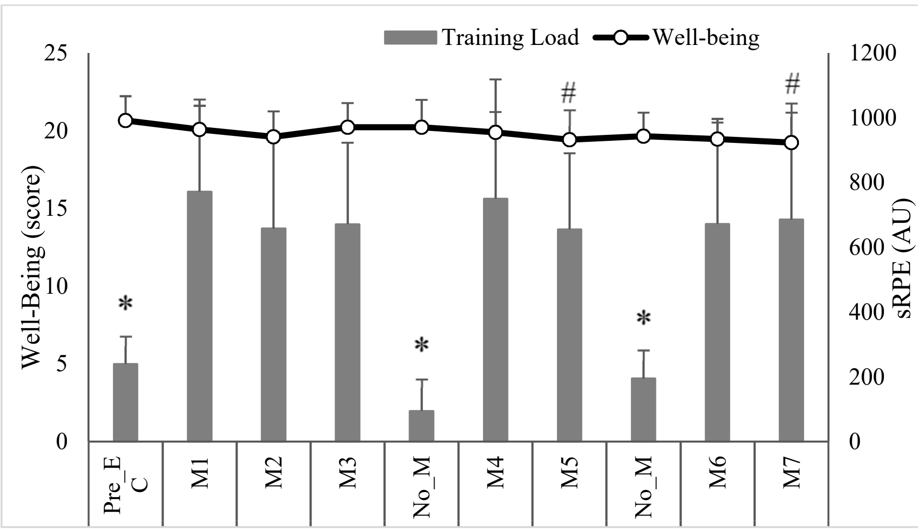
3.2.2. Combined team analysis

When the entire sample of 21 basketball players (combined U18 and U20 teams) was considered, we found significant between-day differences. Post hoc analysis revealed significantly lower ($p < 0.05$) sRPE workload on no-match days (Day 1, Day 5, Day 8) compared with match days (Day 2, Day 3, Day 4, Day 7, Day 9 and Day 10). Conversely, in response to this loading schedule, no significant changes in Ln_rMSSD ($p = 0.12$) for players from the combined U18 and U20 teams were detected during the whole EC (Figure 3.4). However, their total WB was significantly higher on Day 1 compared with Day 7 ($p = 0.03$) and Day 10 ($p = 0.04$) (Figure 3.3).



Note: * significant ($p < 0.05$) difference compared with match days (Day 2, Day 3, Day 4, Day 6, Day 7, Day 9, Day 10). *Abbreviations:* Ln_rMSSD, log-transformed data of root mean square of the successive differences; M, match; sRPE, workload calculated from session-rating of perceived exertion.

Figure 3.3. Heart rate variability and workload changes for players from U18 and U20 teams combined, during the European Championships



Note: * significant ($p < 0.05$) difference compared with match days (Day 2, Day 3, Day 4, Day 6, Day 7, Day 9, Day 10); # significant ($p < 0.05$) difference compared with Day 1. *Abbreviations:* M, match.

Figure 3.4. Well-being and workload changes for players from U18 and U20 teams combined during the European Championships

3.2.3. Between-cluster comparison

Players from both teams were grouped based on their average playing time during the tournament into Cluster 1 ($n = 16$) with an average playing time of 557.66 s and Cluster 2 ($n = 5$) with an average playing time of 1280.30 s. Between-cluster differences in workload and stress-response variables during the EC are displayed in Table 3.5. Cluster 2 showed higher sRPE workload ($p = 0.01$, ES = –0.78 (moderate), CI = –0.92; –0.41), efficiency ($p = 0.04$, ES = –1.14 (moderate), CI = –2.20; –0.06) and playing time ($p < 0.001$, ES = –2.66 (very large), CI = –3.95; –1.33), while no stress-response parameter differed significantly ($p > 0.05$).

3.2.4. Relationships

Spearman's rank coefficients for correlations between HRV, WB and training load parameters are presented in Table 3.6. Trivial to small correlations were observed between training load and stress response parameters.

Table 3.5. Between-cluster differences in workload and stress response variables during the European Championships

Variable	Cluster1 (n = 16)	Cluster2 (n = 5)	P value	LP	95 % CI for LP		ES	95 % CI for ES		Interpretation
					Lower	Upper		Lower	Upper	
Workload										
sRPE_WL (AU)*	497.62 ± 182.19; 568.10	685.10 ± 102.97; 645.30	**0.01**	-131.70	-377.00	-13.70	-0.78	-0.92	-0.41	Moderate
Playing time (s)	557.66 ± 297.36	1280.30 ± 136.96	< .001	-722.64	1013.80	431.42	-2.66	-3.95	-1.33	Very large
Playing quality										
Efficiency (AU)	6.64 ± 5.48	12.48 ± 3.47	**0.04**	-5.85	-11.34	-0.36	-1.14	-2.20	-0.06	Moderate
Readiness										
Ln_rMSSD (ms)	4.34 ± 0.51	4.54 ± 0.41	0.42	-0.204	-0.73	0.32	-0.42	-1.43	0.60	Moderate
WB total	20.00 ± 1.03	19.40 ± 1.45	0.31	0.60	-0.61	1.81	0.53	-0.49	1.54	Small
Fatigue	3.86 ± 0.23	3.80 ± 0.35	0.68	0.056	-0.22	0.33	0.22	-0.80	1.22	Moderate
Sleep	3.89 ± 0.43	3.72 ± 0.22	0.41	0.174	-0.25	0.60	0.44	-0.58	1.45	Small
Soreness	3.98 ± 0.16	3.70 ± 0.59	0.09	0.281	-0.05	0.61	0.92	-0.14	1.95	Moderate
Stress*	4.03 ± 0.32; 4.00	3.96 ± 0.17; 4.00	0.41	0.01	-0.20	0.20	0.25	-0.33	0.70	Small
Mood*	4.24 ± 0.34; 4.05	4.22 ± 0.44; 4.00	0.93	0.01	-0.20	0.40	0.03	-0.514	1.55	Trivial

Notes: data are presented as mean ± standard deviation; * nonparametric data is presented as mean ± standard deviation and median.
Abbreviations: sRPE_WL, workload calculated from session-rating of perceived exertion; Ln_rMSSD, log-transformed data of root mean square of the successive differences; WB, well-being; LP, location parameter (mean difference for parametric variables and Hodges–Lehmann estimate for nonparametric variables); CI, confidence interval; ES, effect size (Cohen’s d for parametric variables and r for nonparametric variables).

Table 3.6. Spearman's rank coefficients for correlations between heart rate variability, well-being and training-load parameters

	sRPE workload (AU)			**Playing time(s)**			**Efficiency (AU)**			**Ln_rMSSD (ms)**		
	P-value	Rho	Interpretation	P-value	Rho	Interpretation	P-value	Rho	Interpretation	P-value	Rho	Interpretation
Ln_rMSSD	0.349	-0.070	Trivial	0.386	-0.063	Trivial	0.300	0.090	Trivial	–	–	–
Fatigue	0.151	-0.107	Small	0.315	-0.073	Trivial	0.732	0.030	Trivial	0.647	0.033	Trivial
Sleep	0.792	-0.020	Trivial	0.848	0.014	Trivial	0.460	0.064	Trivial	0.628	-0.035	Trivial
Soreness	**0.019**	-0.175	Small	**0.011**	-0.184	Small	0.516	0.057	Trivial	0.068	-0.133	Small
Stress	0.552	-0.045	Trivial	0.564	-0.042	Trivial	0.369	0.078	Trivial	0.280	0.079	Trivial
Mood	0.162	-0.104	Small	0.352	-0.068	Trivial	0.875	0.014	Trivial	**0.045**	0.146	Small
WB total	**0.044**	-0.150	Small	0.184	-0.097	Trivial	0.630	0.042	Trivial	0.824	0.016	Trivial

Abbreviations: sRPE workload, previous day workload calculated from session-rating of perceived exertion; Ln_rMSSD, log-transformed data of root mean square of the successive differences; WB, well-being; Rho, Spearman's rank coefficient.

3.2.5. Discussion

The present study provides information on perceptual workload and readiness of female basketball players during a tournament with a congested match schedules tournament. Our main findings did not confirm the expectation that a congested match schedules would lead to significant impairments in objective HRV, however on a few days (i.e. Day 7 and Day 10) lower subjective WB was evident when EC progressed towards the end of the monitoring period. There were no differences in readiness between players exposed to long and short playing times. These findings suggest that young female basketball players coped well with the workload, and generally endorses the feasibility of the FIBA EC format. Moreover, correlations between objective and subjective variables of a player's workload, match performance and readiness proved to be trivial- to- small, indicating the need for using both objective and subjective methods in combination.

It was found that the tournament demands were similar for the U18 and U20 teams as there were no differences in sRPE workloads on match days. Both teams had lower sRPE workloads on the days with no matches, indicating rest or very easy training sessions. In addition, both teams monitored in this study were medallists at their respective championships (i.e. 1st place for U18 and 3rd place for U20), although their accomplishments were achieved differently. Indeed, the U18 team played more unbalanced matches with score differences ranging from 10 to 92 points compared to the U20 team, which played close matches with score differences ranging between 3 to 11 points (Figure 2.1). This result could allow U18 team coaches to substitute main players more frequently, thereby assuring that they were always ready to play, while the U20 team might have relied more on their main players. Despite this potential tactic, similar monitoring variables were observed regardless.

When considering the objective measures of HRV, it was previously demonstrated that low HRV values, which indicates the predominance of the sympathetic nervous system, are expected in athletes who are not tolerating their workload (Abad et al., 2016; Lukonaitienė et al., 2020). It was reported that an Ln_rMSSD value of 4.5 ms indicates optimal performance in sprinters (Peterson, 2018) and in female basketball players (Lukonaitienė et al., 2020). In our study, we found that both U18 and U20 female teams demonstrated no statistically significant changes in daily HRV across the EC compared to pre-match day. Moreover, as the

U18 team tended to advance during the tournament these values became closer to the proposed optimal values (Ln_rMSSD 4.27 ms on Day 10) (Lukonaitienė et al., 2020; Peterson, 2018). The lack of a decrease in HRV indicates sufficient recovery of the players during the EC in both U18 and U20 teams. In agreement with these findings, no changes were observed in lacrosse athletes during a congested match tournament scenario of 7 matches in 8 days (Hauer et al., 2020). It should be noted that, to the best of our knowledge, this is the first study in basketball to compare players' HRV changes during a congested match schedules in youth female basketball, making our findings difficult to compare.

Consistently with the HRV results, no changes in WB were observed in the U20 team during the tournament, but the U18 team had lower total WB in the second half of the tournament compared with the beginning. The lower total WB for U18 compared with the U20 team was observed on Day 8 after two consecutive match days with the first lost game for U18 in on Day 7. The observed decrease in WB values might have been influenced by psychological stress felt by U18 players since they lost their first match after four consecutive wins with unbalanced scores (≥ 16 point score difference). Differently, U20 players had a similar level of opponents from the beginning of the EC considering the close match scores (Figure 2.1). Additionally, this result might be explained by the influence of contextual variables such as team skills, opponent ability, social environment, and competition environment (Mellalieu, Neil, Hanton, & Fletcher, 2009) during the two different tournaments.

The combined team analysis including the entire sample of players from both teams allowed us better understand the effect of a congested match schedule of 7 matches in 9 days. A lack of difference in HRV but a lowered WB at the end of the tournament shows the greater sensitivity of subjective WB over objective HRV (Hauer et al., 2020). These findings are consistent with those of Hauer et al. (2020), who found no changes for male lacrosse athletes in HRV, although the scores from WB questionnaires were lower at the end of the tournament. This notion might suggest that although the rest days during the tournament are sufficient for physiological recovery, the players' well-being might be affected towards the end of the tournament, with the most important matches still ahead.

Match demands and playing times for each individual player depend on their playing position, tactical decisions and player rotation (Conte & Lukonaitiene, 2018; Ferioli et al., 2020b; Puente et al., 2017). Therefore, we expanded our analysis by clustering players based on their average playing time during the whole tournament. The cluster of players who played more demonstrated a very large difference in average playing time (1280 s vs 558 s) and moderately better efficiency (12.5 AU vs 6.6 AU) than the players in the cluster with less playing time. Naturally, the daily sRPE workload of the clusters also differed, with averages of 685 AU and 498 AU for the higher and lower playing-time clusters, respectively. Despite this dissimilarity, the workload seemed to be optimal for players in both clusters because no difference was detected in any readiness variable. This finding might indicate that players with longer playing time could have better fitness and recovery capacities and ability to cope with higher workloads comparing with players experiencing shorter playing time.

Consistent with the findings of previous studies (Ferioli et al., 2020a; Hauer et al., 2020; Puente et al., 2017), we found no relationships between the monitored variables of workload, readiness and match performance, except the relationships between soreness and sRPE workload from the previous day and playing time. This is understandable because players whose playing time is longer execute more actions, thus possibly inducing greater muscle damage (Pliauga et al., 2015). Similar results were observed by Clemente et al. (2020) during a study of a congested period of training for male futsal players in which it was found that muscle soreness and fatigue moderately correlated with sPRE reported from the previous day (Clemente et al., 2020). Moreover, Sansone et al. (2018) demonstrated negative relationships between training load and perceptual recovery in female basketball players throughout the competitive season at daily, weekly and mesocycle levels. In addition, the objective measurement of Ln_rMSSD showed a small correlation with subjective mood, but did not correlate with the workload, playing time and efficiency statistic. It has been showned, that HRV is affected by both physiological and psychological stimulus (Conte et al., 2018); therefore the changes in mood might affect the values of HRV (Carr et al., 2017).

The present study had some limitations. Although several monitoring methods were employed, future studies might provide more insightful information if objective external load measurement using microsensors and internal biochemical markers were included (Bredt et al., 2020; Sansone et al., 2018). In addition, the use of objective measures for sleep quality and duration, diet, fluid, and food supplementation could expand the interpretation of changes in WB observed during the study.

3.3. Workload and well-being across games played on consecutive days during in-season phase in basketball players

3.3.1. Workload changes

Mean ± SD workload measures during total time in games played on Day 1 and Day 2 are displayed in Table 3.7. A significantly higher total time ($p < 0.001$; ES = large) was evident on games on Day 2 compared to Day 1, while no statistically significant differences ($p > 0.05$) between games were found for workload measures with trivial-to-small ES (Table 3.7.).

Mean ± SD workload measures during actual time in games played on Day 1 and Day 2 are shown in Table 3.8. No significant difference ($p > 0.05$; ES = small) was evident in actual time between games played on Day 1 and Day 2 (Table 3.8). Although there were no statistically significant differences in PL ($p > 0.05$) between games, a significantly lower PL/min ($p = 0.03$; ES = small) was observed in games played on Day 2 compared to Day 1. No significant differences ($p > 0.05$; ES = trivial-small) were apparent for any internal workload variable.

3.3.2. Well-being changes

Mean ± SD well-being measures taken prior to games played on Day 1 and Day 2 are presented in Table 3.9. Higher levels of fatigue were evident on Day 2 compared to Day 1 ($p < 0.001$; ES = large), while no significant differences ($p > 0.05$; ES = trivial-small) were shown for sleep, soreness, stress and mood. However, a lower total well-being score ($p < 0.001$; ES = small) was observed on Day 2 compared to Day 1.

Table 3.7. External and internal workloads during total game time in the first and second games played on two consecutive days

Dependent variable	Day 1	Day 2	P value	Fixed effect estimate (95 % CI)	Effect size (95 % CI)	Interpretation
Time						
Total time (min)	94.35 ± 4.29	98.00 ± 39.17	**< 0.001**	-4.05 (-6.18; -1.91)	-1.20 (-1.86; -0.53)	Large
External load						
PL (AU)	531.20 ± 148.85	532.87 ± 157.17	0.836	-1.67 (-98.47; 95.13)	-0.01 (-0.62; 0.60)	Trivial
PL/min (AU/min)	5.62 ± 1.55	5.41 ± 1.61	0.601	0.21 (-0.79; 1.21)	0.14 (-0.48; 0.75)	Trivial
Internal load						
$\%HR_{max}$	71.26 ± 6.02	68.20 ± 8.85	0.161	3.06 (-1.74; 7.87)	0.40 (-0.22; 1.02)	Small
SHRZ (AU)	251.26 ± 57.17	233.03 ± 83.72	0.322	18.23 (-27.29; 63.74)	0.25 (-0.36; 0.87)	Small
sRPE-WL (AU)	763.85 ± 210.00	837.07 ± 218.65	0.128	-73.22 (-208.77; 62.33)	-0.34 (-0.96; 0.28)	Small

Notes: data presented as mean ± standard deviation; three games were played on Day 1 and three games were played on Day 2 across the sample period. *Abbreviations*: CI, confidence interval; PL, AU, arbitrary unit; player load; PL/min, player load per minute; $\%HR_{max}$, percentage of maximum heart rate; SHRZ, summated heart rate zones; sRPE, session-rating of perceived exertion.

Table 3.8. External and internal workloads during actual game time in the first and second games played on two consecutive days

Dependent variable	Day 1	Day 2	P value	Fixed effect estimate (95 % CI)	Effect size (95 % CI)	Interpretation
Time						
Actual time (min)	37.39 ± 11.97	41.34 ± 15.93	0.170	-3.95 (-12.74; 4.84)	-0.28 (-0.89; 0.33)	Small
External load						
PL (AU)	442.84 ± 146.34	457.70 ± 162.50	0.523	-14.87 (-112.72; 82.98)	-0.10 (-0.71; 0.52)	Trivial
PL/min (AU)	11.63 ± 1.46	11.22 ± 1.73	**0.029**	0.41 (-0.60; 1.43)	0.26 (-0.36; 0.87)	Small
Internal load						
%HR_{max}	84.99 ± 5.49	82.07 ± 8.63	0.127	2.92 (0.13; 2.92)	0.40 (-0.22; 1.02)	Small
SHRZ (AU)	154.27 ± 57.75	153.53 ± 72.50	0.944	0.74 (-40.80; 42.28)	0.01(-0.60; 0.62)	Trivial
sRPE-WL (AU)	313.69 ± 139.73	372.65 ± 187.62	0.089	-58.96 (-162.13; 44.22)	-0.36 (-0.96; 0.26)	Small

Notes: data presented as mean ± standard deviation; three games were played on Day 1 and three games were played on Day 2 across the sample period. *Abbreviations*: CI, confidence interval; PL, AU, arbitrary unit; player load; PL/min, player load per minute; %HRmax, percentage of maximum heart rate; SHRZ, summated heart rate zones; sRPE, session-rating of perceived exertion.

Table 3.9. Well-being changes between the first and second games played on two consecutive days

Dependent variable	Day 1	Day 2	P value	Fixed effect estimate (95 % CI)	Effect size (95 % CI)	Interpretation
Fatigue (AU)	3.57 ± 1.03	2.33 ± 0.86	< **0.001**	1.24 (0.65; 1.83)	1.31 (0.63; 1.97)	Large
Sleep (AU)	3.62 ± 0.97	3.76 ± 0.89	0.510	-0.14 (-0.72; 0.44)	-0.15 (-0.76; 0.45)	Trivial
Soreness (AU)	3.14 ± 1.01	2.67 ± 1.02	0.082	0.48 (-0.16; 1.11)	0.47 (-0.15; 1.08)	Small
Stress (AU)	4.14 ± 0.85	3.81 ± 0.81	0.100	0.33 (-0.19; 0.85)	0.40 (-0.21; 1.01)	Small
Mood (AU)	3.67 ± 0.97	3.57 ± 0.81	0.367	0.10 (-0.46; 0.65)	0.11 (-0.50; 0.71)	Trivial
Total well-being (AU)	18.14 ± 3.72	16.14 ± 2.99	< **0.001**	2.00 (-0.10; 4.10)	0.59 (-0.03; 1.21)	Small

Notes: data presented as mean ± standard deviation; three games were played on Day 1 and three games were played on Day 2 across the sample period. *Abbreviations*: CI, confidence interval; AU, arbitrary unit.

3.3.3. Discussion

The aim of this study was to quantify and compare workload and well-being across basketball games played on consecutive days during the in-season phase. Our findings revealed trivial-to-small differences in workload between games, while players perceived higher (large) levels of fatigue prior to the second game compared to the first game, which in turn significantly inflated (small) well-being status.

Previous investigations assessing changes in external workload across games played in close succession have mainly focused on basketball tournaments rather than during regular in-season competitive phases (Klusemann et al., 2013; Pino-Ortega et al., 2019). In turn, studies examining game workloads during basketball tournaments revealed an increase in high-intensity actions in games towards the end of the tournament compared to the beginning of the tournament (Klusemann et al., 2013; Pino-Ortega et al., 2019). In contrast, our data showed similar external workload volume (PL) and intensity (PL/min) during total time between games played on Day 1 and Day 2 during the in-season phase. A possible reason for variations in findings between studies might be that in a tournament scenario, teams usually face stronger opponents towards the end of the tournament, whereas our analysis considered opposition ranking, game location and final score difference, which can potentially influence player workloads during games played across the regular in-season phase (Esteves, Mikojajec, Schelling, & Sampaio, 2020; Fernández-Leo, Gómez-Carmona, García-Rubio, & Ibáñez, 2020). Nevertheless, our results are in line with a previous investigation assessing the workloads encountered across games played on consecutive days during the in-season phase in semi-professional, male basketball players (Fox et al., 2020). Indeed, Fox et al. (2020) showed similar game workloads when 1–3 games were played each week during the in-season phase with trivial-small differences in PL and PL/min across total game time. These results overlap with our findings, which showed trivial differences in PL/min between games (5.62 [1.55] AU/min vs 5.41 [1.61] AU/min) compared to data reported by Fox et al. (game 1: 5.34 [1.77] AU/min; game 2: 5.71 [1.71] AU/min; game 3: 5.39 [2.26] AU/min) (Fox et al., 2020). Interestingly, the present study and the study conducted by Fox et al. (2020) included semi-professional, male players, although competing in different geographical areas (Europe and Australia) and with different training schedules. Nevertheless, these results across studies might collectively provide benchmark values for the intensity of games played on consecutive days, which can inform the design of sound training plans by basketball coaches when preparing for upcoming congested game schedules.

It is important to note that Fox et al. (2020) provided no data relative to actual playing time during games played on consecutive days. Consequently, the players investigated by Fox et al. (2020) might have accumulated different on-court playing times, which in turn may have influenced their workloads when active on the court (Fernández-Leo et al., 2020). To overcome this issue, we analyzed player workloads during actual game time, and showed non-significant, trivial-small differences in most measures between games played on Day 1 and Day 2. However, it should be noted that a statistically significant decrease in PL/min was found in Day 2 compared to Day 1, underlining a possible decrease of the game intensity when players actively participate on the court. The added analysis of game workloads during live time might provide a more precise estimation of workload volumes and intensities players experience during games played in close succession, further guiding player preparation strategies developed by coaches leading into congested periods of the in-season phase.

In addition to external workload data, internal workload data are essential to understand how players are responding to imposed stimuli during games. The investigated internal workload measures mirrored the external workload measures with trivial-small differences in %HRmax, SHRZ workload, and s-RPE during total and actual time between games played on Day 1 and Day 2. These results are in line with those reported in previous basketball investigations assessing internal workload across games played in close succession during the in-season phase (Fox et al., 2020) and in a tournament scenario (Klusemann et al., 2013). Overall, our complete workload dataset encompassing external and internal measures highlighted similar workload volumes and intensities are experienced across games played on consecutive days suggesting no development of performance fatigue. A possible explanation for the lack of decline in workload measures between games might be that basketball coaches likely implement substitutions due to tactical strategies resulting in players accumulating an average playing time of 22.8 [8.0] min, which represents the 57 % of the game live time (i.e. 40 min). Perhaps, players in other teams (to that investigated in this study) might complete more playing time during games and thus being more susceptible to fatigue responses in subsequent games, which emphasizes the need for more studies on this topic in basketball.

In opposition to the predominantly similar workloads evident across games played on consecutive days, the investigated players perceived increased fatigue prior to the second game compared to the first game. Therefore, the prior workload performed during Day 1 might have impacted player perceived fatigue when needing to compete on the subsequent day. To the best of our knowledge, this is the first study assessing perceived fatigue in basketball players across games played in close succession making our findings difficult to compare with other research. However, our results were somewhat expected since previous investigations showed increased perceived fatigue immediately after basketball games with the effect maintained across the following 24 h (Delextrat, Calleja-González, Hippocrate, & Clarke, 2013; Delextrat et al., 2014). Since our well-being questionnaire was administered after awakening before each game, an increase in perceived fatigue on Day 2 might be expected given it was assessed ~12 h after the first game. In general, the contrasting results between performance and perceived fatigue underlines the necessity for basketball practitioners to monitor both components of fatigue for a global understanding of fatigue status in players.

In contrast to previous investigations showing a statistically significant increase in muscle soreness immediately after basketball games and in the following 24 h (Delextrat et al., 2013, 2014), our results revealed a small increase in muscle soreness between Day 1 and Day 2. A possible reason for variations in findings between our study and past investigations might be the different training volume experienced by the investigated players. Indeed, in our study, players completed three 90-min training sessions and three games (one LSKL and two NKL games), while in past studies (Delextrat et al., 2013, 2014), participants completed three 120-min basketball sessions and one match per week. Therefore, higher-trained players might perceive less muscle soreness following a game rather than their lower-trained counterparts. In this regard, further investigations assessing changes in muscle soreness following games, especially during congested schedules, should consider high- and low-trained players in separate analyses (Delextrat et al., 2013, 2014). It should be noted that no differences were found in other well-being scores (stress, mood and sleep quality), while the total well-being score significantly (small) worsened on Day 2 compared to Day 1. We can speculate that the change in total well-being between days was predominantly influenced by the greater perceived fatigue on Day 2, supporting the monitoring and interpretation of each item separately when assessing player well-being across the in-season phase.

While this study provided several interesting findings regarding workload and well-being across basketball games played on consecutive days during the in-season phase, it was subject to some limitations that warrant discussion. Firstly, our sample size was representative of a single team competing in a Lithuanian basketball league. Therefore, the results of this study are unlikely generalizable to other teams playing in different leagues exposed to different game schedules. Secondly, due to the small sample size (n = 7), it was not feasible to separate our data based on factors that may influence game demands such as playing position (guards vs forwards vs centers) (Pino-Ortega et al., 2019) or playing time (starting vs bench players) (Conte et al., 2018). Thus, future studies should include a larger sample size to allow analyses considering these factors. Finally, in the current study, only changes in physical, physiological and perceived demands were assessed, while future studies should focus on the analysis of changes in technical performances across consecutive games.

Basketball practitioners are suggested to monitor changes in workload across consecutive games during the in-season phase to best identify the development of performance fatigue. Furthermore, concurrent assessment of player well-being using questionnaires to monitor, among other psychological components, the perceived fatigue may be particularly important during congested game schedules. In particular, despite some limitations such as relying on subjective information and the lack of validity and reliability studies specifically in basketball, well-being questionnaires are cost-effective, easy to administer and in conjunction with workload monitoring tools can provide insight about how players are coping with imposed game workloads (Edwards et al., 2018). Finally, considering the higher perceived fatigue we observed prior to the second game compared to the first game during congested schedules, basketball practitioners should consider adopting suitable between-game recovery strategies which might enhance perceived fatigue in players and in turn optimize preparation leading into subsequent games during congested schedules (Edwards et al., 2018; Delextrat et al., 2013, 2014).

CONCLUSIONS

1. The main findings indicate that a constant adequate workload positively benefits players' readiness and physical performances during short intensified preparation periods. Conversely, the use of high workload with a periodization strategy encompassing short overload and taper phases induced positive changes on players' aerobic performance, lower readiness values and no changes in anaerobic performances. These findings seem fundamental for youth female basketball coaches and practitioners to optimize their training periodization during short intensified preparation periods.

2. This study showed that a schedule of 7 matches in 9 days was suitable loading for junior female basketball players irrespective of the competition context or individual differences in workload. This might reflect a high level of player preparedness, optimal player rotation or adequate intensity demands during basketball matches. These factors should be considered to avoid performance deterioration during tournaments with a congested match agenda. Moreover, the use of a combination of objective and subjective methods should be recommended because it provides different information about load and readiness.

3. A congested match schedule with two games played on consecutive days elicited similar game workloads with higher perceived fatigue and lower well-being status prior to the second game compared to the first game. These findings suggest basketball coaches and practitioners using recovery strategies to optimize player well-being during congested game schedules.

SANTRAUKA
SANTRUMPOS

U18	–	18 metų arba jaunesnių krepšininkių nacionalinė rinktinė
U20	–	20 metų arba jaunesnių krepšininkių nacionalinė rinktinė
EČ	–	Europos čempionatas
JK	–	judėjimo krūvis (angl. *player load* – PL)
JK/min.	–	judėjimo krūvis per minutę (angl. *player load/min* – PL/min)
PI	–	pastangų indeksas (angl. *rating perceived exertion* – RPE)
PK	–	pratybų krūvis (angl. *session rating perceived exertion* – sRPE)
ŠSDV	–	širdies susitraukimų dažnio variabilumas (angl. *heart rate variability* – HRV)
rMSSD	–	RR intervalų vidutinio kvadratinio skirtumo šaknis (angl. *square root of the mean sum of squared differences between adjacent normal RR intervals*)
Ln_rMSSD	–	logaritmiškai transformuotas rMSSD
VŠ	–	vertikalus šuolis (angl. *countermovement jump* – CMJ)
YYPA1	–	Yo-yo protarpinio atsigavimo 1 lygio testas (angl. *yo-yo intermittent recovery 1 test* – YYRI)
SV	–	sąlyginiai vienetai (angl. *arbitrary units* – AU)
ŠSD	–	širdies susitraukimų dažnis per minutę (angl. *heart rate* – HR)
ŠSDvid	–	vidutinis širdies susitraukimų dažnis per minutę (angl. *mean heart rate* – HRmean)
ŠSDmax	–	didžiausiasis širdies susitraukimų dažnis per minutę (angl. *maximum heart rate* – HRmax)
%ŠSDmax	–	didžiausiojo širdies susitraukimų dažnio išraiška procentais (angl. *%HRmax*)
KIK	–	kintamo intensyvumo krūvis (angl. *training impulse* – TRIMP)
ŠSDZ	–	susumuotos širdies susitraukimų dažnio zonos (angl. *summated heart rate zones* – SHRZ)

ĮVADAS

Komandinių sporto šakų atletai nuolat patiria didelį treniruočių ir rungtynių krūvį, kurio tikslas – pagerinti fizinį pajėgumą ir įgūdžius aikštėje (Kelly et al., 2020; Kniubaite et al., 2019; Marrier et al., 2019; Nakamura et al., 2017; Pliauga et al., 2018). Atitinkamos rūšies ir intensyvumo fizinis krūvis metinės treniruočių periodizacijos metu lemia įvairius fiziologinius pokyčius, gerina nervų, raumenų bei širdies ir kraujagyslių sistemos veiklą (Mohr & Krustrup, 2014; Oliveira et al., 2013). Tam tikrais tarpsniais sportininkams sąmoningai taikomi per dideli treniruočių ar rungtynių krūviai (pasirengimo stovyklos, intensyvūs rungtynių laikotarpiai). Tokie itin intensyvūs treniruočių ir varžybų laikotarpiai yra ne tik neišvengiami, bet ir būtini, kad sportininkai galėtų tobulėti, prisitaikytų prie aukštesnio lygio rezultatų (Cunanan et al., 2018). Kita vertus, jei atsigavimas po krūvio yra nepakankamas, sportininkas gali patekti į nefunkcinę persitempimo ar pervargimo būseną, o tai reiškia pablogėjusius sportinius rezultatus ir padidėjusią traumų riziką (Bosquet et al., 2003; Edwards et al., 2018; Meeusen et al., 2013; Weiss et al., 2017). Todėl optimalaus krūvio taikymas ir nuovargio valdymas yra vieni iš svarbiausių treniruočių krūvio periodizacijos tikslų (Bompa & Buzzichelli, 2018; Cunanan et al., 2018; Issurin, 2010; Nunes et al., 2014; Taylor et al., 2012).

Krepšinis pasižymi dideliais fiziniais ir fiziologiniais poreikiais (Conte et al., 2015; Fox et al., 2018; Sansone et al., 2019; Scanlan et al., 2015; Stojanović et al., 2018), perpildytais įvairių krepšinio lygų rungtynių tvarkaraščiais sezono metu, kai dažnai iš eilės žaidžiama daug rungtynių (Conte et al., 2018; Fox et al., 2020). Be to, nacionalinės krepšinio komandos dažnai dalyvauja tarptautiniuose turnyruose, pvz., Europos čempionatuose (EČ) – tai vienos prestižiškiausių varžybų, pasižyminčios perpildytu varžybų tvarkaraščiu, kai per trumpą laiką sužaidžiama daug rungtynių (Conte & Lukonaitiene, 2018). Krepšininkams, priklausantiems šalies rinktinėms, prieš tokias varžybas rengiamos intensyvios stovyklos, siekiant per trumpą laiką parengti juos būsimam EČ. Taigi intensyvūs periodai krepšininkams yra būtini, tačiau labai svarbu stebėti šiuos laikotarpius, siekiant padėti treneriams padidinti ar išlaikyti žaidėjų pajėgumą (Edwards et al., 2018; Russell et al., 2020). Objektyvių ir subjektyvių krūvio bei parengties varžytis (treniruotis) vertinimo metodų taikymas gali suteikti tikslesnės informacijos, kaip žaidėjai reaguoja į suintensyvėjusias treniruotes ir rungtynių reikalavimus. Tai labai aktualu krepšininkams ir jų treneriams (Aoki, Arruda et al., 2017; Edwards et al., 2018; Fox et al., 2017; Nunes et al., 2014; Sansone et al., 2018).

Pastaruoju metu mokslinėje literatūroje daugiausia dėmesio skiriama parengiamojo laikotarpio periodizacijai, dažniausiai tiriami suaugę vyrai, žaidžiantys įvairiuose klubuose, nustatomas žaidėjų krūvis, patiriamas dėl skirtingų periodizavimo strategijų parengiamuoju laikotarpiu (t. y. prieš sezoną, trunka 5–7 savaites) (Ferioli et al., 2018a, b; Pliauga et al., 2018). Periodizuotų treniruočių strategijose taikomi perkrūvių (t. y. intensyvesni parengiamieji) ir mažėjančio intensyvumo (t. y. atsigavimo) periodai (Bompa & Buzzichelli, 2018; Nunes et al., 2014; Pliauga et al., 2018). Nacionalinės rinktinės pradeda pasirengimą ir varžosi EČ vasarą – perėjimo ir poilsio laikotarpiu po reguliaraus klubų sezono (Bompa & Buzzichelli, 2018). Nunes ir kt. (2014) stebėjo nacionalinę Brazilijos moterų krepšinio rinktinę 12 savaičių parengiamuoju laikotarpiu, kuriame buvo 2 perkrūvių ir atsigavimo periodai, ruošiantis tarptautiniam turnyrui. Rezultatai parodė, kad šis periodizavimo metodas padidino sportininkų jėgą, galingumą, vikrumą ir ištvermę, nes buvo tinkamai paskirstytas krūvis (Nunes et al., 2014). Tačiau manipuliavimas perkrūviais ir atsigavimo laikotarpiais sunkiau pritaikomas trumpesniais parengiamaisiais laikotarpiais (t. y. 3 savaičių parengiamasis laikotarpis prieš EČ). Be to, trūksta informacijos apie krūvį trumpais parengiamaisiais laikotarpiais prieš tarptautinį turnyrą. Todėl trenerių trumpu parengiamuoju laikotarpiu taikomos treniruočių metodikos gali ir teigiamai paveikti sportininkus, ir neturėti jokio poveikio jų rezultatams (Anderson et al., 2003; Ferioli et al., 2018a, b; Halson, 2014). Traumų atvejų padaugėja pradėjus intensyvesnį treniruočių laikotarpį, daugiausia per pirmąsias 2 savaites (Anderson et al., 2003). Ankstesnis tyrimas, kurio metu buvo tiriamas parengiamojo laikotarpio (trunkančio 4 savaites) pirmos dalies poveikis profesionaliems krepšinio klubo komandos žaidėjams, parodė greitumo, galingumo ir ištvermės rodiklių pagerėjimą (Aoki et al., 2017). Remiantis šiais rezultatais, ir trumpas intensyvus parengiamasis laikotarpis gali teigiamai paveikti žaidėjų sportinius rezultatus. Norint lyginti skirtingas periodizacijos strategijas, reikia atlikti tyrimus, kurių metu būtų analizuojamas optimalus krūvis trumpu intensyviu krepšinio komandų parengiamuoju laikotarpiu.

Idealiu atveju, po parengiamojo laikotarpio sportiniai rezultatai pasiekia piką ir išlieka varžybų laikotarpiu (Cunanan et al., 2018). Iš tiesų, sudėtingiausia yra išlaikyti geriausius rezultatus, kai yra perpildyti rungtynių tvarkaraščiai (Fox et al., 2020; Klusemann et al., 2013; Pino-Ortega et al., 2019). Ankstesni tyrimai parodė išorinio (t. y. žaidimo dirgiklių) ir vidinio (t. y. fiziologinių ar suvokimo reakcijų į dirgiklius) krūvio mažėjimą iš eilės žaidžiamų varžybų metu (Fox et al., 2020; Klusemann et al., 2013; Pino-Ortega et al., 2019). Viename tyrime daugiausia dėmesio buvo skiriama žaidėjų individualaus krūvio pokyčiams, analizuojant 1–3 rungtynes, žaidžiamas iš eilės sezono metu, nustatyti nereikšmingi arba maži išorinio ir vidinio krūvio skirtumai (Fox et al., 2020). Tačiau tai yra tik vienos – Australijos antrosios – krepšinio lygos tyrimo rezultatai, kitoms lygoms gali būti taikomas kitoks tvarkaraštis, periodizavimo strategijos ir žaidimų krūviai, todėl reikia atlikti daugiau tyrimų, norint įvertinti rungtynių krūvį, žaidėjų parengties varžytis (treniruotis) įvairių perpildytų tvarkaraščių metu (7 rungtynės per 9 dienas EČ metu, 2 rungtynės iš eilės sezono metu) ar nuovargį, kurį patiria žaidėjai.

Hipotezė: intensyvūs periodai neigiamai veikia krepšininkų parengtį rungtyniauti ir treniruotis.

Tyrimo tikslas – įvertinti krūvio ir parengties varžytis kaitą įvairiais intensyviais krepšinio laikotarpiais.

Tyrimo uždaviniai:

1. Ištirti krepšininkų krūvio ir parengties varžytis kaitą 3 savaičių intensyvaus pasirengimo Europos čempionatui laikotarpiu.

2. Ištirti krepšininkų krūvio ir parengties varžytis kaitą esant intensyviam Europos čempionato rungtynių tvarkaraščiui.

3. Nustatyti ir palyginti krepšininkų krūvį ir savijautą, sezono metu žaidžiant 2 rungtynes iš eilės.

Tyrimo praktinė reikšmė

Naujos tyrimų išvados galėtų suteikti informacijos krepšinio treneriams ir praktikams, kaip per trumpus, intensyvius pasirengimo tarptautiniams turnyrams laikotarpius parinkti tinkamą krūvį. Įvertinus rungtynių pokyčius perpildytų rungtynių tvarkaraščių metu, galima manipuliuoti atsigavimo tarp rungtynių strategijomis. Taip pat šie tyrimai gali suteikti informacijos apie krūvį ir parengtumo rodiklius, kurie vėliau galėtų būti naudojami kaip orientaciniai rodikliai, planuojant treniruočių procesą ir priimant pagrįstus žaidėjų rotacijos sprendimus rungtynių metu.

1. TYRIMO METODIKA IR ORGANIZAVIMAS

1.1. Tiriamieji

Buvo tirti šešiasdešimt du krepšininkai – vyrai ir moterys. Visiems žaidėjams buvo paaiškinti tyrimo tikslai ir eiga, pateikta užpildyti rašytinė sutikimo dalyvauti tyrime forma (jei tiriamieji buvo jaunesni nei 18 metų, forma pateikta jų globėjams). Leidimas atlikti tyrimą gautas iš Kauno regioninio biomedicininių tyrimų etikos komiteto (leidimo Nr. BE-2-97), tyrimas atliktas laikantis Helsinkio deklaracijoje išdėstytų principų.

Dalyvauti **pirmajame** tyrime buvo pakviestos 28 krepšininkės, žaidžiančios Lietuvos U18 ir U20 rinktinėse. Tyrimą baigė 24 šios grupės žaidėjos, keturios (po dvi iš kiekvienos komandos) nebaigė pasirengimo Europos čempionatui (1.1 lentelė).

Į **antrąjį** tyrimą buvo pakviestos 24 krepšininkės. Ištirta 21, nes viena žaidėja žaidė abiejose komandose, o dviem nepavyko surinkti visų tyrimo duomenų (1.1 lentelė).

Dalyvauti **trečiajame** tyrime buvo atrinkta 10 vyrų, žaidžiančių Nacionalinėje krepšinio lygoje (NKL). Tyrime dalyvavo tik tie žaidėjai, kurie dalyvavo visose rungtynėse, per kiekvienas rungtynes žaidė ± 10 min. (vidutinis laikas – 22,8 ± 8,0 min.) ir tyrimo laikotarpiu nepatyrė traumų (Ferioli et al., 2020b). Dalyvavimo tyrime kriterijus atitiko septyni žaidėjai (1.1 lentelė).

1.1 lentelė. Tiriamųjų charakteristikos

Tyrimas	Tiriamieji (n)	Charakteristikos
1. Moterų iki 18 ir 20 metų krepšinio komandų krūvio, parengties varžytis ir fizinio pajėgumo pokyčiai 3 savaičių intensyviu parengiamuoju laikotarpiu	Lietuvos krepšininkių U18 rinktinė (n = 12)	amžius – 18,0 ± 0,5 m.; ūgis – 180,4 ± 7,5 cm; kūno masė – 72,7 ± 9,3 kg; treniravimosi stažas – 9,3 ± 2,3 m.
	Lietuvos krepšininkių U20 rinktinė (n = 12)	amžius – 19,6 ± 0,8 m.; ūgis – 178,6 ± 6,4 cm; kūno masė – 68,0 ± 5,9 kg; treniravimosi stažas – 9,1 ± 1,9 m.
2. Jaunų krepšininkių parengtis varžytis ir krūvis, esant perpildytam rungtynių tvarkaraščiui EČ	Lietuvos krepšininkių U18 rinktinė (n = 10)	amžius – 18,0 ± 0,4 m.; ūgis – 179,9 ± 6,6 cm; kūno masė – 70,2 ± 5,1 kg; treniravimosi stažas – 9,1 ± 1,8 m.
	Lietuvos krepšininkių U20 rinktinė (n = 11)	Amžius – 20,5 ± 2,9 m.; ūgis – 178,4 ± 8,8 cm; kūno masė – 73,0 ± 9,7 kg; treniravimosi stažas – 9,6 ± 2,4 m.
3. Krepšininkų krūvis ir savijauta sezono metu, rungtyniaujant dvi dienas iš eilės	NKL (n = 7, vyrai)	amžius – 20,8 ± 1,6 m.; ūgis – 195,0 ± 5,4 cm; kūno masė – 88,3 ± 4,2 kg; treniravimosi stažas – 11,6 ± 3,7 m.

1.2. Tyrimo procedūros

Visų tyrimų procedūros pateiktos 1.2 lentelėje.

1.2 lentelė. Skirtingų tyrimų procedūros

Tyrimas	Procedūros
1. Moterų iki 18 ir 20 metų krepšinio komandų krūvio, parengties varžytis (treniruotis) ir fizinio pajėgumo pokyčiai 3 savaičių intensyviu parengiamuoju laikotarpiu	Judėjimo krūvis (JK) Kintamo intensyvumo krūvis (KIK) Pratybų krūvis (PK) Monotonija ir įtampa Širdies susitraukimų dažnio variabilumas (ŠSDV) Savijautos vertinimas Vertikalus šuolis (VŠ) 20-m sprinto testas (įskaitant 10 m pertrauką) Yo-yo protarpinio atsigavimo 1 lygio testas (YYPA1)
2. Jaunų krepšininkių parengtis varžytis ir krūvis, esant perpildytam rungtynių tvarkaraščiui EČ	Pratybų krūvis (PK) Širdies susitraukimų dažnio variabilumas (ŠSDV) Savijautos vertinimas
3. Krepšininkų krūvis ir savijauta sezono metu, rungtyniaujant dvi dienas iš eilės	Judėjimo krūvis (JK) Suminės širdies susitraukimų dažnio zonos (ŠSDZ) Pratybų krūvis (PK) Savijautos vertinimas

1.2.1. Judėjimo krūvis (angl. PlayerLoad)

Išorinis treniruočių krūvis buvo matuotas *Catapult OptimEye S5* įrenginiais (Catapult Innovations, Melbourne, Australia). Prieš kiekvieną treniruotę ar draugiškas rungtynes visiems žaidėjams buvo išdalijamos po sportine apranga dėvimos liemenės su mikrojutikliais, pritvirtintais tarp menčių. Judėjimo krūvis (JK) registruoja judėjimą triašėje plokštumoje (sagitaliojoje, frontaliojoje, vertikaliojoje), taip įvertinamas žaidėjų visų pratybų judėjimo krūvis: JK = [√(Ac1 n – Ac1 n1) 2 + (Ac2 n – Ac2 n – 1) 2 – (Ac3 n – Ac3 n – 1) 2]/0,01, kai Ac1, Ac2 ir Ac3 yra sagitalusis, frontalusis ir vertikalusis judėjimas, matuojami triašiu akselerometru, o 0,01 – matavimo dažnis (Fox et al., 2018).

1.2.2. Kintamo intensyvumo krūvis (KIK) (angl. TRIMP) ir suminės širdies susitraukimų dažnio zonos (ŠSDZ) (angl. SHRZ)

Vidinis treniruotės krūvis buvo objektyviai matuojamas H10 Bluetooth širdies ritmo (ŠSD) diržu (Polar Electro, Kempele, Suomija). Kiekvienos treniruotės ir varžybų metu ŠSD buvo nuolat matuojamas dar ir OptimEye S5 prietaisais. Po mankštos JK ir ŠSD duomenys buvo įrašomi ir saugomi pasitelkus patentuotą programinę įrangą (Catapult Sprint Version 5.1.7, Catapults Innovations, Melburnas, Australija).

KIK buvo apskaičiuojamas pagal formulę: KIK (SV) = D × (Δ ŠSD) × $e^{b(\Delta \text{ŠSD})}$, čia D – pratybų trukmė, konstanta e = 2,718, moterų svertinis koeficientas b = 1,67 (Fox et al., 2018), Δ ŠSD = (vidutinis ŠSD fizinio krūvio metu – ramybės ŠSD) ÷ (maksimalus ŠSD fizinio krūvio metu – ramybės ŠSD) (Fox et al., 2017; Morton et al., 1990).

ŠSDZ apskaičiuotas pagal formulę: ŠSDZ (SV) = (trukmė 1 zonoje × 1) + (trukmė 2 zonoje × 2) + (trukmė 3 zonoje × 3) + (trukmė 4 zonoje × 4) + (trukmė 5 zonoje × 5), čia 1 zona = 50–59,9 %ŠSD_{max}, 2 zona = 60–69,9 %ŠSD_{max}, 3 zona = 70–79,9 %ŠSD_{max}, 4 zona = 80–89,9 %ŠSD_{max}, ir 5 zona = 90–100 %ŠSD_{max} (Edwards et al., 1993; Scanlan et al., 2018).

1.2.3. Suvokiamo krūvio įvertinimas pratybų metu

Vidinis treniruotės krūvis buvo subjektyviai įvertintas pasitelkus krepšinyje plačiai naudojamą PK metodą (Conte et al., 2018; Paulauskas et al., 2019; Weiss et al., 2017). Praėjus 15–30 minučių po kiekvienos treniruotės ar varžybų visi žaidėjai turėjo įvertinti bendrą krūvio intensyvumą pagal Borgo skalę (CR-10 Borgo skalė) (Borg, 1998), atsakydami į klausimą „Kiek intensyvi buvo jūsų treniruotė (rungtynės)?“ (Foster et al., 2001). Nustatant suvokiamą PK, treniruotės trukmė minutėmis buvo padauginta iš įvardyto balo (Foster et al., 2001). Kiekvienų pratybų trukmė buvo užrašoma atskirai, įskaičiuojant pramankštos ir atsigavimo laiką, išskyrus laiką, skirtą atvėsimui (Conte et al., 2018; Paulauskas et al., 2019). Rungtynių laikas buvo fiksuojamas nuo žaidimo pradžios iki pabaigos, įskaitant visas pertraukas, išskyrus pramankštą (pvz., pražangos, užribio taisyklės pažeidimas, pertraukos tarp kėlinių) (Conte et al., 2018; Paulauskas et al., 2019). Suvokiamo krūvio balai suregistruoti ir išsaugoti internetinių apklausų bazėje (Google Forms, CA, United States of America) (Paulauskas et al., 2019).

1.2.4. Monotonija ir įtampa

Buvo skaičiuojama JK ir PK monotonija ir įtampa (Paulauskas et al., 2019). Treniruočių JK-monotonija ir PK-monotonija buvo skaičiuojama savaitės krūvį dalijant iš standartinio nuokrypio, o JK-įtampa ir PK-įtampa – monotonijos vertes dauginant iš visos savaitės treniruočių krūvio (Foster et al., 2001).

1.2.5. Širdies dažnio variabilumas

Kiekvieną rytą pabudę žaidėjai 90 sekundžių privalėjo matuoti ŠSD sėdėdami ir natūraliai kvėpuodami (Williams et al., 2018). H10 Bluetooth ŠSD diržas (Polar Electro, Kempele, Suomija) buvo susietas su laisvai prieinama išmaniojo telefono programa (Elite HRV, Ashville, North Carolina, USA), kuri buvo naudota komandinių sporto šakų atstovų kasdieniam ŠSD variabilumui registruoti (Williams et al., 2018). Duomenys buvo apdoroti ir apskaičiuoti tam skirta Elite HRV programa (Williams et al., 2018).

1.2.6. Savijautos vertinimas

Kiekvieno žaidėjo savijautai įvertinti buvo naudojamas psichologinis klausimynas. Klausimynas pagal 5 balų Likerto skalę vertina nuovargį, miego kokybę, bendrą raumenų skausmą, streso lygį ir nuotaiką (balai nuo 1 iki 5 su 0,5 balo intervalais) (Conte et al., 2018). Bendra savijauta buvo nustatyta susumavus penkis kiekvienos srities balus (Conte et al., 2018). Klausimyno duomenys buvo renkami kiekvieną rytą, pasitelkus jau aprašytą internetinės apklausos programinę įrangą (Google Forms, CA, United States of America) (Paulauskas et al., 2019).

1.2.7. Testavimo procedūros

Žaidėjams buvo nurodyta laikytis miego įpročių, įprastos dietos režimo ir vengti bet kokių fiziškai sunkių užduočių likus 24 valandoms iki kiekvieno testavimo. Pirmiausia buvo nustatoma žaidėjų kūno kompozicija (kūno masė ir riebalų procentas), naudojant elektronines svarstykles (TBF 300; Tanita, Tokyo, Japonija). Vėliau žaidėjai atliko 10 minučių standartizuotą pramankštą, kurią sudarė bėgimas, dinaminis tempimas, šuoliai ir sprintai. Po jų sekė žaidėjų sprinto, šuolio ir fizinio parengtumo rezultatų vertinimas (VŠ testas, 20 m sprinto testas ir Yo-Yo protarpinio atsigavimo 1 lygio testas (YYPA1).

20 m sprinto testas

Buvo taikytas 20 m tiesinis bėgimas su papildomu 10 m nuotolio fiksavimu (Kamandulis et al., 2013; Wen et al., 2018). Bėgimo laikas buvo fiksuojamas „Galios laiko testavimo sistema“ (angl. *Power Time Testing System)* (New Test, Oulu, Suomija). Žaidėjai bėgo iš stovinčios starto padėties. Atlikti 3 bandymai su 3 minučių pasyvaus atsigavimo pertraukomis. Tyrimui buvo naudojamas greičiausias sprinto laikas. Šio testo ir jo atkartojamumo patikimumas krepšininkams buvo įrodytas anksčiau (ICC = 0,95) (Kamandulis et al., 2013).

Vertikalaus šuolio aukštis

VŠ testas mojant rankomis taikytas žaidėjų šuolio aukščiui įvertinti Optojump sistema (Optojump, Microgate, Bolzano, Italija). Žaidėjai atliko vertikalų šuolį, pradėdami nuo vertikalios stovėjimo padėties pritūpus, kojas lenkiant per kelius iki maždaug 90° kampo (Pliauga et al., 2018). Atlikti 3 bandymai, darant 20 sek. pasyvaus poilsio pertraukas (Pliauga et al., 2018). Po kiekvieno testavimo analizei buvo pasirenkamas didžiausias šuolio aukštis. Jei geriausias rezultatas buvo pasiektas trečiojo bandymo metu, buvo atliekamas papildomas bandymas (Pliauga et al., 2018). Šio testo patikimumas buvo nustatytas anksčiau (ICC = 0,98) (Attia et al., 2017).

Yo-Yo protarpinio atsigavimo 1 lygio testas

YYPA1 testas buvo atliekamas įprastoje krepšinio aikštėje, siekiant įvertinti žaidėjų fizinį aerobinę ištvermę. Buvo bėgama 2 × 20 m pirmyn ir atgal, palaipsniui didėjančiu greičiu, valdomu įrašytu garso pyptelėjimu (Krustrup et al., 2003). Po kiekvieno bėgimo buvo daroma 10 sek. aktyvaus atsigavimo pertrauka, kurios metu buvo einama 2 × 5 m (Krustrup et al., 2003). Testas buvo baigiamas, kai žaidėjai du kartus nepajėgė nustatytu laiku pasiekti reikiamos linijos (objektyvus įvertinimas) arba nebegalėjo tęsti testo (subjektyvus vertinimas). Pasiektas lygis buvo užregistruotas kaip bandymo rezultatas (Krustrup et al., 2003).

1.3. Eksperimentų dizainas

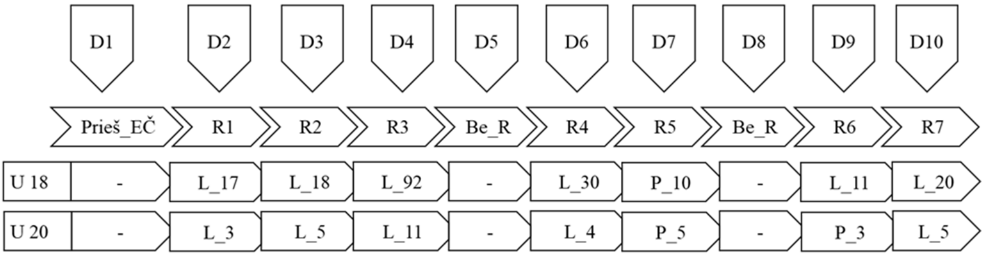
Pirmasis eksperimentas. Tiriamos komandos buvo stebimos 3 savaites (22 dienas) pasirengimo 2018 m. moterų Europos krepšinio čempionatui laikotarpiu – B divizionas (jaunesnės nei 18 metų (U18) – Austrija, rugpjūčio 3–12 d. ir jaunesnės nei 20 metų (U20) – Rumunija, liepos 7–15 d.). Abiejų komandų parengiamieji laikotarpiai buvo suplanuoti kaip intensyvi treniruočių stovykla, kiekvieną komandą treniravo skirtingi treneriai. U18 komandos parengiamasis laikotarpis vyko 2018 m. liepos 5–26 d., U20 – 2018 m. birželio 9–30 d. Šiuo laikotarpiu U18 komandai vyko 29 treniruotės, buvo žaistos 5 draugiškos rungtynės, U20 komandai – 23 treniruotės ir 5 draugiškos rungtynės. Abiejų komandų treniruočių tvarkaraščiai pateikti 1.3 lentelėje. Tiriamuoju laikotarpiu žaidėjos nepatyrė traumų, jų krūvis kiekvienų suplanuotų treniruočių ir draugiškų rungtynių metu buvo stebimas. Remiantis kiekvienos dienos krūviu, buvo apskaičiuotas kiekvienos žaidėjos vidutinis savaitės krūvis. Jei tą pačią dieną vyko daugiau nei viena treniruotė, dienos krūvis buvo apskaičiuojamas susumavus visų tos dienos treniruočių krūvį. Kiekvieną rytą pabudus, naudojant ŠSD variabilumo ir savijautos klausimyną buvo stebimas žaidėjų pasirengtis varžyboms/treniruotėms. Žaidėjų fizinė veikla buvo įvertinta prieš parengiamąjį laikotarpį ir po jo (1 ir 22 dienomis).

1.3 lentelė. Jaunesnių nei 18 metų ir jaunesnių nei 20 metų krepšininkių treniruočių tvarkaraštis 3 savaičių intensyvaus pasirengimo laikotarpiu

Treniruočių charakteristikos		Jaunesnės nei 18 m.							Jaunesnės nei 20 m.						
		1 diena	2 diena	3 diena	4 diena	5 diena	6 diena	7 diena	1 diena	2 diena	3 diena	4 diena	5 diena	6 diena	7 diena
Rytas	Tipologija	TEST	AR	AR	AR	–	AR	AR	TEST	AR	AR	TT	–	–	–
	Trukmė (min.)	104	104	149	70	–	104	117	108	85	128	101	–	–	–
Popietė	Tipologija	AR	AR	TT	TT	TT	TT	TT	TT	TT	–	TT	DG1	DG2	–
	Trukmė (min.)	57	93	131	128	112	117	123	120	126	–	118	104	103	–
		8 diena	9 diena	10 diena	11 diena	12 diena	13 diena	14 diena	8 diena	9 diena	10 diena	11 diena	12 diena	13 diena	14 diena
Rytas	Tipologija	TT	FG2	TT	AR	TT	AR	TT	AR	AR	TT	TT	TT	AR	–
	Trukmė (min.)	91	97	101	120	117	104	120	97	125	66	118	125	95	–
Popietė	Tipologija	DG1	–	TT	TT	TT	–	TT	TT	TT	–	TT	TT	–	–
	Trukmė (min.)	98	–	107	123	121	–	114	99	103	–	123	113	–	–
		15 diena	16 diena	17 diena	18 diena	19 diena	20 diena	21 diena	15 diena	16 diena	17 diena	18 diena	19 diena	20 diena	21 diena
Rytas	Tipologija	–	TT	TT	–	–	TT	TT	–	TT	–	AR	AR	TT	TT
	Trukmė (min.)	–	58	44	–	–	115	124	–	81	–	99	103	90	117
Popietė	Tipologija	TT	DG3	DG4	DG5	–	AR	–	AR	DG3	FG4	–	TT	DG5	–
	Trukmė (min.)	129	106	104	105	–	124	–	119	96	100	–	98	110	–

Santrumpos ir pastabos. TEST, pirmas testavimas (antras testavimas buvo numatytas 22 dieną); AR, atletinio rengimo treniruotės (treniruotės, kurių metu daugiausia laiko skirta AR pratimams); TT, technikos ir taktikos treniruotės (treniruotės, kurių metu daugiausia laiko tenka krepšinio treniruotėms); DG, draugiškos rungtynės.

Antrasis eksperimentas. Dviejų rinktinių krūvis, parengtis varžytis ir rungtynių rezultatai buvo stebimi 10 dienų EČ metu (U18 – Austrija, rugpjūčio 3–12 d. ir U20 – Rumunija, liepos 7–15 d.). U18 komandai buvo skirta viena diena daugiau varžybų dėl didesnio šios amžiaus kategorijos komandų skaičiaus. Tačiau nepaisant to, abi komandos turėjo laisvą dieną prieš varžybas (1 diena), žaidė tiek pat rungtynių (7 rungtynės), dvi dienas rungtynių nebuvo (1.1 pav.).



Santrumpos: D, Europos čempionato diena, R, rungtynės (1 – pirmos; 2 – antros; 3 – trečios; 4 – ketvirtos; 5 – penktos; 6 – šeštos; 7 – septintos); Be_R, dienos be rungtynių, kai komandos treniravosi ar ilsėjosi; L, laimėtos rungtynės (nurodant, kiek taškų); P, pralaimėtos rungtynės (nurodant, kiek taškų).

1.1 pav. Europos čempionato metu tirtų 10 dienų struktūra

Trečiasis eksperimentas. Šis tyrimas buvo skirtas 2018–2019 m. sezono metu dvi dienas iš eilės žaistų rungtynių krūvio ir savijautos skirtumams palyginti (tarp rungtynių – < 24 val. poilsis). Žaidėjai buvo supažindinti su visomis krūvio ir savijautos stebėjimo procedūromis prieš sezoną ir pradinio sezono etapo metu. Per tris savaites buvo stebimos šešerios NKL rungtynės (nuo 2018 m. lapkričio 23 d. iki gruodžio 8 d.). Per savaitę vyko dvejos rungtynės – penktadienį (1 diena) 18.00 val. ir šeštadienį (2 diena) 16.00 val. (1.2 pav.). Savaitės treniruočių tvarkaraščio struktūra buvo panaši visas tris savaites: vienerios Lietuvos studentų lygos rungtynės (LSKL), trys treniruotės po 90 minučių, dvejos NKL rungtynės ir viena poilsio diena (1.4 lentelė).

	1 diena Penktadienis, 18.00 val.	2 diena Šeštadienis, 16.00 val.
1 savaitė	1 rungtynės – svečiuose	2 rungtynės – namuose
2 savaitė	3 rungtynės – namuose	4 rungtynės – svečiuose
3 savaitė	5 rungtynės – namuose	6 rungtynės – svečiuose

Prieš rungtynes:
- Savijautos klausimynas

Per rungtynes:
- JK
- JK/min
- $\%ŠSD_{max}$
- ŠSDZ
- PK

Santrumpos: JK, judėjimo krūvis; JK/min, judėjimo krūvis per minutę; $\%HR_{max}$, maksimalaus ŠSDZ procentas; SŠ, susumuotos širdies susitraukimų dažnio zonos; PK, pratybų krūvis, apskaičiuotas pagal suvokiamo krūvio įvertinimą.

1.2 pav. Stebėtos rungtynės ir jų metu užfiksuoti rodikliai

1.4 lentelė. Tirtų 3 savaičių treniruočių ir rungtynių tvarkaraštis

Savaitė	Pirma-dienis	Antra-dienis	Trečia-dienis	Ketvirta-dienis	Penkta-dienis	Šešta-dienis	Sekma-dienis
1	LSKL žaidimas	Techninės treniruotės	Taktinė ir sąlyginė treniruotė	Techninės treniruotės	NKL 1 žaidimas	NKL 2 žaidimas	Poilsis
2	LSKL žaidimas	Techninės treniruotės	Taktinė ir sąlyginė treniruotė	Techninės treniruotės	NKL 3 žaidimas	NKL 4 žaidimas	Poilsis
3	LSKL žaidimas	Techninės treniruotės	Taktinė ir sąlyginė treniruotė	Techninės treniruotės	NKL 5 žaidimas	NKL 6 žaidimas	Poilsis

Santrumpos: LSKL, Lietuvos studentų krepšinio lyga; NKL, Nacionalinė krepšinio lyga.

1.4. Statistinė analizė

Pateikiami pirmojo tyrimo duomenys – kiekvieno priklausomo kintamojo vidurkis ± standartinis nuokrypis (SN). Normalus duomenų pasiskirstymas tikrintas Shapiro ir Wilko testu. Duomenys buvo analizuojami pasitelkus tiesinius mišrius modelius (angl. *Linear mixed models*). Skirtumams įvertinti buvo sukurti trys modeliai: a) komandų rezultatų skirtumai, b) komandos rezultatų pokyčiai per savaitę, c) rezultatų skirtumai prieš testavimą ir po jo. Trijų modelių fiksuoti kintamieji buvo komandos (U20 ir U18), savaitės (1, 2 arba 3) ir laikas (prieš testavimą ir po jo). Žaidėjas ir diena buvo 1 ir 2 modelių atsitiktiniai kintamieji, o

3 modelio atsitiktinis kintamasis buvo žaidėjas. Pirmų dviejų modelių priklausomi kintamieji buvo krūvio, monotonijos, įtampos, parengties ir savijautos rodikliai, 3 modelio – testavimo rezultatai. Pagal 2 modelį (vertinant savaitės pokyčius komandoje), esant statistiškai reikšmingiems skirtumams, buvo atlikta *Tukey post hoc* analizė. Linijiniai mišrūs modeliai ir *post hoc* analizė buvo atlikti naudojant „ImerTest“, „emmeans“ paketus ir RStudio (R.3.5.2, R Foundation for Statistical Computing). Lyginant duomenis buvo apskaičiuotas ir efekto dydis (ED) su 95 % pasikliovimo intervalu (PI). ED skaičiuotas naudojant Microsoft Excel (Version 15, Microsoft Corporation, Redmond, USA) ir interpretuotas 2,0 – labai didelis (Hopkins et al., 2009). Patikimumo lygmuo $p < 0,05$.

Antrojo tyrimo metu atlikta kiekvieno kintamojo aprašomoji statistika (vidurkis ± SN). Duomenų pasiskirstymas įvertintas naudojant Shapiro ir Wilko testą, kuris parodė normalų ŠSDV duomenų pasiskirstymą ir nenormalų PK krūvio bei S duomenų pasiskirstymą. Siekiant įvertinti U18 ir U20 komandų ŠSDV rezultatų skirtumus bei rezultatų pokyčius komandose, buvo taikyta 2 × 10 pakartotinių matų dispersijos analizė (ANOVA). Nustačius reikšmingus skirtumus, taikytas Bonferroni pakoreguotas nepriklausomų imčių t testas ir *post hoc* analizė, siekiant nustatyti komandų rezultatų dienos pokyčius. Kadangi PK ir S duomenys nebuvo pasiskirstę normaliai, komandų dienos rezultatų pokyčiams ir rezultatų skirtumams tarp komandų įvertinti buvo taikyti Friedman bei Mann ir Whitney *U* testai. Friedmano testui parodžius reikšmingus skirtumus, buvo naudota Bonferroni pakoreguota Connoverio *post hoc* analizė. Kiekvieno priklausomo kintamojo dienos pokyčiams patikrinti tokiu pačiu būdu buvo išanalizuoti visi 21 U18 ir U20 komandų krepšininkų rezultatai. Antram tikslui abiejų komandų žaidėjai buvo sugrupuoti pagal jų vidutinį žaidimo laiką turnyro metu, atlikta hierarchinė grupių analizė naudojant Wardo metodą ir kvadratinį Euklido atstumą kaip intervalą (Conte & Lukonaitienė, 2018). Šios analizės efektyvumo statistika buvo įtraukta ir į klasterių palyginimą. Duomenų pasiskirstymas įvertintas Shapiro ir Wilko testu, kuris parodė normalų visų kintamųjų pasiskirstymą, išskyrus PK, miego ir nuotaikos rezultatus iš S klausimyno. Po klasterių analizės imtims palyginti naudotas nepriklausomų imčių t-testas arba Mann ir Whitney *U* testas (PK, miegui, nuotaikai tirti). Priklausomų imčių skirtumų dydis įvertintas Coheno *d* efekto dydžiu su 95 % PI. ED buvo interpretuojamas taip: < 0,20 – nežymus, 0,20–0,59 – mažas, 0,60–1,19 – vidutinis, 1,2–1,99 – didelis ir ≥ 2,0 – labai didelis (Hopkins et al., 2009). Neparametriniam imčių palyginimui buvo skaičiuojamas efekto dydis *r* ir interpretuojamas taip: 0,1 –

mažas; 0,3 – vidutinis; 0,5 – didelis (Hauer et al., 2020). Reikšmingumo lygmuo $p < 0,05$.

Trečiojo tyrimo metu nustatytas kiekvieno priklausomo kintamojo vidurkis ± standartinis nuokrypis (SN). Duomenis patikrinus Shapiro ir Wilko testu, jie buvo analizuojami naudojant linijinius mišrius modelius, kur fiksuotu kintamuoju buvo pasirinktas dienos efektas (rungtynės, žaistos 1 ar 2 dieną), o žaidėjai, varžovų komanda, vieta ir taškų skirtumas – kaip atsitiktiniai kintamieji. Pirmos ir antros dienos imčių rezultatams palyginti skirtumai įvertinti ED su 95 % PI. Efekto dydis buvo interpretuojamas taip: nežymus – < 0,20, mažas – 0,20–0,59, vidutinis – 0,60–1,19, didelis – 1,20–1,99, labai didelis – ≥ 2,00 (Hopkins et al., 2009). Visos statistinės analizės buvo atliktos naudojant RStudio testo paketą (version 3.5.2, Eggshell Igloo, R Foundation for Statistical Computing) ir JASP (version 0.11.1). Reikšmingumo lygmuo $p < 0,05$.

2. REZULTATAI

2.1. Moterų iki 18 ir 20 metų krepšinio komandų krūvio, parengties varžytis (treniruotis) ir fizinio pajėgumo pokyčiai 3 savaičių intensyviu parengiamuoju laikotarpiu

2.1.1. Komandų krūvio, parengties varžytis (treniruotis) ir savijautos rezultatų palyginimas

2.1 lentelėje pateikti U18 ir U20 komandų krūvio, parengtumo ir savijautos rodiklių skirtumai parengiamuoju laikotarpiu. U20 tiriamųjų reikšmingai žemesnės buvo JK ($p = 0,010$; ED – mažas), KIK ($p = 0,004$; ED – vidutinis), PK ($p < 0,001$; ED – vidutinis), JK-įtampos ($p = 0,023$; ED – mažas) ir PK-įtampos ($p < 0,001$; ED – vidutinis) rodiklių reikšmės (2.1 lentelė). Reikšmingai didesnės, lyginant su U18 tiriamosiomis, nustatytos U20 tiriamųjų Ln_rMSSD ($p = 0,015$; ED – vidutinis) ir rMSSD ($p = 0,023$; ED – vidutinis) rodiklių reikšmės (2.1 lentelė). Bendras komandų tiriamųjų savijautos balas nesiskyrė, tačiau streso lygis U18 komandos tiriamųjų buvo reikšmingai mažesnis ($p = 0,023$; ED – mažas).

2.1.2. Komandų krūvio, parengties varžytis (treniruotis) ir savijautos rezultatų analizė

U18 ir U20 komandų savaitiniai krūvio, parengtumo ir savijautos rezultatų pokyčiai pateikti 2.2 ir 2.3 lentelėse. Visų krūvio kintamųjų skirtumai nustatyti vertinant U18 grupės savaitinius pokyčius ($p < 0,05$) (2.2 lentelė). *Post hoc* analizė 3 savaitę parodė mažesnį JK nei 1 savaitę ($p = 0,009$; ED – vidutinis) ir 2 savaitę ($p = 0,002$; ED – mažas). Atsižvelgiant į vidinę apkrovą, 3 savaitę užregistruotas KIK ($p = 0,006$; ED – mažas) ir PK ($p = 0,001$; ED – vidutinis) rezultatų sumažėjimas, lyginant su 1 savaitės rezultatais (2.2 lentelė). Tačiau, vertinant tiek išorinius, tiek vidinius U20 grupės apkrovos rodiklius, nenustatyta statistiškai reikšmingų skirtumų tarp savaičių rezultatų (2.3 lentelė). JK-monotoniškumo rezultatų skirtumai abejose grupėse buvo statistiškai reikšmingi (U18 – $p < 0,001$ ir U20 – $p < 0,034$), oPK-monotoniškumo rezultatai reikšmingai skyrėsi tik U18 grupėje ($p < 0,001$). U18 grupės JK-monotoniškumo *post hoc* analizė parodė statistiškai reikšmingą savaitinį rezultatų sumažėjimą, ED kito nuo vidutinio iki labai didelio (2.2 lentelė).U20 grupėje *post hoc* analizė reikšmingų skirtumų neparodė. U18 grupės PK-monotoniškumo *post hoc* analizė parodė statistiškai reikšmingus skirtumus tarp savaičių rezultatų, išskyrus skirtumus tarp 2 ir 3 savaitės rezultatų ($p = 0,330$) (2.2 lentelė). Įtampos reikšmių analizė parodė tik U18 grupės rezultatų statistiškai reikšmingus skirtumus (JK-įtampos $p < 0,001$ ir PK-įtampos $p = 0,047$). *Post hoc* analizė parodė reikšmingus JK-įtampos skirtumus tarp 1 ir 2 savaitės ($p = 0,005$) bei 1 ir 3 savaitės rezultatų ($p < 0,001$), o PK-įtampos reikšmingai skyrėsi tik 1 ir 2 savaitės rezultatai ($p = 0,037$) (2.2 lentelė). Savijautos analizė parodė reikšmingus savaitinius abejų grupių rezultatų svyravimus (2.2 ir 2.3 lentelė). *Post hoc* analizė parodė, kad U18 grupės tiriamosios 3 savaitę pasiekė aukščiausią rezultatą (20,74 ± 1,86 SV), jų ED svyravo nuo vidutinio iki mažo, lyginant 1 ir 2 savaičių rezultatus (2.2 lentelė), o U20 grupės tiriamosios didžiausią rezultatą pasiekė 2 savaitę (20,75 ± 2,16 SV), lyginant su 1 ir 3 savaitės rezultatais (2.3 lentelė).

2.1.3. Komandų veiklos analizė ir rezultatų palyginimas

Pirmojo testavimo (prieš tyrimą) rezultatų analizė neparodė statistiškai reikšmingų skirtumų tarp grupių rezultatų. Komandų rezultatų analizė parodė, kad U18 grupėje pagerėjo tik YYPA1 rezultatai ($p < 0,001$; ED – labai didelis). U20 komandos užregistruoti geresni 10 m sprinto laiko ($p = 0,003$; ED – vidutinis), CMJ ($p = 0,025$; ED – vidutinis) ir YYPA1 testo ($p < 0,001$; ED – didelis) rezultatai, o atliekant YYPA1 testą ŠSDmax sumažėjimas buvo vidutinis (2.4 lentelė).

2.1 lentelė. Krūvio, monotonijos, įtampos, parengties varžytis (treniruotis) ir savijautos rezultatų skirtumai tarp grupių parengiamuoju laikotarpiu

Kintamasis	U20	U18	P reikšmė	VS	95 % PI VS		ED	95 % PI ED		Paaiškinimas
					Apatinė	Viršutinė		Apatinė	Viršutinė	
Krūvis										
JK (SV)	706,37 ± 295,2	816,36 ± 333,19	**0,010**	109,99	53,27	166,70	0,35	0,17	0,53	Mažas
KIK (SV)	214,60 ± 109,42	304,95 ± 171,83	**0,004**	90,35	64,47	116,23	0,63	0,45	0,81	Vidutinis
PK (SV)	617,29 ± 328,24	942,82 ± 436,51	**< 0,001**	325,54	255,92	395,15	0,85	0,66	1,03	Vidutinis
Monotonija ir įtampa										
Monotonija-JK (SV)	4,68 ± 1,26	5,29 ± 1,78	0,083	0,62	-0,09	1,32	0,40	-0,06	0,86	Mažas
Įtampa-JK (SV)	965,50 ± 154,82	1064,68 ± 217,66	**0,023**	99,18	12,77	185,59	0,53	0,07	0,99	Mažas
Monotonija-PK (SV)	3,77 ± 1,74	3,60 ± 0,98	0,610	-0,17	-0,82	0,49	-0,12	-0,57	0,34	Nežymus
Įtampa-PK (sut. v.)	1288,11 ± 715,77	1792,69 ± 365,51	**< 0,001**	504,58	239,67	769,49	0,88	0,40	1,35	Vidutinis
Parengtis										
rMSSD (ms)	100,77 ± 38,03	63,98 ± 49,82	**0,023**	-36,79	-44,83	-28,74	-0,85	-1,04	-0,66	Vidutinis
Ln_rMSSD (ms)	4,54 ± 0,41	3,83 ± 0,90	**0,023**	-0,70	-0,83	-0,58	-1,07	-1,27	-0,87	Vidutinis
Savijauta										
Bendra	19,87 ± 3,02	19,59 ± 2,45	0,410	-0,28	-0,75	0,20	-0,10	-0,27	0,07	Nežymus
Nuovargis	3,86 ± 0,63	3,75 ± 0,67	0,397	-0,11	-0,22	0,00	-0,17	-0,34	0,01	Nežymus
Miegas	3,98 ± 0,72	3,91 ± 0,84	0,635	-0,07	-0,20	0,07	-0,09	-0,26	0,09	Nežymus
Skausmas	3,84 ± 0,74	3,83 ± 0,74	0,992	0,00	-0,13	0,13	0,00	-0,18	0,17	Nežymus
Stresas	4,14 ± 0,57	3,87 ± 0,60	**0,023**	-0,27	-0,37	-0,17	-0,46	-0,63	-0,28	Mažas
Nuotaika	4,29 ± 0,50	4,23 ± 0,48	0,661	-0,06	-0,14	0,03	-0,11	-0,29	0,06	Nežymus

Pastaba. Pateiktas rezultatų vidurkis ± standartinė paklaida. *Santrumpos:* SV, sutartiniai vienetai; JK, judėjimo krūvis; KIK, kintamo intensyvumo krūvis; PK, treniruotės krūvis, apskaičiuotas pagal suvokiamo krūvio įvertinimą; RR intervalų vidutinio kvadratinio skirtumo rMSSD šaknis; Ln_rMSSD, logaritmiškai transformuoti rMSSD duomenys; VS, vidurkio skirtumas; PI, pasikliautinumo intervalas; ED, efekto dydis.

2.2 lentelė. U18 komandos savaitiniai krūvio, monotonijos, įtampos, parengties varžytis (treniruotis) ir savijautos rezultatų pokyčiai parengiamuoju laikotarpiu

	U18			ED					
	1 savaitė	2 savaitė	3 savaitė	1savaitė / 2savaitė		1savaitė / 3 savaitė		2savaitė / 3savaitė	
Krūvis									
JK (SV)	868,20 ± 312.,49	855,82 ± 371,97	713,13 ± 290,53*#	0,02	Nežymus	0,89	Vidutinis	0,26	Mažas
KIK (SV)	338,18 ± 178,86	303,45 ± 136,78	267,83 ± 191,43*	0,16	Mažas	0,35	Mažas	0,16	Nežymus
PK (SV)	1045,77 ± 481,74	957,80 ± 449,66	806,90 ± 321,78*	0,14	Nežymus	0,90	Vidutinis	0,23	Mažas
Monotonija ir įtampa									
Monotonija-JK (SV)	6,84 ± 0,88	5,31 ± 1,82*	3,64 ± 0,38*#	0,78	Vidutinis	3,50	Labai didelis	0,87	Vidutinis
Įtampa-JK (SV)	906,71 ± 103,05	1124,54 ± 266,72*	1182,14 ± 125,4*	-0,89	Vidutinis	-2,27	Labai didelis	-0,19	Nežymus
Monotonija-PK (SV)	4,61 ± 0,58	3,31 ± 0,96*	2,96 ± 0,55*	1,17	Vidutinis	2,13	Labai didelis	0,40	Mažas
Įtampa-PK (sut. v.)	1634,38 ± 397,77	1937,81 ± 418,35*	1791,82 ± 214,88	-0,84	Vidutinis	-0,37	Mažas	0,32	Mažas
Parengtis									
rMSSD (ms)	55,68 ± 43,16	72,71 ± 55,26*	62,91 ± 48,91*	-0,37	Mažas	-0,48	Mažas	0,06	Nežymus
Ln_rMSSD (ms)	3,65 ± 0,97	3,99 ± 0,83*	3,88 ± 0,76*	-0,62	Vidutinis	-0,68	Vidutinis	-0,06	Nežymus
Savijauta									
Bendra	18,85 ± 2,57	19,18 ± 2,46	20,74 ± 1,86*#	-0,13	Nežymus	-0,61	Vidutinis	-0,56	Mažas
Nuovargis	3,63 ± 0,74	3,60 ± 0,68	4,01 ± 0,5*#	0,05	Nežymus	-0,49	Mažas	-0,58	Mažas
Miegas	3,71 ± 0,87	3,86 ± 0,87	4,15 ± 0,74*#	-0,12	Nežymus	-0,40	Mažas	-0,29	Mažas
Skausmas	3,55 ± 0,90	3,81 ± 0,67*	4,14 ± 0,47*#	-0,26	Mažas	-0,58	Mažas	-0,45	Mažas
Stresas	3,70 ± 0,60	3,77 ± 0,65	4,13 ± 0,46*#	-0,09	Nežymus	-0,56	Mažas	-0,45	Mažas
Nuotaika	4,25 ± 0,49	4,14 ± 0,47	4,30 ± 0,46#	0,24	Mažas	-0,08	Nežymus	-0,25	Mažas

Pastaba. Pateiktas rezultatų vidurkis ± standartinė paklaida; * statistiškai reikšmingi ($p < 0,05$) skirtumai, lyginant su 1 savaitės rezultatais; # statistiškai reikšmingi skirtumai ($p < 0,05$), lyginant su 2 savaitės rezultatais. *Santrumpos:* SV, sutartiniai vienetai; JK, judėjimo krūvis; KIK, kintamo intensyvumo krūvis; PK, treniruotės krūvis, apskaičiuotas pagal suvokiamo krūvio įvertinimą; RR intervalų vidutinio kvadratinio skirtumo rMSSD šaknis; Ln_rMSSD, logaritmiškai transformuoti rMSSD duomenys; VS, vidurkio skirtumas; PI, pasikliautinumo intervalas; ED, efekto dydis.

2.3 lentelė. U20 komandos savaitiniai krūvio, monotonijos, įtampos, parengties varžytis (treniruotis) ir savijautos rezultatų pokyčiai parengiamuoju laikotarpiu

	U20			ED					
	1 savaitė	2 savaitė	3 savaitė	1 savaitė / 2 savaitė		1 savaitė / 3 savaitė		2 savaitė / 3 savaitė	
Krūvis									
JK (SV)	680,90 ± 256,99	695,48 ± 340,01	744,16 ± 275,85	-0,09	Nežymus	0,08	Nežymus	0,18	Nežymus
KIK (SV)	214,37 ± 101,18	228,90 ± 122,87	198,68 ± 100,00	-0,12	Nežymus	0,21	Mažas	0,48	Mažas
PK (SV)	679,92 ± 332,16	586,80 ± 364,38	589,09 ± 271,69	0,16	Nežymus	0,41	Mažas	0,26	Mažas
Monotonija ir įtampa									
Monotonija-JK (SV)	4,33 ± 0,85	4,33 ± 0,85	5,32 ± 1,50	-0,02	Nežymus	-0,54	Mažas	-0,64	Vidutinis
Įtampa-JK (SV)	978,39 ± 128,07	978,39 ± 128,07	947,80 ± 211,25	0,04	Mažas	0,11	Nežymus	0,10	Nežymus
Monotonija-PK (SV)	3,89 ± 2,58	3,89 ± 2,58	3,82 ± 1,28	0,09	Nežymus	0,02	Nežymus	-0,12	Nežymus
Įtampa-PK (sut. v.)	1637,02 ± 1083,93	1637,02 ± 1083,93	1147,66 ± 363,73	0,49	Mažas	0,42	Mažas	-0,12	Nežymus
Parengtis									
rMSSD (ms)	92,25 ± 36,89	106,49 ± 38,75*	102,63 ± 37,09*	-0,39	Mažas	-0,28	Mažas	0,12	Nežymus
Ln_rMSSD (ms)	4,44 ± 0,45	4,61 ± 0,39*	4,48 ± 0,51*	-0,39	Mažas	-0,24	Mažas	0,14	Nežymus
Savijauta									
Bendra	18,88 ± 4,36	20,75 ± 2,16*	19,74 ± 1,57*#	-0,38	Mažas	-0,28	Mažas	0,05	Nežymus
Nuovargis	3,80 ± 0,68	3,97 ± 0,58	3,76 ± 0,61#	-0,10	Nežymus	-0,06	Nežymus	0,03	Nežymus
Miegas	3,98 ± 0,69	3,98 ± 0,81	3,97 ± 0,62	0,10	Nežymus	-0,11	Nežymus	-0,24	Mažas
Skausmas	3,44 ± 0,96	4,15 ± 0,52*	3,82 ± 0,48*#	-0,71	Vidutinis	-0,46	Mažas	0,24	Mažas
Stresas	4,09 ± 0,57	4,27 ± 0,56*	4,01 ± 0,55#	-0,24	Mažas	-0,02	Nežymus	0,13	Nežymus
Nuotaika	4,27 ± 0,50	4,38 ± 0,52	4,18 ± 0,45#	-0,15	Nežymus	0,05	Nežymus	0,13	Nežymus

Pastaba. Pateiktas rezultatų vidurkis ± standartinė paklaida, * statistiškai reikšmingi ($p < 0,05$) skirtumai, lyginant su 1 savaitės rezultatais; # statistiškai reikšmingi skirtumai ($p < 0,05$), lyginant su 2 savaitės rezultatais. *Santrumpos:* SV, sutartiniai vienetai; JK, judėjimo krūvis; KIK, kintamo intensyvumo krūvis; PK, treniruotės krūvis, apskaičiuotas pagal suvokiamo krūvio įvertinimą; RR intervalų vidutinio kvadratinio skirtumo rMSSD šaknis; Ln_rMSSD, logaritmiškai transformuoti rMSSD duomenys; VS, vidurkio skirtumas; PI, pasikliautinumo intervalas; ED, efekto dydis.

2.4 lentelė. U18 ir U20 komandų testavimo rezultatai prieš parengiamąjį laikotarpį ir po jo

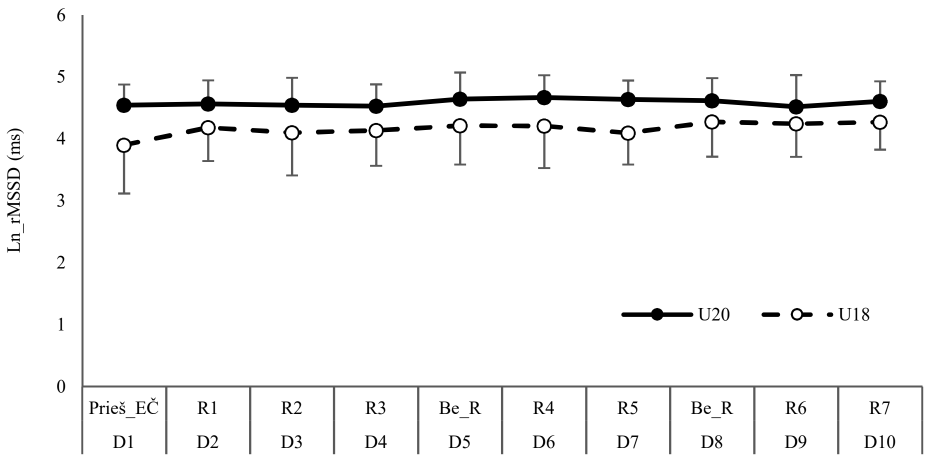
Kintamasis	Prieš	Po	P reikšmė	VS	95 % PI VS		ED	95 % CI for ES		Paaiškinimas
					Apatinė	Viršutinė		Apatinė	Viršutinė	
U18										
10-m (s)	1,93 ± 0,08	1,91 ± 0,08	0,311	0,02	-0,03	0,07	0,29	-0,29	0,87	Mažas
20-m (s)	3,35 ± 0,15	3,31 ± 0,13	0,152	0,04	-0,02	0,10	0,42	-0,18	1,01	Mažas
VŠ (cm)	37,97 ± 4,45	39,06 ± 4,84	0,128	-1,09	-2,63	0,44	-0,45	-1,04	0,15	Mažas
YYPA1 (lygis)	15,14 ± 0,68	16,08 ± 0,82	**< 0,001**	-0,94	-1,34	-0,54	-1,49	-2,31	-0,64	Didelis
HR_{max} (k./min.)	197,58 ± 8,64	193,42 ± 8,54	**0,043**	4,17	-0,06	8,40	0,63	-0,01	1,24	Vidutinis
Kūno masė (kg)	68,03 ± 5,87	69,48 ± 5,61	**< 0,001**	-1,46	-2,15	-0,76	-1,34	-2,11	-0,53	Didelis
Riebalinė masė (%)	19,79 ± 4,01	18,51 ± 2,51	0,081	1,28	-0,27	2,83	0,53	-0,09	1,12	Mažas
U20										
10-m (s)	1,93 ± 0,08	1,90 ± 0,07	**0,003**	0,03	0,01	0,05	1,09	0,32	1,83	Vidutinis
20-m (s)	3,34 ± 0,13	3,21 ± 0,31	0,150	0,13	-0,07	0,33	0,45	-0,19	1,06	Mažas
VŠ (cm)	39,48 ± 5,48	42,67 ± 6,21	**0,025**	-3,19	-6,06	-0,32	-0,75	-1,41	-0,06	Vidutinis
YYPA1 (lygis)	15,06 ± 0,58	16,33 ± 1,1	**< 0,001**	-1,21	-1,82	-0,61	-1,43	-2,31	-0,52	Didelis
HR_{max} (k./min.)	195,64 ± 6,47	192,30 ± 5,79	**0,013**	4,00	0,95	7,05	0,94	0,17	1,67	Vidutinis
Kūno masė (kg)	72,65 ± 9,25	74,00 ± 9,98	**0,004**	-1,36	-2,22	-0,49	-1,05	-1,78	-0,29	Vidutinis
Riebalinė masė (%)	21,13 ± 2,36	22,08 ± 3,32	0,072	-0,96	-2,08	0,17	-0,57	-1,20	0,08	Mažas

Pastaba. Pateiktas rezultatų vidurkis ± standartinė paklaida. *Santrumpos:* Prieš, Po – prieš parengiamąjį laikotarpį ir po jo; VŠ, vertikalus šuolis; YYPA1, yo-yo protarpinio atsigavimo 1 lygio testas; HR_{max}, didžiausias širdies susitraukimų dažnis per minutę; VS, vidurkių skirtumas; PI, pasikliautinumo intervalas; ED, efekto dydis.

2.2. Jaunų krepšininkių parengtis varžytis ir krūvis, esant perpildytam rungtynių tvarkaraščiui

2.2.1. Komandų rezultatai ir jų palyginimas

EČ metu nė vieną dieną, išskyrus 6-ąją (nebuvo varžybų) nenustatyta skirtumų tarp komandų krūvio rezultatų, nors U18 komandos PK krūvis buvo žymiai didesnis (p = 0,04; ED = 0,56, didelis, 95 % PI = –0,82, –0,11) nei U20 komandos. 10 EČ dienų ŠSD variabilumo pokyčiai grupėse ir tarp grupių (U18 ir U20) pateikti 2.1 paveiksle. Reikšmingų rezultatų skirtumų EČ dienomis nepastebėta (analizė subjekto viduje (p = 0,09, ED = 0,48, mažas)), nerasta ir sąveikos (p = 0,45) su Ln_rMSSD, nors pastebėtas reikšmingas skirtumas tarp komandų rezultatų (p = 0,04, ED = 0,48, mažas). *Post hoc* analizė neparodė skirtumų tarp komandų kiekvienos dienos rezultatų (p > 0,05) (2.1 pav.).

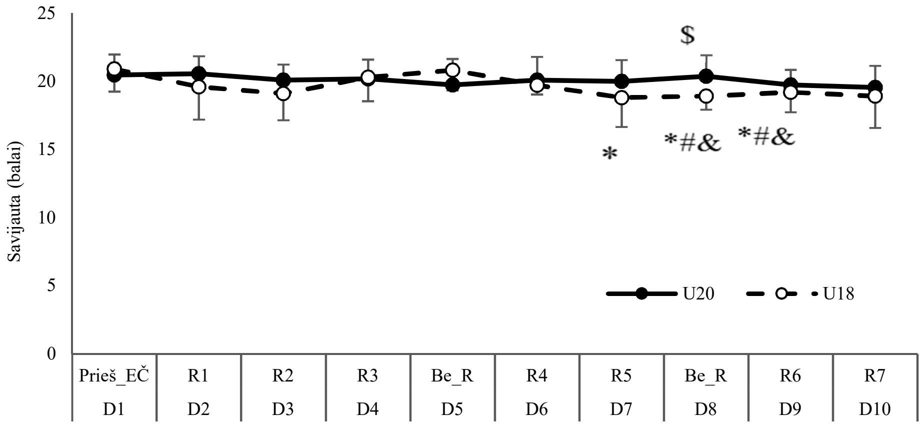


Santrumpos: Ln_rMSSD, logaritmiškai transformuota RR intervalų vidutinio kvadratinio skirtumo šaknis; R, rungtynės; D, diena; EČ, Europos čempionatas; Be_R, dienos be rungtynių.

2.1 pav. U18 ir U20 komandų ŠSD variabilumo pokyčiai per Europos čempionatą

Bendros savijautos rezultatų skirtumas tarp grupių (U18 ir U20) EČ metu pavaizduotas 2.2 paveiksle. Nustatyti reikšmingi U18 komandos tiriamųjų skirtingų dienų rezultatų pokyčiai (analizė subjekto viduje p < 0,001); *post hoc* analizė parodė reikšmingai žemesnį bendros savijautos rezultatą 7 dieną (p = 0,004; p = 0,03; p = 0,006) ir 8 dieną (p = 0,002; p = 0,02; p = 0,003), rezultatus lyginant su 1, 4, 5 dienos rezultatais, ir 9 dienos rezultatus (p = 0,04) lyginant su 1 dienos rezultatais.

Analizuojant U20 komandos rezultatus, reikšmingų skirtumų tarp dienų rezultatų nenustatyta (p = 0,30). Palyginus grupių rezultatus nustatyta, kad U18 komandos bendros savijauta rezultatai 8 dieną po 2 iš eilės rungtynių buvo reikšmingai mažesni (M4 ir M5) (p = 0,03; ED = 0,56, didelis).

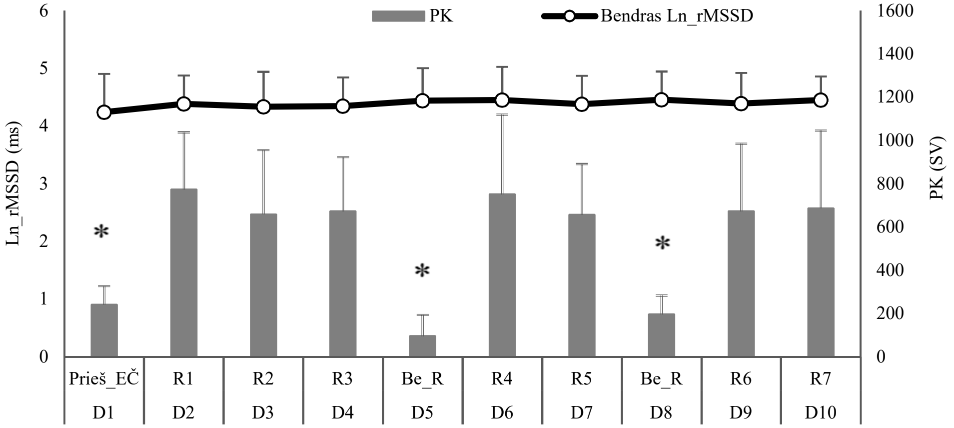


Pastaba. * reikšmingi skirtumai (p < 0,05), rezultatus lyginant su 1 dienos rezultatais; # reikšmingi skirtumai (p < 0,05), rezultatus lyginant su 4 dienos rezultatais; & reikšmingi skirtumai (p < 0,05), rezultatus lyginant su 5 dienos rezultatais; $ reikšmingi skirtumai (p < 0,05), rezultatus lyginant su U18 tiriamųjų rezultatais. *Santrumpos:* R, rungtynės; D, diena; EČ, Europos čempionatas; Be_R, dienos be rungtynių.

2.2 pav. U18 ir U20 komandų tiriamųjų savijautos pokyčiai Europos čempionato metu

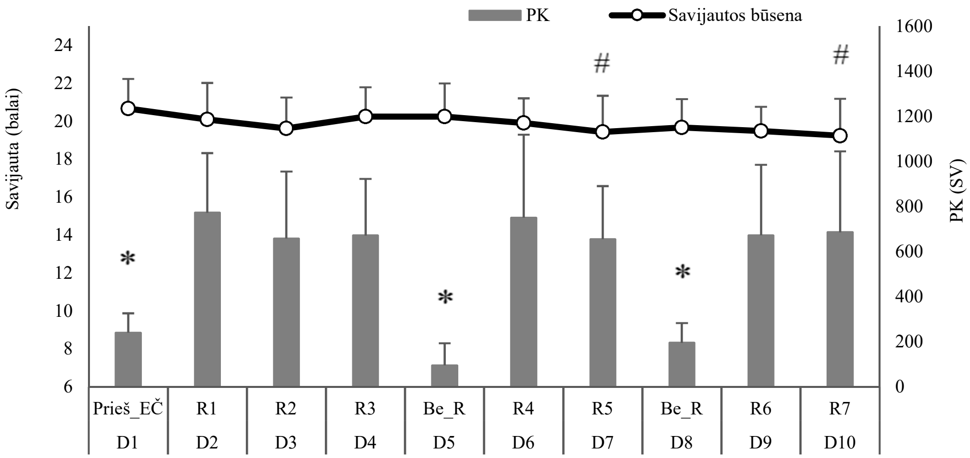
2.2.2. Bendra abiejų komandų rezultatų analizė

Kai buvo analizuojama visa 21 krepšininkės imtis (jungtinė U18 ir U20 komanda), nustatėme reikšmingus skirtumus tarp dienų rezultatų. *Post hoc* analizė parodė reikšmingai mažesnį (p < 0,05) PK dienomis be varžybų (1, 5, 8 dienos), lyginant su varžybų dienomis (2, 3, 4, 7, 9, 10 dienos). Per visą EČ laikotarpį nenustatyta reikšmingų abiejų komandų (U18 ir U20) žaidėjų Ln_rMSSD pokyčių (p = 0,12) (2.3 pav.). Tačiau bendros savijautos rezultatas 1 dieną buvo reikšmingai didesnis nei 7 (p = 0,03) ir 10 (p = 0,04) dienas(2.4 pav.).



Pastaba. * reikšmingi skirtumai (p < 0,05), rezultatus lyginant su varžybų dienų (2, 3, 4, 6, 7, 9, 10 dienos) rezultatais. *Santrumpos:* Ln_rMSSD, logaritmiškai transformuota RR intervalų vidutinio kvadratinio skirtumo šaknis; R, varžybos; PK, krūvis, apskaičiuotas pagal suvokiamo treniruotės krūvio įvertinimą; D, diena; EČ, Europos čempionatas; Be_R, dienos be rungtynių.

2.3 pav. U18 ir U20 komandų žaidėjų širdies ritmo variabilumo ir krūvio pokyčiai Europos čempionato metu



Pastaba. * reikšmingi skirtumai (p < 0,05), rezultatus lyginant su varžybų dienų (2, 3, 4, 6, 7, 9, 10 dienos) rezultatais; # reikšmingi skirtumai (p < 0,05), rezultatus lyginant su 1 dienos rezultatais. *Santrumpos:* R, varžybos; PK, krūvis, apskaičiuotas pagal suvokiamo treniruotės krūvio įvertinimą; D, diena; EČ, Europos čempionatas; Be_R, dienos be rungtynių.

2.4 pav. U18 ir U20 komandų tiriamųjų savijautos ir krūvio pokyčiai Europos čempionato metu

2.2.3. Klasterių palyginimas

Abiejų komandų žaidėjos pagal vidutinį žaidimo laiką turnyro metu buvo suskirstytos į klasterius – į 1 klasterį pateko žaidėjos, kurių vidutinis žaidimo laikas buvo 557,66 sek. (n = 16), į 2 klasterį – žaidėjos, kurių vidutinis žaidimo laikas buvo 1280,30 sek. (n = 5). Klasterių krūvio ir atsako į stresą kintamųjų skirtumai pateikti 2.5 lentelėje. 2 klasterio tiriamųjų buvo reikšmingai didesnis PK (p = 0,01; ED = –0,78 (vidutinis); PI = –0,92; –0,41), produktyvumas (p = 0,04; ED = –1,14 (vidutinis); PI = –2,20; –0,06) ir ilgesnis žaidimo laikas (p < 0,001; ED = –2,66 (labai didelis); PI = –3,95; –1,33), o atsako į stresą rezultatai reikšmingai nesiskyrė (p > 0,05).

2.2.4. Santykiai (sąsajos)

ŠSD variabilumo, savijautos ir treniruočių krūvio Spirmeno koreliacijos koeficientai pateikti 2.6 lentelėje. Pastebėta nežymi ir maža treniruočių krūvio ir atsako į stresą rezultatų koreliacija.

2.5 lentelė. Klasterių krūvio ir parengties varžytis kintamųjų skirtumai Europos čempionato metu

Kintamasis	1 klasteris (n = 16)	2 klasteris (n = 5)	P reikšmė	VP	95 % PI VP		ED	95 % PI ED		Paaiškinimas
					Apatinė	Viršutinė		Apatinė	Viršutinė	
Krūvis										
PK (SV)*	497,62±182,19; 568,10	685,10±102,97; 645,30	**0,01**	-131,70	-377,00	-13,70	-0,78	-0,92	-0,41	Vidutinis
Žaidimo laikas (sek.)	557,66±297,36	1280,30±136,96	< ,001	-722,64	1013,80	431,42	-2,66	-3,95	-1,33	Labai didelis
Žaidimo kokybė										
Efektyvumas (SV)	6,64±5,48	12,48±3,47	**0,04**	-5,85	-11,34	-0,36	-1,14	-2,20	-0,06	Vidutinis
Parengtis										
Ln_rMSSD (ms)	4,34±0,51	4,54± 0,41	0,42	-0,204	-0,73	0,32	-0,42	-1,43	0,60	Vidutinis
Bendra savijauta	20,00±1,03	19,40±1,45	0,31	0,60	-0,61	1,81	0,53	-0,49	1,54	Mažas
Nuovargis	3,86±0,23	3,80 ±0,35	0,68	0,056	-0,22	0,33	0,22	-0,80	1,22	Vidutinis
Miegas	3,89±0,43	3,72 ±0,22	0,41	0,174	-0,25	0,60	0,44	-0,58	1,45	Mažas
Skausmas	3,98±0,16	3,70 ±0,59	0,09	0,281	-0,05	0,61	0,92	-0,14	1,95	Vidutinis
Stresas*	4,03±0,32; 4,00	3,96 ±0,17; 4,00	0,41	0,01	-0,20	0,20	0,25	-0,33	0,70	Mažas
Nuotaika*	4,24±0,34; 4,05	4,22 ±0,44; 4,00	0,93	0,01	-0,20	0,40	0,03	-0,514	1,55	Nežymus

Pastaba. Pateiktas rezultatų vidurkis ± standartinė paklaida; * pateikta neparametrinių duomenų vidurkis ± standartinė paklaida ir mediana. *Santrumpos:* PK, treniruotės krūvis, apskaičiuotas pagal suvokiamo krūvio įvertinimą; Ln_rMSSD, logaritmiškai transformuota RR intervalų vidutinio kvadratinio skirtumo šaknis; VP, vietos parametras (parametrinių rodiklių vidurkių skirtumas ir neparametrinų rodiklių Hodges–Lehmann'o regresija); PI, pasikliautinumo intervalas; ED, efekto dydis (Cohen's *d* parametriniams rodikliams ir *r* neparametriniams rodikliams).

2.6 lentelė. Širdies susitraukimų dažnio variabilumo, savijautos ir krūvio rodiklių Spearman'o ranginės koreliacijos koeficientai

	PK (SV)			**Žaidimo laikas (s)**			**Efektyvumas (AU)**			**Ln_rMSSD (ms)**		
	P reikšmė	Rho	Paaiški-nimas	P reikšmė	Rho	Paaiški-nimas	P reikšmė	Rho	Paaiški-nimas	P reikšmė	Rho	Paaiški-nimas
Ln_rMSSD	0,349	-0,070	Nežymus	0,386	-0,063	Nežymus	0,300	0,090	Nežymus	–	–	–
Nuovargis	0,151	-0,107	Mažas	0,315	-0,073	Nežymus	0,732	0,030	Nežymus	0,647	0,033	Nežymus
Miegas	0,792	-0,020	Nežymus	0,848	0,014	Nežymus	0,460	0,064	Nežymus	0,628	-0,035	Nežymus
Skausmas	**0,019**	-0,175	Mažas	**0,011**	-0,184	Mažas	0,516	0,057	Nežymus	0,068	-0,133	Mažas
Stresas	0,552	-0,045	Nežymus	0,564	-0,042	Nežymus	0,369	0,078	Nežymus	0,280	0,079	Nežymus
Nuotaika	0,162	-0,104	Mažas	0,352	-0,068	Nežymus	0,875	0,014	Nežymus	**0,045**	0,146	Mažas
Savijauta	**0,044**	-0,150	Mažas	0,184	-0,097	Nežymus	0,630	0,042	Nežymus	0,824	0,016	Nežymus

Santrumpos: PK, treniruotės krūvis, apskaičiuotas pagal suvokiamo krūvio įvertinimą; Ln_rMSSD, logaritmiškai transformuota RR intervalų vidutinio kvadratinio skirtumo šaknis; Rho, Spearman'o koreliacijos koeficientas.

2.3. Krepšininkų krūvis ir savijauta sezono metu, rungtyniaujant dvi dienas iš eilės

2.3.1. Krūvio pokyčiai

Pirmą ir antrą dieną žaidžiamų varžybų krūvio vidurkis ± SN pateiktas 2.7 lentelėje. Reikšmingai ilgesnis bendras laikas ($p < 0,001$; ED – didelis) buvo užregistruotas per antros dienos varžybas, lyginant su pirmos dienos laiku, tarp varžybų reikšmingų krūvio pokyčių nenustatyta ($p > 0,05$), ED svyravo nuo nežymaus iki mažo (2.7 lentelė).

Krūvio vidurkis ± SN pateiktas realiuoju laiku per pirmą ir antrą dieną žaistas rungtynes (2.8 lentelė). Reikšmingų skirtumų tarp pirmos ir antros dienos varžybų realaus žaidimo laiko nenustatyta ($p > 0,05$; ED – mažas) (2.8 lentelė). Taip pat nenustatyta reikšmingų skirtumų ($p > 0,05$) tarp varžybų JK, reikšmingai mažesnis JK/min ($p = 0,03$; ED – mažas) nustatytas antros dienos varžybų metu, lyginant su pirmos dienos varžybų rezultatais. Vertinant vidinius krūvio rodiklius, reikšmingų skirtumų nebuvo rasta ($p > 0,05$; ED – nežymus arba mažas).

Savijautos pokyčiai

Savijautos rezultatų vidurkis ± SN pateiktas 2.9 lentelėje. Savijauta buvo vertinta pirmą ir antrą dieną prieš varžybas. Didesnis nuovargis buvo nustatytas antrą dieną nei pirmą ($p < 0,001$; ED – didelis), tačiau vertinant miegą, skausmą ir nuotaiką, reikšmingų skirtumų nenustatyta ($p > 0,05$; ED – nežymus arba mažas). Bendras žemesnis savijautos lygis nustatytas antrą dieną ($p < 0,001$; ED – mažas) lyginant su pirmos dienos rodikliais.

2.7 lentelė. Išoriniai ir vidiniai krūvio rodikliai, užregistruoti per visą žaidimo laiką

Rodikliai	1 diena	2 diena	P reikšmė	Atsitiktinio veiksnio įvertis (95 % PI)	ED (95 % PI)	Paaiškinimas
Laikas						
Bendras laikas (min.)	94,35 ± 4,29	98,00 ± 39,17	**< 0,001**	-4,05 (-6,18; -1,91)	-1,20 (-1,86; -0,53)	Didelis
Išoriniai krūvio rodikliai						
JK (SV)	531,20 ± 148,85	532,87 ± 157,17	0,836	-1,67 (-98,47; 95,13)	-0,01 (-0,62; 0,60)	Nežymus
JK/min (SV/min.)	5,62 ± 1,55	5,41 ± 1,61	0,601	0,21 (-0,79; 1,21)	0,14 (-0,48; 0,75)	Nežymus
Vidiniai krūvio rodikliai						
$\%HR_{max}$	71,26 ± 6,02	68,20 ± 8,85	0,161	3,06 (-1,74; 7,87)	0,40 (-0,22; 1,02)	Mažas
ŠSDZ (SV)	251,26 ± 57,17	233,03 ± 83,72	0,322	18,23 (-27,29; 63,74)	0,25 (-0,36; 0,87)	Mažas
PK (SV)	763,85 ± 210,00	837,07 ± 218,65	0,128	-73,22 (-208,77; 62,33)	-0,34 (-0,96; 0,28)	Mažas

Pastabos. Pateiktas rezultatų vidurkis ± standartinė paklaida; trejos rungtynės buvo žaistos pirmą dieną ir trejos – antra dieną.
Santrumpos: PI, patikimumo lygmuo; SV, sutartiniai vienetai; JK, judėjimo krūvis; JK/min, judėjimo krūvis per minutę, $\%HR_{max}$, didžiausio širdies susitraukimų dažnio išraiška procentais; ŠSDZ, susumuotos širdies susitraukimų dažnio zonos; PK, treniruotės krūvis, apskaičiuotas pagal suvokiamo krūvio įvertinimą; PI, pasikliautinumo intervalas; ED, efekto dydis.

2.8 lentelė. Išoriniai ir vidiniai krūvio rodikliai, užregistruoti per realųjį žaidimo laiką

Rodikliai	1 diena	2 diena	P reikšmė	Atsitiktinio veiksnio įvertis (95 % PI)	ED (95 % PI)	Paaiškinimas
Laikas						
Bendras laikas (min.)	37,39 ± 11,97	41,34 ± 15,93	0,170	-3,95 (-12,74; 4,84)	-0,28 (-0,89; 0,33)	Mažas
Išoriniai krūvio rodikliai						
JK (SV)	442,84 ± 146,34	457,70 ± 162,50	0,523	-14,87 (-112,72; 82,98)	-0,10 (-0,71; 0,52)	Nežymus
JK/min (SV/min.)	11,63 ± 1,46	11,22 ± 1,73	**0,029**	0,41 (-0,60; 1,43)	0,26 (-0,36; 0,87)	Mažas
Vidiniai krūvio rodikliai						
$\%HR_{max}$	84,99 ± 5,49	82,07 ± 8,63	0,127	2,92 (0,13; 2,92)	0,40 (-0,22; 1,02)	Mažas
ŠSDZ (SV)	154,27 ± 57,75	153,53 ± 72,50	0,944	0,74 (-40,80; 42,28)	0,01 (-0,60; 0,62)	Nežymus
PK (SV)	313,69 ± 139,73	372,65 ± 187,62	0,089	-58,96 (-162,13; 44,22)	-0,36 (-0,96; 0,26)	Mažas

Pastabos. Pateiktas rezultatų vidurkis ± standartinė paklaida; tiriamuoju laikotarpiu trejos rungtynės buvo žaistos pirmą dieną ir trejos – antrą dieną. *Santrumpos:* PI, patikimumo lygmuo; SV, sutartiniai vienetai; JK, judėjimo krūvis; JK/min, judėjimo krūvis per minutę; %HRmax, didžiausio širdies susitraukimų dažnio išraiška procentais; ŠSDZ, susumuotos širdies susitraukimų dažnio zonos; PK, treniruotės krūvis, apskaičiuotas pagal suvokiamo krūvio įvertinimą; PI, pasikliautinumo intervalas; ED, efekto dydis.

2.9 lentelė. Bendros savijautos pokyčiai, lyginat pirmos ir antros dienos rezultatus, rungtyniaujant dvi dienas iš eilės

Rodikliai	**1 diena**	**2 diena**	**P reikšmė**	**Atsitiktinio veiksnio įvertis (95 % PI)**	**ED (95 % PI)**	**Paaiškinimas**
Nuovargis	3,57 ± 1,03	2,33 ± 0,86	**< 0,001**	1,24 (0,65; 1,83)	1,31 (0,63; 1,97)	Didelis
Miegas	3,62 ± 0,97	3,76 ± 0,89	0,510	-0,14 (-0,72; 0,44)	-0,15 (-0,76; 0,45)	Nežymus
Skausmas	3,14 ± 1,01	2,67 ± 1,02	0,082	0,48 (-0,16; 1,11)	0,47 (-0,15; 1,08)	Mažas
Stresas	4,14 ± 0,85	3,81 ± 0,81	0,100	0,33 (-0,19; 0,85)	0,40 (-0,21; 1,01)	Mažas
Nuotaika	3,67 ± 0,97	3,57 ± 0,81	0,367	0,10 (-0,46; 0,65)	0,11 (-0,50; 0,71)	Nežymus
Bendra savijauta	18,14 ± 3,72	16,14 ± 2,99	**< 0,001**	2,00 (-0,10; 4,10)	0,59 (-0,03; 1,21)	Mažas

Pastabos. Pateiktas rezultatų vidurkis ± standartinė paklaida; tiriamuoju laikotarpiu trejos rungtynės buvo žaistos pirmą dieną ir trejos – antrą dieną. *Santrumpos:* PI, pasikliautinumo intervalas; ED, efekto dydis.

IŠVADOS

1. Šiuo tyrimu nustatyta, kad trumpų intensyvių parengiamųjų laikotarpių metu tinkamai parinktas pastovus krūvis teigiamai veikia krepšininkių parengtį varžytis (treniruotis). Didelių krūvių taikymas naudojant periodizacijos strategiją, kai manipuliuojama trumpo perkrūvio ir atsigavimo fazėmis, teigiamai veikia aerobinį krepšininkių pajėgumą, tačiau nedidina pasirengimo treniruotis (rungtyniauti) ir anaerobinio pajėgumo.

2. Rungtynių tvarkaraštis, kai per 9 dienas žaidžiamos 7 rungtynės, jaunoms krepšininkėms yra įveikiamas krūvis, nepaisant rungtynių sudėtingumo ar individualių krūvio skirtumų. Tai rodo didelį krepšininkių parengtį varžytis (treniruotis), pasirinktą optimalią žaidėjų keitimo taktiką ir tinkamą rungtynių intensyvumą. Į šiuos veiksnius turėtų būti atsižvelgiama, norint išvengti rezultatų blogėjimo turnyrų metu, esant intensyviam rungtynių tvarkaraščiui. Be to, rekomenduojama objektyvius ir subjektyvius metodus taikyti kartu, nes taip suteikiama skirtinga informacija apie krepšininkių krūvį ir parengtį varžytis (treniruotis).

3. Žaidžiant dvejas rungtynes iš eilės, kai jas skiria mažiau nei 24 valandos, žaidėjai patiria panašų išorinį ir vidinį krūvį, tačiau antrųjų rungtynių metu jaučiamas didesnis nuovargis ir yra blogesnė bendroji savijauta. Šis tyrimas parodė, kad, žaidžiant dvejas rungtynes iš eilės, labai svarbu taikyti optimalias atsigavimo strategijas, kurios padėtų žaidėjams geriau jaustis ir intensyviau žaisti antrų rungtynių metu.

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SCIENTIFIC PUBLICATIONS

The thesis based on the following articles:

1. Lukonaitienė, I., Kamandulis, S., Paulauskas, H., Domeika, A., Pliauga, V., Kreivytė, R., Stanislovaitienė, J., & Conte, D. (2020). Investigating the workload, readiness and physical performance changes during intensified 3-week preparation periods in female national Under18 and Under20 basketball teams. *Journal of Sports Sciences, 38*(9), 1018–1025.
2. Lukonaitienė, I., Conte, D., Paulauskas, H., Pliauga, V., Kreivytė, R., Stanislovaitienė, J., & Kamandulis, S. (2021). Investigation of readiness and perceived workload in junior female basketball players during a congested match schedule. *Biology of Sports, 38*(3), 341–349.
3. Conte, D., Kamarauskas, P., Ferioli, D., Scanlan, A. T., Kamandulis, S., Paulauskas, H., & Lukonaitienė, I. (2020). Workload and well-being across games played on consecutive days during inseason phase in basketball players. *The Journal of Sports Medicine and Physical Fitness*.

Other publications:

1. Pliauga, V., Lukonaitiene, I., Kamandulis, S., Skurvydas, A., Sakalauskas, R., Scanlan, A. T., ... & Conte, D. (2018). The effect of block and traditional periodization training models on jump and sprint performance in collegiate basketball players. *Biology of Sport, 35*(4), 373.
2. Sansone, P., Tessitore, A., Paulauskas, H., Lukonaitiene, I., Tschan, H., Pliauga, V., & Conte, D. (2019). Physical and physiological demands and hormonal responses in basketball small-sided games with different tactical tasks and training regimes. *Journal of Science and Medicine in Sport, 22*(5), 602–606.
3. Sansone, P., Tessitore, A., Lukonaitiene, I., Paulauskas, H., Tschan, H., & Conte, D. (2020). Technical-tactical profile, perceived exertion, mental demands and enjoyment of different tactical tasks and training regimes in basketball small-sided games. *Biology of Sport, 37*(1), 15.
4. Conte, D., & Lukonaitiene, I. (2018). Scoring strategies differentiating between winning and losing teams during FIBA EuroBasket Women 2017. *Sports, 6*(2), 50.

The thesis data presented in conferences:

1. Lukonaitienė, Inga; Kamandulis, Sigitas; Stanislovaitienė, Jūratė; Paulauskas, Henrikas; Kreivytė, Rasa; Pliauga, Vytautas; Conte, Daniele. The influence of an intensified 3-week preparation period of women's European basketball championships 2018 on physical preparation in under18 and under20 teams // Sportininkų rengimo valdymas ir sportininkų darbingumą lemiantys veiksniai: respublikinė mokslinė konferencija, skirta Lietuvos valstybės atkūrimo šimtmečiui paminėti: programa, plenariniai pranešimai, pranešimų tezės. Kaunas, 2018 m. gruodžio 20 d. Kaunas: Lietuvos sporto universitetas. eISSN 2538-7952. 2018, p. 28.
2. Lukonaitienė, I.; Kamandulis, S.; Stanislovaitienė, J.; Paulauskas, H.; Kreivytė, R.; Pliauga, V.; Conte, D. Monitoring training load, stress response and physical performance in under18 and under20 Lithuanian women national basketball teams preparing for the women's European basketball championships 2018 – division B // Sport science for sports practice, teacher training and health promotion: 12th conference of Baltic Society of Sport Sciences: April 25–26, 2019, Vilnius, Lithuania: abstracts. Kaunas: Vytautas Magnus University, 2019. ISBN 9786094673849. p. 101–102.
3. Lukonaitienė, Inga; Kamandulis, Sigitas; Paulauskas, Henrikas; Pliauga, Vytautas; Kreivytė, Rasa; Stanislovaitienė, Jūratė; Conte, Daniele. Daily changes in well-being during women's European Basketball Championships for under18 and under20 female national teams // Sportininkų rengimo valdymas ir sportininkų darbingumą lemiantys veiksniai: sporto forumas – tarptautinė mokslinė konferencija, skirta Lietuvos sporto universiteto 85-mečiui paminėti: programa ir pranešimų tezės, 2019 m. lapkričio 21–22 d., Kaunas, Lietuva. Kaunas: Lietuvos sporto universitetas. eISSN 2538-7952. 2019, p. 51–52.

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Investigation of readiness and perceived workload in junior female basketball players during a congested match schedule

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ABSTRACT: This study aimed to: a) investigate the differences in workload and readiness between two junior female national basketball teams competing at different European Championships (EC); b) compare workload, readiness and match performance for players with longer and shorter playing times, and; c) examine the relationship between workload, readiness and match performance variables. Under-18 (U18) (n = 10, height = 179.9 ± 6.6 cm, body mass = 70.2 ± 5.1 kg) and under-20 (U20) female national basketball teams (n = 11, height = 178.4 ± 8.8 cm, body mass = 73.0 ± 9.7 kg) were monitored during congested match schedules encompassing 7 matches within 9 days. Daily workload was determined via the session rating of perceived exertion (sRPE workload); readiness was measured by heart-rate variability (HRV) and well-being (WB); and match performance was assessed using the efficiency statistic and playing time. Analysis of workload and readiness during the EC showed no statistically significant between-team differences in any variables except WB for the U18 team, which was lower on Day 8 compared to the U20 team ($p = 0.03$; effect size [ES] = large). Players accumulating longer playing time showed a higher sRPE workload ($p = 0.01$, ES = moderate) and efficiency statistic ($p = 0.04$, ES = moderate) while no readiness variable differed significantly ($p > 0.05$) compared to players with shorter playing time. Trivial-to-small correlations were observed between workload, readiness and match performance variables. The study shows that junior female basketball players were able to cope with a congested schedule of 7 matches in 9 days irrespective of the competition context or individual differences in workload. Finally, combining objective and subjective methods to assess workload and readiness is recommended due to the weak relationships observed between these methods.

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INTRODUCTION

Basketball is one of the most popular team sports worldwide, with high participation rates for both men and women [1]. Basketball is characterized by repeated high-intensity sprinting, jumping, and changes of direction and thus requires significant effort by players [2, 3]. In fact, basketball players are exposed to periods of high physical loads, during which it is particularly important to manage stress and balance recovery in competitive athletes to avoid negative effects such as injuries and nonfunctional overreaching [4–6]. An example of a high physical loading period is the European Championship (EC), which is one of the most prestigious competitions organized by the International Basketball Association (FIBA), including youth and senior national teams [7].

Readiness to perform is fundamental during congested match schedules [8, 9]. Specifically, in above-mentioned EC tournaments conducted by the FIBA Europe, junior female basketball players are exposed to a congested game schedule that involves playing between 7 and 8 matches within a 9- to 10-day period [7, 10, 11]. In addition to the demands of a congested match schedule, junior national teams start their preparation and compete in EC during summer, which in basketball traditionally represents a period of transition and rest after the regular club season [12]. Therefore, national team players may increase their risk of injuries and nonfunctional overreaching because of the demanding preparations for upcoming tournaments [13] followed by the congested match schedule of the tournament [7]. Monitoring player workload, readiness and evaluating match performance during the EC might help to understand the demands of a congested match schedule, improve workload management and optimize player performances.

Competition demands can depend on several different aspects such as the athlete's skills, the skills of the opposing teams, and the tournament environment [8, 14]. Moreover, competition stress also depends on the social environment and athlete's role within the team [15]. Altogether, these possible differences support the need for comparison between teams playing in two separate ECs at a similar level (e.g. U18 and U20 EC) for greater understanding of the effects of a congested match schedule. Comparisons between teams might also enable identification as to whether playing level (i.e. U18 vs. U20) impacts demands in young athletes, and this may provide data to aid the transition of players from lower to higher levels of competition with advancing age in young adulthood. Furthermore, individual players are exposed to different workloads during a match [16, 17], and thus, it is essential to monitor each athlete individually in order to manage their loading and recovery strategies appropriately.

During international tournaments, it is important to implement monitoring tools that are minimally invasive and not time consuming [18]. Indeed, subjective well-being (WB) questionnaires and objective heart-rate variability (HRV) measures of athlete's readiness are easy-to-use and widely applied tools to understand whether athletes are effectively coping with external demands [13, 18]. Previous studies have assessed the relationship between objective and subjective methods to assess athlete readiness with the aim to evaluate whether they could provide similar information [19–21]. These studies indicated limited commonality between these two methodologies and the need to include both objective and subjective approaches to assess player readiness status [19–21]. However, no previous study has assessed the relationship between objective and subjective measure of readiness in basketball during a congested match schedule when players are under significant stress from increased match demands, calling for further investigations. Additionally, the assessment of match performance can provide information about the performance fluctuations of basketball players during congested match periods [22]. It seems essential to monitor players' performances and assess the relationships with workload and readiness variables as previously suggested [23]. Indeed, identifying these relationships in basketball is important in developing a fundamental understanding of what workload can be most effectively tolerated to sustain a high level of match performance.

Therefore, this study aimed to: a) investigate the differences in workload and readiness between two junior female national basketball teams competing at two different ECs (i.e., Under 18 [U18] and Under 20 [U20]); b) compare workload, readiness and match performance for players with longer and shorter playing times, and; c) assess the relationship between workload, readiness and match performance variables. We hypothesized that congested EC schedules would lead to significant impairment in readiness variables independently of the tournament environment, mainly in players exposed to extended playing times, and that a player's match performance would correlate strongly with readiness variables.

MATERIALS AND METHODS

Participants

Twenty-four female basketball players from Lithuanian national female U18 and U20 teams were recruited for this study. From the initial sample, 21 players (U18 [first place in EC], n = 10, age = 18.0 ± 0.4 years, height = 179.9 ± 6.6 cm, body mass = 70.2 ± 5.1 kg and training experience = 9.1 ± 1.8 years; U20 [third place in EC], n = 11, age = 20.5 ± 2.9 years, height = 178.4 ± 8.8 cm, body mass = 73.0 ± 9.7 kg and training experience = 9.6 ± 2.4 years) were investigated. Three players were excluded: one player competed in both teams and thus was analysed only as a member of the U20 team; and two players (one from each team) failed to complete full data collection. Players were informed about the study aims and procedures and provided personal written informed consent (and that of their guardian if less than 18 years old). Ethics approval was granted from the Kaunas Regional Ethical Committee Review Board in accordance with the ethical standards of the Helsinki Declaration, approval number BE-2–97.

Design

Workload, readiness and match performance of the two national teams were monitored for 10 days (U18, Austria, 3–12 August and

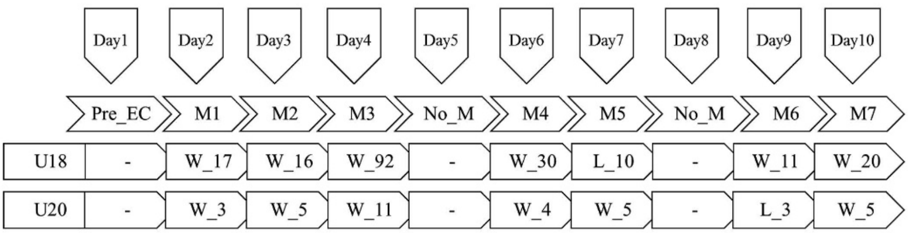

FIG. 1. Structure and match outcomes of the 10 days studied during the European Championship. Abbreviations: M, match (1-first; 2-second; 3-third; 4-fourth; 5-fifth; 6-sixth; 7-seventh matches); No_M, no-match day during which teams were training or resting; W, win match (indicating by how many points); L, lost match (indicating by how many points).

U20, Romania, 7–15 July). The U18 team was exposed to 1 day more of competition because of the greater number of teams in this EC age category. However, both Championships had a pre-EC day (Day 1) and the same distribution of matches (7) within the first 9 days of the tournament, with no matches on two days. Therefore, we used a 10-day time frame for a better comparison between the teams, although the U18 team later played one additional game which was not considered in this study. The structure and match outcomes of the 10-day study period are presented in Figure 1. On the days on which there was no match, teams had court-based training sessions or complete rest.

Procedures

Players were monitored during a 3-week preparation period prior to the commencement of the EC [13]. Therefore they were fully familiarized with all procedures to monitor workload and readiness.

Workload

Internal workload was subjectively assessed using the sRPE method, which is extensively used in basketball [13, 21, 22]. Each player was required to provide a global intensity score using the category ratio scale (Borg's CR-10) approximately 30 min after each match or training session in answer to the question, "How intense was your match/training session?" [23]. To determine sRPE workload, the duration of match or training session in minutes was multiplied by the sRPE score [23]. The match duration was recorded from the beginning to the end of the match including all stoppages (i.e., fouls, out of bounds, timeouts and inter-quarter breaks) but excluding the pre-match warmup [22]. Each training session duration was recorded individually including warmup and recovery periods but excluding the cooldown [21, 22]. The sRPE scores were collected and stored using cloud-based online survey software (Google Forms, Google, Mountainview, CA, USA) [22].

HRV

Every morning upon waking, players were required to measure their HRV for 90 s while seated and breathing spontaneously [24]. Heart-rate monitoring straps (H10 Bluetooth, Polar Electro, Kempele, Finland) were paired with a freely available smartphone application (Elite HRV, Ashville, North Carolina, USA), which has been previously used in basketball [13] to take daily measurements of players' HRV. The log-transformed square root of the mean sum of the squared differences between R-R intervals (Ln-rMSSD) was calculated using the Elite HRV app. The validity of the Elite HRV application for computing Ln rMSSD has been shown previously with nearly perfect correlations with the electrocardiogram ($r = 0.99$, $p < 0.05$) [24].

Well-being

Based on past recommendations, questionnaires were used to assess the daily WB status of each player [13, 22]. The questionnaire assessed fatigue, sleep quality, general muscle soreness, stress levels and mood on a five-point Likert scale (scores of 1 to 5 with 0.5-point increments) [21]. Each item of the WB score was assessed independently and the total WB score was calculated summing each item score [21]. Questionnaire data were collected every morning using the previously described online survey software (Google Forms) [22].

Match performance

Individual playing times and player efficiency statistical values for each match were collected from the official box scores on the websites of the FIBA EuroBasket Women 2018 U18 division B [11] and U20 division B [10]. The efficiency statistic value collected from the official box scores was used as a match performance variable in this study. The efficiency statistic formula used by FIBA organizers is as follows: PT+RT+AS+ST+BS–TO–(P3A–P3M)–(P2A–P2M)–(P1A–P1M) [25], where PT refers to points scored, RT to total rebounds, AS to assists, ST to steals, BS to blocked shots, TO to turnovers, P3A to 3-point shots attempted, P3M to 3-point shots made, P2A to 2-point shots attempted, P2M to 2-point shots made, P1A to free throws (1 point) attempted, and P1M to free throws (1 point) made [25].

Statistical analysis

Descriptive statistics (mean ± SD) were calculated for each variable. Data distribution was assessed using the Shapiro–Wilk test, which demonstrated a normal distribution for the HRV data and a non-normal distribution for the sRPE workload and WB data. Therefore, a 2×10 repeated-measures analysis of variance (ANOVA) was used to test differences in HRV between U18 and U20 teams (between-team) and changes in daily values (within-team). If significant differences were found, the independent t-test using the Bonferroni correction was used for post hoc analysis of daily differences. Because sRPE workload and WB were not normally distributed, Friedman and Mann–Whitney U tests were used to assess within-day changes and between-team differences, respectively. When the Friedman test showed a significant difference, Conover's post hoc non-parametric analysis with Bonferroni correction was used. In addition, the same analysis to check the daily changes in each dependent variable was carried out for the entire sample of 21 basketball players (U18 and U20 teams combined) together.

For the second aim, players from both teams were grouped based on their average playing time during the tournament via hierarchical cluster analysis using Ward's method and the squared Euclidian distance as the interval [7]. In this analysis, the efficiency statistic was also included in the cluster comparison. Data distribution was assessed using the Shapiro–Wilk test, which revealed normal distribution for all variables except for sRPE workload and sleep and mood from the WB questionnaire. Following the cluster analysis, the independent t-test or Mann–Whitney U test (sRPE workload, sleep, mood) was used for pairwise comparisons. The magnitude of differences for pairwise comparisons was assessed using Cohen's d effect size (ES) with 95% confidence intervals for parametric statistics. ES were interpreted as < 0.20 = trivial, 0.20–0.59 = small, 0.60–1.19 = moderate, 1.2–1.99 = large, and ≥ 2.0 = very large [26]. For nonparametric pairwise comparisons, ES was calculated as r and interpreted as 0.1 = small; 0.3 = moderate; 0.5 = large [27].

Finally, Spearman's rank test was used to correlate values of sRPE workload, playing time, efficiency statistic and HRV with values for WB (overall and each variable separately) and HRV. The magnitude of correlation (rho) between variables was interpreted according to the following benchmarks: < 0.1 = trivial; 0.1–0.29 = small; 0.3–0.49 = moderate; 0.5–0.69 = large; 0.7–0.89 = very large; and ≥ 0.9 = nearly perfect (29).

Statistical analyses were performed using SPSS v25.0 for Windows (IBM, Armonk, NY, USA) and JASP (Version 0.11.1). The level of significance was set at 0.05.

RESULTS

Between-team and within-team analysis

Analysis of workload during the EC showed no between-team differences for any day except Day 6 (no match), where the U18 team was exposed to significantly higher sRPE workload ($p = 0.04$; ES = 0.56, large, 95% CI = –0.82, –0.11) compared to the U20 team. HRV changes across the 10 days of the EC within and between groups (U18 and U20) are displayed in Figure 2. No significant differences were observed across EC days (within-team analysis [$p = 0.09$, ES = 0.48, small]) and no interaction ($p = 0.45$) was found with Ln_rMSSD, although a significant difference was observed between teams ($p = 0.04$, ES = 0.48, small). However, post hoc analysis revealed no daily differences between teams ($p > 0.05$) (Figure 2). The total within- and between-group (U18 and U20) changes in WB during the EC are presented in Figure 3. Significant differences between days were found for the U18 team (within-team analysis $p < 0.001$); post hoc analysis showed a significantly lower WB total score on Day 7 ($p = 0.004$; $p = 0.03$; $p = 0.006$) and Day 8 ($p = 0.002$; $p = 0.02$; $p = 0.003$) compared with Day 1, Day 4 and Day 5, respectively and for Day 9 ($p = 0.04$) compared with Day 1. No significant differences between days were found for the U20 team ($p = 0.30$). Between-team analysis found that the U18 team compared to the U20 team demonstrated significantly lower total WB on Day 8 after 2 consecutive match days (M4 and M5) ($p = 0.03$; ES = 0.56, large).

Combined team analysis

When considering both teams (U18 and U20) together as one sample, we found significant between-day differences. Post hoc analysis revealed significantly lower ($p < 0.05$) sRPE workload on no-match days (Day 1, Day 5, Day 8) compared with match days (Day 2, Day 3, Day 4, Day 7, Day 9 and Day 10). Conversely, in response to this loading schedule, no significant changes in Ln_rMSSD ($p = 0.12$) for players from the combined U18 and U20 teams were detected during the whole EC (Figure 4). However, total WB was significantly higher on Day 1 compared with Day 7 ($p = 0.03$) and Day 10 ($p = 0.04$) (Figure 5).

Longer vs. shorter playing time analysis

Players from both teams were grouped based on their average playing time during the tournament into Cluster 1 (n = 16) with an average playing time of 9.29 min and Cluster 2 (n = 5) with an

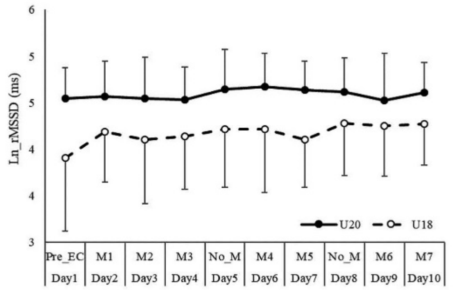

FIG. 2. Heart rate variability changes in U18 and U20 teams during the European Championships. Abbreviations: Ln_rMSSD, log-transformed data of root mean square of the successive differences; M, match.

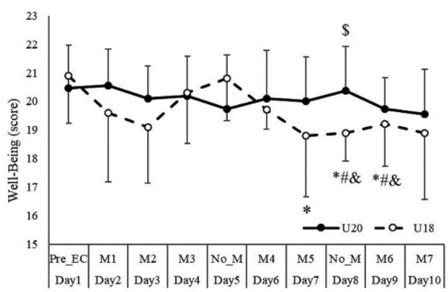

FIG. 3. Well-being changes in U18 and U20 teams during the European Championships. Note: * Significant ($p < 0.05$) difference compared with Day 1; # Significant ($p < 0.05$) difference compared with Day 4; & Significant ($p < 0.05$) difference compared with Day 5; $ Significant ($p < 0.05$) difference compared with U18. Abbreviations: M, match.

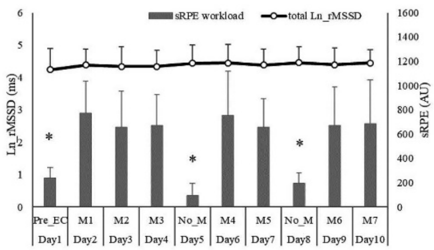

FIG. 4. Heart rate variability and workload changes for players from U18 and U20 teams combined, during the European Championships. Note: * Significant ($p < 0.05$) difference compared with match days (Day 2, Day 3, Day 4, Day 6, Day 7, Day 9, Day 10). Abbreviations: Ln_rMSSD, log-transformed data of root mean square of the successive differences; M, match; sRPE, workload calculated from session rating of perceived exertion.

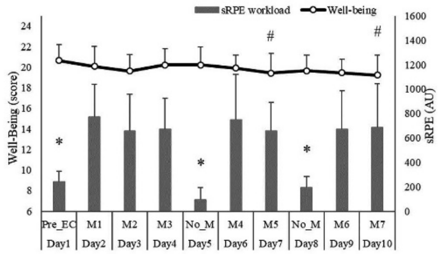

FIG. 5. Well-being and workload changes for players from U18 and U20 teams combined during the European Championships Note: * Significant ($p < 0.05$) difference compared with match days (Day 2, Day 3, Day 4, Day 6, Day 7, Day 9, Day 10); # Significant ($p < 0.05$) difference compared with Day 1. Abbreviations: M, match.

TABLE I. Comparison of workload and readiness variables between players with greater and lower playing time during the European Championships.

Variable	Cluster1 (n = 16)	Cluster2 (n = 5)	P value	LP	95% CI for LP		ES	95% CI for ES		Interpretation
					Lower	Upper		Lower	Upper	
Workload										
sRPE_WL (AU)*	497.62 ± 182.19; 568.10	685.10 ± 102.97; 645.30	**0.01**	-131.70	-377.00	-13.70	-0.78	-0.92	-0.41	Moderate
Playing time (s)	557.66 ± 297.36	1280.30 ± 136.96	< **.001**	-722.64	1013.80	431.42	-2.66	-3.95	-1.33	Very Large
Playing quality										
Efficiency (AU)	6.64 ± 5.48	12.48 ± 3.47	**0.04**	-5.85	-11.34	-0.36	-1.14	-2.20	-0.06	Moderate
Stress Response										
Ln_rMSSD (ms)	4.34 ± 0.51	4.54 ± 0.41	0.42	-0.204	-0.73	0.32	-0.42	-1.43	0.60	Moderate
WB total	20.00 ± 1.03	19.40 ± 1.45	0.31	0.60	-0.61	1.81	0.53	-0.49	1.54	Small
Fatigue	3.86 ± 0.23	3.80 ± 0.35	0.68	0.056	-0.22	0.33	0.22	-0.80	1.22	Moderate
Sleep	3.89 ± 0.43	3.72 ± 0.22	0.41	0.174	-0.25	0.60	0.44	-0.58	1.45	Small
Soreness	3.98 ± 0.16	3.70 ± 0.59	0.09	0.281	-0.05	0.61	0.92	-0.14	1.95	Moderate
Stress*	4.03 ± 0.32; 4.00	3.96 ± 0.17; 4.00	0.41	0.01	-0.20	0.20	0.25	-0.33	0.70	Small
Mood*	4.24 ± 0.34; 4.05	4.22 ± 0.44; 4.00	0.93	0.01	-0.20	0.40	0.03	-0.514	1.55	Trivial

Note: data are presented as mean ± standard deviation; bolded values indicate significant differences ($p < 0.05$); *nonparametric data are presented as mean ± standard deviation and median. Abbreviations: sRPE_WL, workload calculated from session-rating of perceived exertion; Ln_rMSSD, log-transformed data of root mean square of the successive differences; WB, well-being; LP, location parameter (mean difference for parametric variables and Hodges–Lehmann estimate for nonparametric variables); CI, confidence interval; ES, effect size (Cohen's d for parametric variables and r for nonparametric variables).

TABLE II. Spearman's rank coefficients for correlations between heart rate variability, well-being and workload variables.

	sRPE workload (AU)			Playing Time(s)			Efficiency (AU)			Ln_rMSSD (ms)		
	P-value	Rho	Interpretation	P-value	Rho	Interpretation	P-value	Rho	Interpretation	P-value	Rho	Interpretation
Ln_rMSSD	0.349	-0.070	Trivial	0.386	-0.063	Trivial	0.300	0.090	Trivial	—	—	—
Fatigue	0.151	-0.107	Small	0.315	-0.073	Trivial	0.732	0.030	Trivial	0.647	0.033	Trivial
Sleep	0.792	-0.020	Trivial	0.848	0.014	Trivial	0.460	0.064	Trivial	0.628	-0.035	Trivial
Soreness	**0.019**	-0.175	Small	**0.011**	-0.184	Small	0.516	0.057	Trivial	0.068	-0.133	Small
Stress	0.552	-0.045	Trivial	0.564	-0.042	Trivial	0.369	0.078	Trivial	0.280	0.079	Trivial
Mood	0.162	-0.104	Small	0.352	-0.068	Trivial	0.875	0.014	Trivial	**0.045**	0.146	Small
WB total	**0.044**	-0.150	Small	0.184	-0.097	Trivial	0.630	0.042	Trivial	0.824	0.016	Trivial

Note: bolded values indicate significant correlations ($p < 0.05$). Abbreviations: sRPE workload, previous day workload calculated from session-rating of perceived exertion; Ln_rMSSD, log-transformed data of root mean square of the successive differences; WB, well-being; Rho, Spearman's rank coefficient.

average playing time of 21.34 min. Between-cluster differences in workload and readiness variables during the EC are displayed in Table I. Cluster 2 showed a higher sRPE workload (p = 0.01, ES = –0.78 (moderate), CI = –0.92; –0.41), efficiency statistic (p = 0.04, ES = –1.14 (moderate), CI = –2.20; –0.06) and playing time (p < 0.001, ES = –2.66 (very large), CI = –3.95; –1.33), while no readiness variables differed significantly (p > 0.05).

Relationships

Spearman's rank coefficients of the relationships for sRPE workload, playing time, efficiency statistic and HRV with values of WB (overall and each variable separately) are presented in Table II, indicating trivial-to-small correlation coefficients.

DISCUSSION

The present study provides information on perceptual workload and readiness of junior female basketball players during a tournament with a congested match schedule. Our main findings did not confirm the expectation that a congested match schedule would lead to significant impairments in objective HRV, but on a few days (i.e. Day 7 and Day 10) lower subjective WB was evident when EC progressed towards the end of the monitoring period. There were no differences in readiness between players exposed to long and short playing times. These findings suggest that young female basketball players coped well with the workload, and generally endorse the feasibility of the FIBA EC format. Moreover, correlations between objective and subjective variables of a player's workload, match performance and readiness proved to be trivial to small, indicating the need for using both objective and subjective methods in combination.

It was found that the tournament demands were similar for the U18 and U20 teams as there were no differences in sRPE workloads on match days. Both teams had lower sRPE workloads on the days with no matches, indicating rest or very easy training sessions. In addition, both teams monitored in this study were medallists at their respective championships (i.e. 1st place for U18 and 3rd place for U20), although their accomplishments were achieved differently. Indeed, the U18 team played more unbalanced matches with score differences ranging from 10 to 92 points compared to the U20 team, which played close matches with score differences ranging from 3 to 11 points (Figure 1). This result could allow U18 team coaches to substitute main players more frequently, thereby ensuring that they were always ready to play, while the U20 team might have relied more on their main players. Despite this potential tactic, similar monitoring variables were observed regardless.

When considering the objective measures of HRV, it was previously demonstrated that low HRV values, which indicate the predominance of the sympathetic nervous system, are expected in athletes who are not tolerating their workload [13, 28]. It was reported that an Ln_rMSSD value of 4.5 ms indicates optimal performance in sprinters [29] and in female basketball players [13]. In our study, we found that both U18 and U20 female teams demonstrated no statistically significant changes in daily HRV across the EC compared to pre-match day. Moreover, as the U18 team tended to advance during the tournament these values became closer to the proposed optimal values (Ln_rMSSD 4.27 ms on Day 10) [13, 29]. The lack of a decrease in HRV indicates sufficient recovery of the players during the EC in both U18 and U20 teams. In agreement with these findings, no changes were observed in lacrosse athletes during a congested match tournament scenario of 7 matches in 8 days [30]. It should be noted that, to the best of our knowledge, this is the first study in basketball to compare players' HRV changes during a congested match schedule in youth female basketball, making our findings difficult to compare.

Consistently with the HRV results, no changes in WB were observed in the U20 team during the tournament, but the U18 team had lower total WB in the second half of the tournament compared with the beginning. Lower total WB for U18 compared with the U20 team was observed on Day 8 after two consecutive match days with the first lost game for U18 on Day 7. The observed decrease in WB values might have been influenced by psychological stress felt by U18 players since they lost their first match after four consecutive wins with unbalanced scores (≥ 16 point score difference). In contrast, U20 players had a similar level of opponents from the beginning of the EC considering the close match scores (Figure 1). Additionally, this result might be explained by the influence of contextual variables such as team skills, opponent ability, social environment, and competition environment [15] during the two different tournaments.

The combined team analysis including the entire sample of players from both teams allowed us to better understand the effect of a congested match schedule of 7 matches in 9 days. A lack of difference in HRV but a lowered WB at the end of the tournament shows the greater sensitivity of subjective WB over objective HRV [30]. These findings are consistent with those of Hauer et al. [30], who found no changes for male lacrosse athletes in HRV, although the scores from WB questionnaires were lower at the end of the tournament. This notion might suggest that although the rest days during the tournament are sufficient for physiological recovery, the players' well-being might be affected towards the end of the tournament, with the most important matches still ahead.

Match demands and playing times for each individual player depend on their playing position, tactical decisions and player rotation [7, 31, 32]. Therefore, we expanded our analysis by clustering players based on their average playing time during the whole tournament. The cluster of players who played more demonstrated a very large difference in average playing time (1280 s vs 558 s) and moderately better efficiency (12.5 AU vs 6.6 AU) than the players in the cluster with less playing time. Naturally, the daily sRPE workload of the clusters also differed, with averages of 685 AU and 498 AU for the higher and shorter playing-time clusters, respectively. Despite this dissimilarity, the workload seemed to be optimal for players in both clusters because no difference was detected in any readiness variable. This finding might indicate that players with longer playing time could have better fitness and recovery capacities and ability to cope with higher workloads compared with players experiencing shorter playing time.

Consistent with the findings of previous studies [30, 31, 32], we found no relationships between the monitored variables of workload, readiness and match performance, except the relationships between soreness and sRPE workload from the previous day and playing time. This is understandable because players whose playing time is longer execute more actions, thus possibly inducing greater muscle damage [35]. Similar results were observed by Clemente et al. [36] during a study of a congested period of training for male futsal players in which it was found that muscle soreness and fatigue were moderately correlated with sRPE reported from the previous day [36]. Moreover, Sansone et al. [6] demonstrated negative relationships between training load and perceptual recovery in female basketball players throughout the competitive season at daily, weekly and mesocycle levels. In addition, the objective measurement of Ln_rMSSD showed a small correlation with subjective mood, but did not correlate with the workload, playing time and efficiency statistic. It has been shown that HRV is affected by both physiological and psychological stimuli [37]; therefore changes in mood might affect the values of HRV.

The present study had some limitations. Although several monitoring methods were employed, future studies might provide more insightful information if objective external load measurement using microsensors and internal biochemical markers were included [38, 39]. In addition, the use of objective measures for sleep quality and duration, diet, fluid, and food supplementation could expand the interpretation of changes in WB observed during the study.

CONCLUSIONS

This study showed that junior female basketball players of international level were able to cope with a congested schedule of 7 matches in 9 days irrespective of the competition context or individual differences in workload. This finding might reflect a high level of player preparedness to cope with congested schedules, and optimal player rotation by coaching staff, which appropriately managed training and match workloads. Therefore, the use of tools to monitor workload and readiness should be adopted to avoid performance deterioration during tournaments with congested match schedules. Specifically, the combination of objective and subjective methods to assess workload and readiness is recommended due to weak relationships observed between these methods, suggesting they provide different insight.

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Conflict of interest declaration

The authors declare that they have no conflict of interest.

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Third publication

Workload and well-being across games played on consecutive days during inseason phase in basketball players

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RUNNING TITLE: Workload and well-being in consecutive games

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ABSTRACT

Background. Study aimed to quantify and compare workload and well-being across basketball games played on consecutive days during the in-season phase. ***Methods.*** Seven players (mean [SD]: age, 20.8 [1.6] y; stature, 195.0 [5.4] cm; body mass, 88.3 [4.2] kg; training experience, 11.6 [3.7] y) competing in the second-tier Lithuanian league were recruited. Changes in workload and well-being were monitored across six NKL games in three separate weeks during the in-season phase, with two games per week played on Friday (Day 1) and Saturday (Day 2). External workload was determined as PlayerLoad (PL) and PL per minute (PL/min) via microsensors. Internal workload was determined as percentage of maximum heart rate (%HRmax), summated heart rate zones (SHRZ) workload, and session-rating of perceived exertion (sRPE) workload. Well-being was evaluated using questionnaires assessing fatigue, sleep quality, general muscle soreness, stress levels and mood. Linear mixed models and effect size analyses were used to compare workload and well-being between recorded in Day 1 and Day 2. ***Results.*** Significantly lower PL/min ($P = 0.029$; ES = 0.26, small), greater perception of fatigue ($P < 0.001$; ES = 1.31, large) and lower total well-being score ($P < 0.001$; ES = 0.59, small) were observed for basketball games played on Day 2 compared to games played on Day 1. ***Conclusion.*** Two games played on consecutive days elicited similar game workloads with higher perceived fatigue and lower well-being in the second game day. These findings suggest basketball coaches using recovery strategies to optimize player well-being during congested game schedules.

KEY WORDS: training load; fatigue; microsensor; wellness.

Introduction

Basketball is a team sport characterized by high physical and physiological demands.[1] These demands are compounded by congested game schedules during the in-season in many basketball leagues, which involve multiple games played in close succession.[2, 3] Understanding the workload imposed during games across congested schedules seems fundamental for basketball coaches and practitioners to optimally adjust the prescribed workloads given to players during these congested weeks.[3, 4] Additionally, monitoring workload during consecutive games can provide insight regarding potential decrements in performance due to fatigue-related mechanisms as a consequence of the high physical demand and physiological stress imposed on players during basketball games.[5, 6] In this regard, an early identification and subsequent management of fatigue may prevent maladaptive responses in players and provide desired preparation for games played in close succession.[5]

Fatigue is generated by the interaction of two main attributes: performance and perceived fatigability.[5] Performance fatigability is defined as a decline in objective performance measures derived from reduced capacity of the nervous system and contractile properties of muscles over time, while perceived fatigability is described as the maintenance of homeostasis and subjective psychological state.[7] Previous investigations have mainly focused on the assessment of performance fatigability in basketball games played in close succession.[2, 8, 9] Indeed, these studies evaluated decrements in external (game stimuli imposed) and internal (the physiological or perceptual reactions to the imposed stimuli) workload across games played in close succession.[2, 8, 9] To date, only a recent paper focused on the analysis of players' individual workload changes during 1-to-3 games played on close succession during the in-season phase, revealing trivial-to-small differences in external and internal load.[2] However, these data are likely representative only of a single league (second-tier Australian basketball league), while other leagues might be characterized by a different schedule, with likely different periodization strategies and game workloads calling for further investigations.

Monitoring objective workload to evaluate performance fatigability only partially provides the essential information needed to understand player fatigue status.[5] Conversely, combining objective and subjective workload measures and perceptions of well-being reported by players can provide basketball practitioners with a global picture of how players are responding to game demands.[5] In this regard, several objective (i.e. heart rate indices[10] and biochemical markers[6, 11]) and subjective (i.e. self-reported exertion and wellness measures[3, 4, 10]) monitoring tools have been implemented in combination to assess player well-being in basketball. Specifically, self-reported wellness questionnaires containing questions concerning fatigue, sleep, stress, muscle soreness and mood, have been widely used since they are cost-effective and measure the emotional responses of players not represented in workload measures.[3-5, 10, 12] However, no research has concurrently monitored the workload and well-being status across basketball games played in close succession. Provision of game workload data and player well-being across games during congested schedules seems essential to provide a comprehensive evaluation of potential fatigue encountered by players. In turn, this evidence might suggest basketball coaches and practitioners about the adoption of between games recovery strategies. Therefore, the aim of this study was to quantify and compare workload and well-being across games played on consecutive days during the in-season phase in basketball players.

Materials and methods

Participants

Ten male basketball players competing in the second-tier Lithuanian league [Nacionalinė Krepšinio Lyga (NKL)] were selected for this study. Players were informed about the study aims and procedures before providing personal written informed consent. Only players participating in all games and playing >10 min per game (average time = 22.8 [8.0] min) and not reporting injuries during the investigated period were involved in the study [13]. Therefore, seven players (mean [SD], age = 20.8 [1.6] y, stature = 195.0 [5.4] cm., body mass = 88.3 [4.2] kg., training experience = 11.6 [3.7] y) met the inclusion criteria. Ethical approval was received by the local Institutional Review Board (code: BEK-KIN(B)-2019-184) in accordance with the ethical standards of the Helsinki Declaration.

Design

This observational study was designed to compare the differences in workload and well-being between games played across two consecutive days (<24 h rest between games) during the 2018-2019 in-season phase. Players were fully familiarized with all procedures to monitor workload and well-being during the pre-season and the initial stages of the in-season phase. A total of six NKL games were monitored across three weeks (from 23rd of November to 8th of December 2018) with two games played per week on Friday (Day 1) at 18:00h and on Saturday (Day 2) at 16:00h (Figure 1). The final analysis included 21 game samples (i.e. 7 players across 3 games) for Day 1 and Day 2, respectively. The weekly training schedule was organized with a similar structure across the three separate investigated weeks encompassing one Lithuanian student league game [Lietuvos Studentų Krepšinio Lyga (LSKL)], three 90-min training sessions, the two investigated NKL games and one rest day (Table 1).

INSERT FIGURE 1 AROUND HERE

INSERT TABLE 1 AROUND HERE

Procedures

Game time and details

During each game, the total, actual and live time were calculated. Total time consists of the time between the start (i.e. tip-off) and the end of the game, including all stoppages.[3, 14] In contrast, actual time refers to the time players spent on the court, excluding between-quarter periods, time-outs and bench time with all other in-game stoppages (e.g. out-of-bounds, free-throws) included.[15] In addition, opposition rank leading into the game, game location and final score differences were collected for each game.

Workload monitoring

Both external and internal workloads were monitored during each basketball game and were calculated across total and actual time. For external workload, players were individually equipped with microsensors (Catapult ClearSky T6, Catapult Innovations, Melbourne, Australia) prior to each game. Microsensors were placed in manufacturer-provided vests for secure attachment onto each player between the scapulae and worn under competitive sportswear. Players were assigned the same wearable device every game to minimize any variations in data between microsensors.[16] External workload measures included absolute PlayerLoad (PL) and relative PL per minute

(PL/min), which have been widely used in basketball research.[2, 12, 17, 18] PL was calculated as the instantaneous change rate in accelerations using the tri-axial accelerometer component of the microsensors sampling at 100 Hz with the following formula: PL (AU) = $[\sqrt{(Ac1_n - Ac1_{n-1})^2 + (Ac2_n - Ac2_{n-1})^2 - (Ac3_n - Ac3_{n-1})^2}]/0.01$, where Ac1, Ac2, and Ac3 are the orthogonal components measured from the triaxial accelerometer and 0.01 is the scaling factor.[17]

Objective internal workload measures included percentage of maximum heart rate ($\%HR_{max}$) and summated heart rate zones (SHRZ) workload measured using chest-worn heart-rate (HR) monitors (H10, Polar Electro, Kempele, Finland). During each game, HR was continuously monitored together with microsensor data and post-exercise PL and HR data were downloaded and stored within the same proprietary software (Catapult Openfield, v1.17; Catapult Innovations, Melbourne, Australia). To determine individualized HR_{max}, players completed a 30-15 intermittent fitness test (30-15 IFT)[19] within two weeks prior to the first monitored game. Additionally, in the case where higher HR_{max} than those observed during the 30-15 IFT were identified during games, these data were used for calculating $\%HR_{max}$ and SHRZ workload.[20] The SHRZ workload was calculated using the following formula: SHRZ (AU) = (duration in zone 1 * 1) + (duration in zone 2 * 2) + (duration in zone 3 * 3) + (duration in zone 4 * 4) + (duration in zone 5 * 5), where zone 1 = 50%–59.9% HR_{max}, Zone 2 = 60%–69.9% HR_{max}, Zone 3 = 70%–79.9% HR_{max}, Zone 4 = 80%–89.9% HR_{max}, and Zone 5 = 90% to 100% HR_{max}.[21, 22]

Subjective internal workload was assessed using session-rating of perceived exertion (sRPE), which has been extensively used in basketball research.[3, 10, 14] Each player was individually required to provide a global intensity score using the category ratio scale (Borg's CR-10 scale)[23] approximately 30 min after each game answering to the question: "How intense was the game?"[24] sRPE workload was then calculated multiplying the sRPE score by the game duration (i.e. total and actual time) in minutes.[24] sRPE scores were collected and stored on cloud-based online survey software (Google Forms, CA, United States of America).[14]

Well-being

Every game day, player well-being was individually evaluated upon awakening via administration of questionnaires based on past recommendations.[3, 10] The questionnaire assessed fatigue, sleep quality, general muscle soreness, stress levels and mood on a five-point Likert scale (scores of 1 to 5 with 0.5-point increments).[3] Total well-being score was determined by summing the five scores from each item.[3] Data were collected every morning before each game using online survey software (Google Forms, CA, United States of America).[14]

Statistical analysis

Data are presented as mean ± standard deviation (SD) for each dependent variable (i.e. workload and well-being measures). After confirming the normality of data through the Shapiro-Wilk test, data were analyzed using linear mixed models with day as a fixed effect (i.e. games played on Day 1 or Day 2) and player, opposition rank, location and score difference as random effects. The magnitude of differences for pairwise comparisons between measures obtained for Day 1 and Day 2 was assessed using effect sizes (ES) with 95% confidence intervals. ES were interpreted as: trivial = <0.20, small = 0.20-0.59, moderate = 0.60-1.19, large = 1.20-1.99. very large = ≥2.00 [25]. All statistical analyses were conducted using the lmer test package in RStudio (version 3.5.2, Eggshell Igloo, R Foundation for Statistical Computing) and JASP (version 0.11.1). The level of significance was set at $P < 0.05$.

Results

Mean ± SD workload measures during total time in games played on Day 1 and Day 2 are displayed in Table 2. A significantly higher total time ($P < 0.001$; ES = large) was evident on games on Day 2 compared to Day 1, while no statistically significant differences ($P > 0.05$) between games were found for workload measures with trivial-to-small ES (Table 2).

INSERT TABLE 2 AROUND HERE

Mean ± SD workload measures during actual time in games played on Day 1 and Day 2 are shown in Table 3. No significant difference ($P > 0.05$; ES = small) was evident in actual time between games played on Day 1 and Day 2 (Table 3). Although there were no statistically significant differences in PL ($P > 0.05$) between games, a significantly lower PL/min ($P = 0.03$; ES = small) was observed in games played on Day 2 compared to Day 1. No significant differences ($P > 0.05$; ES = trivial-small) were apparent for any internal workload variable.

INSERT TABLE 3 AROUND HERE

Mean ± SD well-being measures taken prior to games played on Day 1 and Day 2 are presented in Table 4. Higher levels of fatigue were evident on Day 2 compared to Day 1 (P <0.001; ES = large), while no significant differences (P >0.05; ES = trivial-small) were shown for sleep, soreness, stress and mood. However, a lower total well-being score (P <0.001; ES = small) was observed on Day 2 compared to Day 1.

INSERT TABLE 4 AROUND HERE

Discussion

The aim of this study was to quantify and compare workload and well-being across basketball games played on consecutive days during the in-season phase. Our findings revealed trivial-to-small differences in workload between games, while players perceived higher (large) levels of fatigue prior to the second game compared to the first game, which in turn significantly inflated (small) well-being status.

Previous investigations assessing changes in external workload across games played in close succession have mainly focused on basketball tournaments rather than during regular in-season competitive phases.[8, 9] In turn, studies examining game workloads during basketball tournaments revealed an increase in high-intensity actions in games towards the end of the tournament compared to the beginning of the tournament.[8, 9] In contrast, our data showed similar external workload volume (PL) and intensity (PL/min) during total time between games played on Day 1 and Day 2 during the in-season phase. A possible reason for variations in findings between studies might be that in a tournament scenario, teams usually face stronger opponents towards the end of the tournament, whereas our analysis considered opposition ranking, game location and final score difference, which can potentially influence player workloads during games played across the regular in-season phase.[26, 27] Nevertheless, our results are in line with a previous investigation assessing the workloads encountered across games played on consecutive days during the in-season phase in semi-professional, male basketball players.[2] Indeed, Fox et al.[2] showed similar game workloads when 1-3 games were played each week during the in-season phase with trivial-small differences in PL and PL/min across total game time. These results overlap with our findings, which showed trivial differences in PL/min between games (5.62 [1.55] AU/min vs 5.41 [1.61] AU/min) compared to data reported by Fox et al. (game 1: 5.34 [1.77] AU/min; game 2: 5.71 [1.71] AU/min; game 3: 5.39 [2.26] AU/min).[2] Interestingly, the present study and the study conducted by Fox et al.[2] included semi-professional, male players, although competing in different geographical areas (Europe and Australia) and with different training schedules. Nevertheless, these results across studies might collectively provide benchmark values for the intensity of games played on consecutive days, which can inform the design of sound training plans by basketball coaches when preparing for upcoming congested game schedules.

It is important to note that Fox et al.[2] provided no data relative to actual playing time during games played on consecutive days.[2] Consequently, the players investigated by Fox et al.[2] might have accumulated different on-court playing times, which in turn may have influenced their workloads when active on the court.[27] To overcome this issue, we analyzed player workloads during actual game time, and showed non-significant, trivial-small differences in most measures between games played on Day 1 and Day 2. However, it should be noted that a statistically significant decrease in PL/min was found in Day2 compared to Day1, underlining a possible decrease of the game intensity when players actively participate on the court. The added analysis of game workloads during live time might provide a more precise estimation of workload volumes and intensities players experience during games played in close succession, further guiding player preparation strategies developed by coaches leading into congested periods of the in-season phase.

In addition to external workload data, internal workload data are essential to understand how players are responding to imposed stimuli during games. The investigated internal workload measures mirrored the external workload measures with trivial-small differences in $\%HR_{max}$, SHRZ workload, and s-RPE during total and actual time between games played on Day 1 and Day 2. These results are in line with those reported in previous basketball investigations assessing internal workload across games played in close succession during the in-season phase[2] and in a tournament scenario.[8] Overall, our complete workload dataset encompassing external and internal measures highlighted similar workload volumes and intensities are experienced across games played on consecutive days suggesting no development of performance fatigue. A possible explanation for the lack of decline in workload measures between games might be that basketball coaches likely implement substitutions due to tactical strategies resulting in players accumulating an average playing time of 22.8 [8.0] min, which represents the 57% of the game live time (i.e. 40 min). Perhaps, players in other teams (to that investigated in this study) might complete more playing time during games and thus being more susceptible to fatigue responses in subsequent games, which emphasizes the need for more studies on this topic in basketball.

In opposition to the predominantly similar workloads evident across games played on consecutive days, the investigated players perceived increased fatigue prior to the second game compared to the first game. Therefore, the prior workload performed during Day 1 might have impacted player perceived fatigue when needing to compete on the subsequent day. To the best of our knowledge, this is the first study assessing perceived fatigue in basketball players across games played in close succession making our findings difficult to compare with other research. However, our results were somewhat expected since previous investigations showed increased perceived fatigue immediately after basketball games with the effect maintained across the following 24 h.[28, 29] Since our well-being questionnaire was administered after awakening before each game, an increase in perceived fatigue on Day 2 might be expected given it was assessed ~12 h after the first game. In general, the contrasting results between performance and perceived fatigue underlines the necessity for basketball practitioners to monitor both components of fatigue for a global understanding of fatigue status in players.

In contrast to previous investigations showing a statistically significant increase in muscle soreness immediately after basketball games and in the following 24 h[28, 29], our results revealed a small increase in muscle soreness between Day 1 and Day 2. A possible reason for variations in findings between our study and past investigations might be the different training volume experienced by the investigated players. Indeed, in our study, players completed three 90-min training sessions and three games (one LSKL and two NKL games), while in past studies[28, 29], participants completed three 120-min basketball sessions and one match per week. Therefore, higher-trained players might perceive less muscle soreness following a game rather than their lower-trained counterparts. In this regard, further investigations assessing changes in muscle soreness following games, especially during congested schedules, should consider high- and low-trained players in separate analyses.[28, 29] It should be noted that no differences were found in other well-being scores (stress, mood and sleep quality), while the total well-being score significantly (small) worsened on Day 2 compared to Day 1. We can speculate that the change in total well-being between days was predominantly influenced by the greater perceived fatigue on Day 2, supporting the monitoring and interpretation of each item separately when assessing player well-being across the in-season phase.

While this study provided several interesting findings regarding workload and well-being across basketball games played on consecutive days during the in-season phase, it was subject to some limitations that warrant discussion. Firstly, our sample size was representative of a single team competing in a semiprofessional Lithuanian basketball league and playing in a congested game schedule with less than 24h rest. Therefore, the results of this study are unlikely generalizable to other teams playing in different leagues exposed to different game schedules. Thirdly, due to the small sample size (n = 7), it was not feasible to separate our data based on factors that may influence game demands such as playing position (guards vs forwards vs centers) [9] or playing time (starting vs bench players) [3]. Thus, future studies should include a larger sample size to allow analyses considering these factors. Finally, in the current study, only changes in physical, physiological and perceived demands were assessed, while future studies should focus on the analysis of changes in technical performances across consecutive games.

Practical applications

Basketball practitioners are suggested to monitor changes in workload across consecutive games during the in-season phase to best identify the development of performance fatigue. Furthermore, concurrent assessment of player well-being using questionnaires to monitor, among other psychological components, the perceived fatigue may be particularly important during congested game schedules. In particular, despite some limitations such as relying on subjective information and the lack of validity and reliability studies specifically in basketball, well-being questionnaires are cost-effective, easy to administer and in conjunction with workload monitoring tools can provide insight about how players are coping with imposed game workloads [5]. Finally, considering the higher perceived fatigue we observed prior to the second game compared to the first game during congested schedules, basketball practitioners should consider adopting suitable between-game recovery strategies such as massage [29] or cold-water immersion [28], which might enhance perceived fatigue in players and in turn optimize preparation leading into subsequent games during congested schedules [5].

Conclusion

A congested match schedule with two games played on consecutive days elicited similar game workloads with higher perceived fatigue and lower well-being status prior to the second game compared to the first game. These findings suggest basketball coaches and practitioners using recovery strategies to optimize player well-being during congested game schedules.

Conflicts of interest. — The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions. — All authors contributed equally to the conceptaulization, methology, investigation, formal analysis and drafting the manuscript and read, revised and approved the final version of the manuscript.

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Table 1. — Training and game schedule during the investigated 3-week in-season period

Week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	LSKL Game	Technical session	Tactical and conditioning session	Tactical session	NKL Game 1	NKL Game 2	Rest
2	LSKL Game	Technical session	Tactical and conditioning session	Tactical session	NKL Game 3	NKL Game 4	Rest
3	LSKL Game	Technical session	Tactical and conditioning session	Tactical session	NKL Game 5	NKL Game 6	Rest

Abbreviations: LSKL, Lithuanian Student Basketball League [Lietuvos Studentų Krepšinio Lyga (LSKL)]; NKL, second-tier Lithuanian league [Nacionalinė Krepšinio Lyga (NKL)]

Table 2. — External and internal workloads during total game time in the first and second games played on two consecutive days.

Dependent variables	Day1	Day2	P value	Fixed effect estimate (95% CI)	Effect size (95% CI)	Interpretation
Time						
Total time (min)	94.35 ± 4.29	98.00 ± 39.17	**<0.001**	-4.05 (-6.18; -1.91)	-1.20 (-1.86; -0.53)	Large
External load						
PL (AU)	531.20 ± 148.85	532.87 ± 157.17	0.836	-1.67 (-98.47; 95.13)	-0.01 (-0.62; 0.60)	Trivial
PL/min (AU/min)	5.62 ± 1.55	5.41 ± 1.61	0.601	0.21 (-0.79; 1.21)	0.14 (-0.48; 0.75)	Trivial
Internal load						
%HR_{max}	71.26 ± 6.02	68.20 ± 8.85	0.161	3.06 (-1.74; 7.87)	0.40 (-0.22; 1.02)	Small
SHRZ (AU)	251.26 ± 57.17	233.03 ± 83.72	0.322	18.23 (-27.29; 63.74)	0.25 (-0.36; 0.87)	Small
sRPE-TL (AU)	763.85 ± 210.00	837.07 ± 218.65	0.128	-73.22 (-208.77; 62.33)	-0.34 (-0.96; 0.28)	Small

Table notes: Data presented as mean ± standard deviation; three games were played on Day 1 and three games were played on Day 2 across the sample period. *Abbreviations*: CI, confidence interval; PL, AU, arbitrary unit; player load; PL/min, player load per minute; %HR_{max}, percentage of maximum heart rate; SHRZ, summated heart rate zones; sRPE, session-rating of perceived exertion.

Table 3. — External and internal workloads during actual game time in the first and second games played on two consecutive days.

Dependent variable	Day1	Day2	P value	Fixed effect estimate (95% CI)	Effect size (95% CI)	Interpretation
Time						
Actual time (min)	37.39 ± 11.97	41.34 ± 15.93	0.170	-3.95 (-12.74; 4.84)	-0.28 (-0.89; 0.33)	Small
External load						
PL (AU)	442.84 ± 146.34	457.70 ± 162.50	0.523	-14.87 (-112.72; 82.98)	-0.10 (-0.71; 0.52)	Trivial
PL/min (AU)	11.63 ± 1.46	11.22 ± 1.73	**0.029**	0.41 (-0.60; 1.43)	0.26 (-0.36; 0.87)	Small
Internal load						
$\%HR_{max}$	84.99 ± 5.49	82.07 ± 8.63	0.127	2.92 (0.13; 2.92)	0.40 (-0.22; 1.02)	Small
SHRZ (AU)	154.27 ± 57.75	153.53 ± 72.50	0.944	0.74 (-40.80; 42.28)	0.01(-0.60; 0.62)	Trivial
sRPE-TL (AU)	313.69 ± 139.73	372.65 ± 187.62	0.089	-58.96 (-162.13; 44.22)	-0.36 (-0.96; 0.26)	Small

Table notes: data presented as mean ± standard deviation; three games were played on Day 1 and three games were played on Day 2 across the sample period. *Abbreviations*: CI, confidence interval; PL, AU, arbitrary unit; player load; PL/min, player load per minute; %HRmax, percentage of maximum heart rate; SHRZ, summated heart rate zones; sRPE, session-rating of perceived exertion.

Table 4. — Well-being changes between the first and second games played on two consecutive days.

Dependent variable	Day 1	Day 2	*P* value	Fixed effect estimate (95% CI)	Effect size (95% CI)	Interpretation
Fatigue (AU)	3.57 ± 1.03	2.33 ± 0.86	**<0.001**	1.24 (0.65; 1.83)	1.31 (0.63; 1.97)	Large
Sleep (AU)	3.62 ± 0.97	3.76 ± 0.89	0.510	-0.14 (-0.72; 0.44)	-0.15 (-0.76; 0.45)	Trivial
Soreness (AU)	3.14 ± 1.01	2.67 ± 1.02	0.082	0.48 (-0.16; 1.11)	0.47 (-0.15; 1.08)	Small
Stress (AU)	4.14 ± 0.85	3.81 ± 0.81	0.100	0.33 (-0.19; 0.85)	0.40 (-0.21; 1.01)	Small
Mood (AU)	3.67 ± 0.97	3.57 ± 0.81	0.367	0.10 (-0.46; 0.65)	0.11 (-0.50; 0.71)	Trivial
Total well-being (AU)	18.14 ± 3.72	16.14 ± 2.99	**<0.001**	2.00 (-0.10; 4.10)	0.59 (-0.03; 1.21)	Small

Table notes: Data presented as mean ± standard deviation; three games were played on Day 1 and three games were played on Day 2 across the sample period. *Abbreviations*: CI, confidence interval; AU, arbitrary unit

Figure 1. — The congested monitored games and measurements collected during each game day.
Abbreviations: PL, player load; PL/min, player load per minute; $\%HR_{max}$, percentage of maximum heart rate; SHRZ, summated heart rate zones; sRPE, session-rating of perceived exertion.

	Day1 Friday 18:00 h	**Day2** Saturday 16:00 h
Week1	Game1 – away	Game2 – home
Week2	Game3 – home	Game4 – away
Week3	Game5 – home	Game6 – away

Pre-game:
- Well-being questionnaire

During each game:
- PL
- PL/min
- $\%HR_{max}$
- SHRZ workload
- sRPE workload

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