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Differences In Player Load Of Professional Basketball Players As A Function Of Distance To The Game Day During A Competitive Season

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ABSTRACT

Purpose: The aim of this study was to investigate the dynamics of external training load (eTL), internal training load (iTL), and well-being status, during a regular season week with one game, and to examine the differential workloads of players depending on their distance from game day during a competitive season. **Method:** Subjects were 10 full-time professional basketball players (24.6 ± 4.9 years old; 204.2 ± 16.8 cm; 97.9 ± 10.4 kg). Workload was recorded and classified as total duration training and duration of full game during a competitive season. A wearable tracking system collected eTL via Player Load (PL) and Player Load per minute (PL/min). Training sessions were classified based on days before a match (four days before the match day = MD-4, MD-3, MD-2, and MD-1), and MD. Session rate of perceived exertion (sRPE) and rate of perceived exertion (RPE) were used for iTL. In addition, the Hooper index (HI) was used for well-being. **Results:** A significant difference was found between MD-1 and MD workload, MD workload being the highest of all variables: RPE ($p <$ .001), PL/min ($p <$.001), PL ($p <$.001), and sRPE (p <.001). Regarding Hooper's categories, significant differences between training days and match were only found in soreness ($p <$.001). **Conclusion:** The results show that MD provides a unique stimulus in terms of volume and intensity. Consequently, coaches must incorporate specific training exercises to adapt players to the demands of competition. Finally, special attention should be paid to MD-2 and MD-1 in terms of potential accumulated fatigue and thus to ensure appropriate recovery time for athletes to adapt before the match.

Keywords: External Workload, Internal Workload, Load Management, Team Sports, Sports Monitoring

INTRODUCTION

Basketball is an intermittent, indoor court-based team sport where high-intensity movements, such as changes of direction, accelerations, decelerations, and jumps, alternate with low-to-moderate-intensity periods (Conte et al., 2015; Narazaki et al., 2009; Petway et al., 2020; Sampaio et al., 2015; Stojanović et al., 2018). Therefore, physical conditioning is considered a fundamental requirement to compete at elite level in modern basketball (Abdelkrim et al., 2006; Klusemann et al., 2013; Simenz et al., 2005).

According to the German statutory accident insurance (VBG, 2022), 66.2% of the players competing in the Basketball Bundesliga (BBL, first German national league) were injured in 2021, with an average injury rate of 93 injuries per 1000 hours of competition. Compared to the National Collegiate Athletic Association, the injury rate for athletes who compete appears to be significantly lower at 4.3 per 1000 athletes (Dick et al., 2007). Given that many of these injuries are attributed to excessive training loads, they might be largely preventable if the appropriate training loads were prescribed (Gabbett et al., 2016). Load monitoring approaches and feedback on the effects and adjustments during rehabilitation have been an integral part of the return-to-play algorithm (Locus et al., 2021) and can also assist in reducing the likelihood of maladaptive responses in players (e.g., illness, injury, or non-functional over – reaching; Locus et al., 2021; Fox et al., 2017; Clemente et al., 2017; Moalla et al., 2016; Sansone et al., 2020, 2021).

It is important to know if a training intervention has been effective and whether the team as a whole has benefited. Quantifying the specific demands of a sport is important not only for developing team training plans, but also for analyzing individual athletic performance (Clemente et al., 2020; Taylor et al., 2017). When considering the effects of individual characteristics on an athlete's response to training, it may be more beneficial to use an individual approach to model this relationship. For example, the same load stimulus may trigger different effects and adaptive responses (Borresen & Lambert, 2009) in two athletes due to variations in factors such as genetics or level of fitness (Bouchard & Rankinen, 2001), injury history (Hulin et al., 2016), and age (de la Rubia et al., 2020). Monitoring workload, when correctly managed, may lead to a better understanding of athletes' responses to stimuli and may allow to obtain the desired training response (Impellizzeri et al., 2019; Piedra et al., 2021; Torres-Ronda et al., 2022). In addition, it can be used to make training increasingly individualized (Clemente et al., 2020). Consequently, load monitoring and workload management in basketball is critical to create an optimal environment for athlete success (Manzi et al., 2010; Petway et al., 2020b; Heishman et al., 2018; Aoik et al., 2016). Workload monitoring should aim to optimize the physical stimuli delivered to athletes at different stages of training and competition (West et al., 2021). It is a relevant element in any phase of the season (Drew & Finch, 2016).

To be effective, training programs should be tailored to the load imposed during matches (Scott et al., 2014) with appropriate periodization of a daily and weekly microcycle. A commonly used approach is tapering. Tapering is a reduction in workload for a period prior to a competition to minimize the psychobiological stress of chronic training and thereby improve performance (Svilar et al., 2019; Bompa & Haff, 2012). The main manipulated variables are volume, intensity, frequency, and duration (Bompa & Haff, 2012; Mujika & Padilla, 2003; Svilar et al., 2019). Therefore, quantifying training and game-day load is useful to understand how much players are exposed to gamelike demands during training sessions. (Clemente et al., 2019b; Modric et al., 2021; Mujika et al., 2017; Stevens et al., 2017). This approach utilizes individual loads from training and matches and provides important information for adjusting individual training programs according to the match loads (Borresen & Lambert, 2009; Bourdon et al., 2017; Clemente et al., 2020; Paulauskas et al., 2019). Determining the process that should be implemented to achieve the desired workload is complex and requires accurate analysis and objective and subjective measurements, combined with the experience and perspective of coaches (Portes et al., 2019; Rabelo et al., 2016).

The aims of load management is to reduce risk factors for injury and to optimizing decision making by the coaching staff. As such, monitoring the external load and the internal load, during both training and competition, is recognized as key in informing the management of athletes (Fox et al., 2017; Sansone et al., 2020; Schelling & Torres, 2016; McLaren et al., 2017; Vanrenterghem et al., 2017).

There are several possibilities to quantify training load such as changes of direction, accelerations, decelerations, and jumps used in basketball (Fox et al., 2017). One of the most commonly adopted tools to assess external load in basketball are wearable inertial measurement units (IMUs) (Fox et al., 2017; Russell et al., 2020). These devices collect inertial data and combine the instantaneous rate of change of acceleration in all three planes of movement to obtain a single measure of accumulated load that reflects the external load imposed on the athlete, such as the player load (PL). Further parameters that can be calculated from the data are player load per minute played (PL/min) (©Catapult Innovation, Melbourne, Australia), which can provide information about the inertial movements that players execute on the court (Fox et al., 2017).

Fox et al. (2018) defined days without travel,

games, or team practice and minimal (i.e., <200 player load (arbitrary units) AU) or no on-court activity accumulated by the player which typically represents <45 minutes (min) of light basketball activity as recovery days.
In addition to the external training load (eTL), it is also important to quantify the internal training load (iTL). The assessment of iTL requires evaluation of the psychobiological response to the stimuli imposed by the eTL (Impellizzeri et al., 2005). While the duration of a training session is easily measurable as time in minutes, the intensity can be determined by different methods as heart rate, subjective rating of perceived exertion (RPE), blood lactate concentration, hormonal concentration among other factors that are fundamental to the athlete's perception of load determination and adaptation (Halson, 2014). Thus, internal load can be quantified objectively or subjectively (Ferreira et al., 2021). Among them, RPE scales are interesting tools due to their validity and reliability, as well as their low cost and ease of use in most contexts (Haddad et al., 2013; Herman et al., 2006). Multiplying the duration of the training session by RPE values has been used to determine the volume of exercise (Foster et al., 2001). Scanlan et al. (2014) showed that session-RPE is significantly correlated with external load if measured by accelerometers.

Due to the numerous commitments and potential stressors players face during the season, not only training load should be monitored, but also player well-being (Clemente et al., 2020; Conte et al., 2018; Ferreira et al., 2021). Well-being can be subjectively quantified using questionaries and may be influenced by different physical and psychological factors and can be assessed by variables such as delayed onset muscle soreness (DOMS), stress, fatigue, mood, and sleep quality (Haddad et al., 2013; Hooper & Mackinnon, 1995).

Previous research has reported that not only sleep disturbance but also fatigue increases the risk, prevalence, and severity of musculoskeletal injuries and is associated with cognitive, technical, and physical performance impairment, whereas healthier sleep habits and therefore players with low fatigue may lead to enhanced physical and technical performance (Edwards et al., 2018; Fullagar et al., 2015). For example, DOMS is the main cause of reduced exercise performance including muscle strength and range of motion (Serinken et al., 2013). Moreira et al. (2003) showed that basketball players have increased levels of stress and decreased levels of immunoglobulin during the competitive phase. In this context, sleep quality, stress, fatigue, and DOMS are considered important psychological and physiological functions that may influence the recovery process in elite basketball players (Edwards et al., 2018; Mah et al., 2011). As session RPE, well-being questionnaires are easy to implement and inexpensive. They could be helpful in conjunction with other monitoring metrics such as external and internal load to obtain better information about the biological and physical stress that training and competition imposes on players (Mello et al., 2017; Moalla et al., 2016).

Specifically, Clemente et al. (2019a), Svilar et al. (2018), and Manzi et al. (2010) reported about workload depending on the distance to the game day. However, the studies lacked either game data, wearables data, or athlete self-report measures (ASRM). To date, the authors are not aware of any studies that have investigated the workload of all training days preceding the match day in addition to the match day (MD) itself with internal and external measure, and ASRM in professional basketball players. Despite the importance of the above-mentioned issues, literature on internal and external training loads and athletes' well-being status during a competitive basketball season are rare, especially in professional basketball. Analysis of weekly player load distribution in temporal relation to the match day can provide important information about training periodization in professional basketball. Therefore, the aim of this longitudinal study was the quantification of workload difference in external load measured via IMUs, the perceived training load and well-being status over a competitive basketball season. Knowing these changes in workload and physical demands during in-season macrocycles could help coaches, athletic-performance staff and medical staff to optimize training and match performance.

METHODS

Participants

Sixteen professional basketball players from a German first league club (24.6 ± 4.9 years old; 204.2 ± 16.8 cm; 97.9 ± 10.4 kg) participated in this study. Players who participated in less than 80% of the training sessions (n = 204) were excluded from the study. All the players were accustomed to the daily procedures of this research as part of their regular training routines (Winter & Maughan, 2009). Players were routinely monitored during all training sessions and matches in the course of the competitive season, so no ethics committee approval was needed.

Study Design

This study followed a longitudinal approach during the 2021/2022 basketball season (August 2021 – Mai 2022). During the pre-season phase, players were familiarized with the monitoring tools used. Following this period, weekly training load, game performance data and well-being questionnaires were collected during 37 weeks of the competitive season (including all regular season and cup games). The team weekly schedule featured five team-based basketball sessions of 90–120 min, which focused on skills development, game-based conditioning, two physical training sessions of 40–60 min including strength, power, and speed training. The researchers did not intervene in the training plans or the tasks of the trainers. Therefore, the data for the analysis was collected four days before the match day (MD-4), three days before the match day (MD-3), two days before the match day (MD-2), one day before the match day (MD-1), and on MD.

Match Analysis

IMA analysis was made for the four quarters in every competitive game including the 30 min standardized warm-up, excluding the rest intervals between quarters (Torres-Ronda et al., 2016). Game quarters lasted a total of 19 to 26 min. Only the players on the court were analyzed. According to the FIBA rules, games consisted of four 10- min quarters, with 24-s shot clock, 2-min inter-quarter breaks and a 15-min half-time break (FIBA, 2018).

Practice Analysis

IMA analysis was made for all training sessions. All training sessions started with a standardized team warm-up and were performed on the practice or game court under similarly controlled environmental conditions. Players were allowed to consume water during recovery periods. During these practice sessions, groups of teammates and opponents were varied randomly.

Data Collection and Processing

Openfield™ was used to process inertial movement data. As described above, PL was calculated using the manufacturer's algorithm (t = time, fwd = forward acceleration, side = sideways acceleration, up = vertical acceleration), using the formula presented above. PL describes the sum of movements and their intensity in different axes during the entire activity or during one minute of the activity (PL/min). Established literature refers PL as a reliable and reproducible metric in the quantification of cumulative motion for indoor sports (Peterson & Quiggle, 2017). The manufacturer's inertial movement analysis (IMA) can be used to analyze micro-movements, regardless of unit orientation and positional data. The algorithm considers tri-axial accelerometer, and gyroscope data (100 Hz) are taken into consideration to evaluate the magnitude of the athlete's movements. To differentiate between athlete and device movement, an advanced gravity filtering model (Kalman filtering technique) is used in the manufacturer's algorithm to create non-gravity vectors. In this investigation, IMA metrics were analyzed as PL and PL/min. To avoid inter-sensor variations, each athlete wore the same sensor when capturing data.

Internal Training Load Monitoring

For every practice session and game, each player estimated the intensity approximately 30 min post-session using Foster's modified rating of perceived exertion (RPE) scale (Foster et al., 2001). All players had been familiarized with the RPE scale according to standard procedure (Foster et al., 2001) and classified their effort from 1 (very light activity) to 10 (maximal exertion). The RPE values were collected within 15-30 min following the training session and entered into an application by the players (Catapult Forms). Training load scores were then calculated via session RPE (sRPE). The sRPE method of quantifying iTL via the multiplication of RPE and session duration is a simple and cost-effective use in practice with team-sport athletes (Coutts et al., 2004; Impellizzeri et al., 2004; Lambert & Borressen 2010) and has been employed in previous research (Gabbett & Domrow 2007; Piggott et al., 2009; Rogalski et al., 2013; Montgomery et al., 2013) for reliability and validity (Singh et al., 2007; Foster,1998; Wallace et al., 2014; Williams et al., 2016). The validity of using sRPE for monitoring training and competition loads in basketball players has previously been demonstrated (Manzi et al., 2010).

Monitoring of Well Being

The Hooper Questionnaire (Hooper & Mackinnon, 1995) with four categories (delayed onset muscle soreness - DOMS; stress, fatigue, and sleep) was completed approximately 30 min after awakening via an application (Catapult Forms). Each category can be rated from 1 to 7. For DOMS, stress, and fatigue, 1 represents “very, very low” and 7 means “very, very high”. For sleep quality, 1 represents “very, very good” and 7 represents “very, very poor” (Clemente et al., 2017). The sum of the four categories is the Hooper index (Haddad et al., 2013). Lower indices mean better well-being.

Monitoring of External Training Load

The external training load (eTL) data were processed using the manufacturer’s software (OpenfieldTM version 3.3.0, Catapult Sports©, Melbourne, Australia). Vector 7 receiver tags (81 mm length, 43.5 mm width, 15.9 mm thickness) were attached at the upper back between the athletes’ shoulders using Vector Elite Vest (Catapult Sports©, Melbourne, Australia). A 3D-accelerometer (± 16 G, 100 Hz), a magnetometer (-D ±4900 μT, 100 Hz), and a gyroscope (-2000 degrees per sec, 100 Hz) are built into the receiver, allowing inertial movement analysis (IMA). The obtained data included the following variables: PL,PL/min, accelerations, decelerations, jumps and changes of direction. The variables for the analysis were PL and PL/min. The definition, “a modified vector magnitude, expressed as the square root of the sum of the squared rates of change in acceleration between each moment of a training session in each movement axis (x, y, and z)” is presented in Montgomery et al.’s (2010) and Boyd et al.’s (2013) work in arbitrary units (AU) (Barrett et al., 2014; Heishman et al., 2018) and accompanied by the following PL equation:

$$PL = \sqrt{((fwd_{t=i+1} - fwd_{t=i}))^2 + (side_{t=i+1} - side_{t=i})^2 + (up_{t=i+1} - up_{t=1})^2)}$$

Statistical Analysis

The results were expressed as means (M) ± standard deviation (SD). The differences in player load, RPE, sRPE and Hooper categories for days with different distance to the match (MD-4, MD-3, MD-2, MD-1 and MD) were analyzed using one-way analysis of variance (ANOVA). Partial eta squared (η^2p) effect size (ES) was used for ANOVA and classified as no effect (ES < 0.04); minimum effect (0.04 ≤ ES < 0.25); moderate effect (0.25 ≤ ES < 0.64); and strong effect (ES≥ 0.64) (Ferguson, 2009). The least significant difference (LSD) test was used in ANOVA as a post-hoc approach. Independent t-tests were used for pairwise comparison between training day and match day. All statistical analyses were carried out using the SPSS statistical analysis software (SPSS version 28.0, Chicago, USA). The level of statistical significance was set at $p \leq 0.05$. All figures were produced using R Studio (Version 4.0.0).

RESULTS

Descriptive values for player load and player load per/min on different training sessions and official basketball games are shown in Figure 1. The descriptive values for RPE and sRPE on different training sessions and official basketball games are shown in Figure 2. Descriptive statistics for Hopper index on different training sessions and official basketball games are shown in Figure 3. In Table 1 can be found the descriptive statistics of daily individual Hopper index value ratings for DOMS, sleep, fatigue, and stress.

Player load differs by MD ($F(1.18,10.63) = 7.942$, $p < .001$, $\eta^2p = .469$). The Mauchly-W(2)=.001,

Table 1. Median and standard deviation for individual Hooper categories and index regarding every day.

	DOMS	Sleep	Fatigue	Stress	Hooper Index
	Scale 1-7	Scale 1-7	Scale 1-7	Scale 1-7	Scale 4-28
Week and Day Type	M ± SD	M ± SD	M ± SD	M ± SD	M ± SD
MD-4	1.9 ± 0.8	3.4 ± 0.6	2.5 ± 1.2	1.9 ± 1.7	9.9 ± 2.4
MD-3	2.3 ± 1.1	3.2 ± 0.5	2.7 ± 1.0	1.9 ± 0.7	10.4 ± 2.3
MD-2	2.2 ± 1.0	3.2 ± 0.8	2.9 ± 1.3	2.1 ± 0.8	10.4 ± 2.4
MD-1	2.1 ± 1.0	3.1 ± 0.8	2.8 ± 1.2	2.0 ± 0.7	9.9 ± 2.0
MD	1.7 ± 0.7	3.3 ± 0.6	2.6 ± 1.2	1.8 ± 0.8	9.5 ± 2.2

Legend: *Athlete self-report measure: Hooper categories; DOMS: Delayed Onset Muscle Soreness (scale from 1 to 7, in which 1 indicates “very, very low and 7 was “very, very high”); Sleep: sleep quality (scale from 1 to 7, in which 1 indicates “very, very good” and 7 was “very, very poor”); Fatigue: level of fatigue (scale from 1 to 7, in which 1 indicates “very, very low” and 7 was “very, very high”); Stress: level of stress (scale from 1 to 7, in which 1 indicates “very, very low and 7 was “very, very high”); HI: Hooper index (scale from 4 to 28); M.: Mean values; SD: Standard deviation.*

p <.001) revealed no sphericity, so the Greenhouse-Geisser correction was applied (ϵ = 1.181), resulting in corrected degrees of freedom. An LSD pairwise comparison shows a significant (*p* <.001) difference between MD-4 and MD-1 (555.7 ± 75.3, 419.9 ± 39.5). MD-3 is significantly (*p* = <.004) different from MD-2 (570.4 ± 58.2, 538.5 ± 49.6) and MD-1 (*p* <.001, 419.9 ± 39.5) which is shown in Figure 1. In addition, MD-1 is significantly (*p* <.001) lower for player load compared to MD-3, MD-2, and MD (p = .007, 578.7 ± 162.3). Figure 1 also visualize that payer load per minute varies by MD (F(1.32,11.89) = 22.716, p < .001, η^2p = .716). The Mauchly-W(2)=.010, p<.001) revealed no sphericity, so the Greenhouse-Geisser correction was applied (ϵ = 1.322), resulting in corrected degrees of freedom. LSD pairwise comparison shows a significant (*p* = .002) difference between MD-4 and MD (*p* = .002, 4.9 ± 0.3, 6.5 ± 1.1). MD-3 is significantly (*p* = .001) different from MD and MD-1 (*p* = .041, 5.0 ± 0.4, 4.7 ± 0.4). A significant difference was found for MD-2 (*p* = .041, 5 ± 0.4) in comparison MD-1 and MD (*p* < .001). Finally, MD-1 was significantly different from MD-3 (*p* = .024) and MD (*p* < .001).

Figure 2 shows that sRPE differs by MD (F(1.71, 15.67) = 34.865, *p* <.001, η^2p = .796). The Mauchly-W(2) =.070, *p* = .030) revealed no sphericity, so the Greenhouse-Geisser correction was applied (ϵ = 1.741), resulting in corrected degrees of freedom. LSD pairwise comparison shows significant difference from MD-4, MD-3 (*p* = .009,) and MD-1 (*p* <.001, 694.6 ± 149.3, 799 ± 190.9, 412.7 ± 114.9) and to MD (*p* = .010, 904.7 ± 248.23). MD-3 shows significant (*p* = .002) difference from MD-2 (799 ± 190.9, 674.6 ± 139.9) and MD-1 (*p* <.001, 412.7 ± 114.9). In addition, MD-1 shows significant (*p* <.001) difference for sRPE MD-3, MD-2 as well as for MD. Figure 2 also shows that RPE differs by MD (F(4,36) = 11.905, *p* < .001, partial η^2p = .569). The Mauchly-W(2) = .116, *p* = .073) assumed sphericity. LSD pairwise comparisons show that RPE is significant higher (*p* < .001) MD-4 and MD-1 (6.1 ± 1.1, 6.2 ± 1.4). MD-3 shows significant (*p* = .027) lower for MD-2 (6.2 ± 1.4, 5.8 ± 1,2) and MD-1 (*p* <.001). In addition, MD-1 is significant (*p* < .001) for MD-3, MD-2, and MD.

Regarding Hooper Index (Figure 3), significant

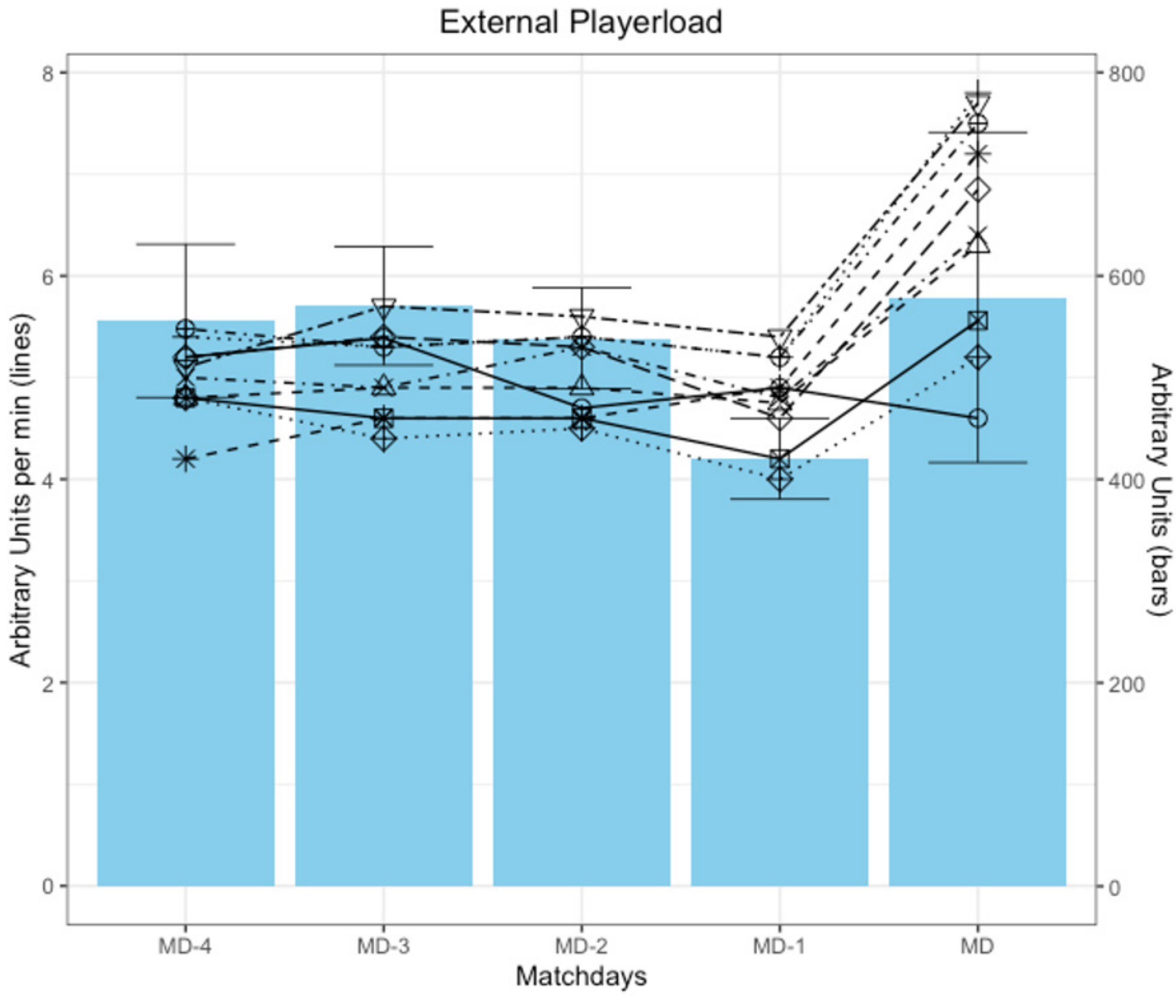

Figure 1. Mean and SD for player load over all athletes (bars). Individual data for player load per min of all athletes are presented as lines.

differences between training days and match were only found for soreness ($F(4,36) = 7.334$, $p < .001$, $\eta^2p = .449$), $W(2) = .506$, $p = .835$). The largest differences were found for MD-3 ($p = .006$, 2.3 ± 1.1), MD-2 ($p = .005$, 2.2 ± 1), MD-1 ($p = .011$, 2.1 ± 1). In addition, MD-4 ($p = .021$, 2.9 ± 0.8) was significantly different from MD-3 ($p = .021$) and MD-2 ($p = .023$). Stress ($F(4,36) = 5.490$, $p = .263$, $\eta^2p = .132$), $W(2) = .330$, $p = .736$), sleep ($F(4,36) = 5.267$, $p = .282$, $\eta^2p = .128$), $W(2) = .175$, $p = .605$) and fatigue ($F(4,36) = 5.593$, $p = .254$, $\eta^2p = .134$) showed no significant differences between training days and match.

DISCUSSION

This study aimed to describe the volume and intensity of in-season workload of professional basketball players and to compare the workload between training sessions (MD-4>MD-3>MD-2>MD-1) match (MD). Workload quantification of eTL was achieved via IMUs, iTL and well-being status were queried with an application before and after practice. The results of the study showed differences in all workload variables (volume and intensity) between the sessions analyzed (MD-4>MD-3>MD-2>MD-1 and MD). MD workload was the most demanding not only in volume but also in intensity. Significant workload differences in eTL (PL and PL/min) and iTL (RPE and sRPE) variables were only found between MD-1 and MD. In addition, Hooper index results show higher DOMS from MD-4 up to MD.

In team sports, tapering strategies have been implemented, as an attempt to decrease the stress of training and prepare players better for the official match (Moraes et al., 2017; Nunes et al., 2014). Coaches tend to reduce physical load parameters the days before a competition as part of a tapering strategy to achieve maximum performance through

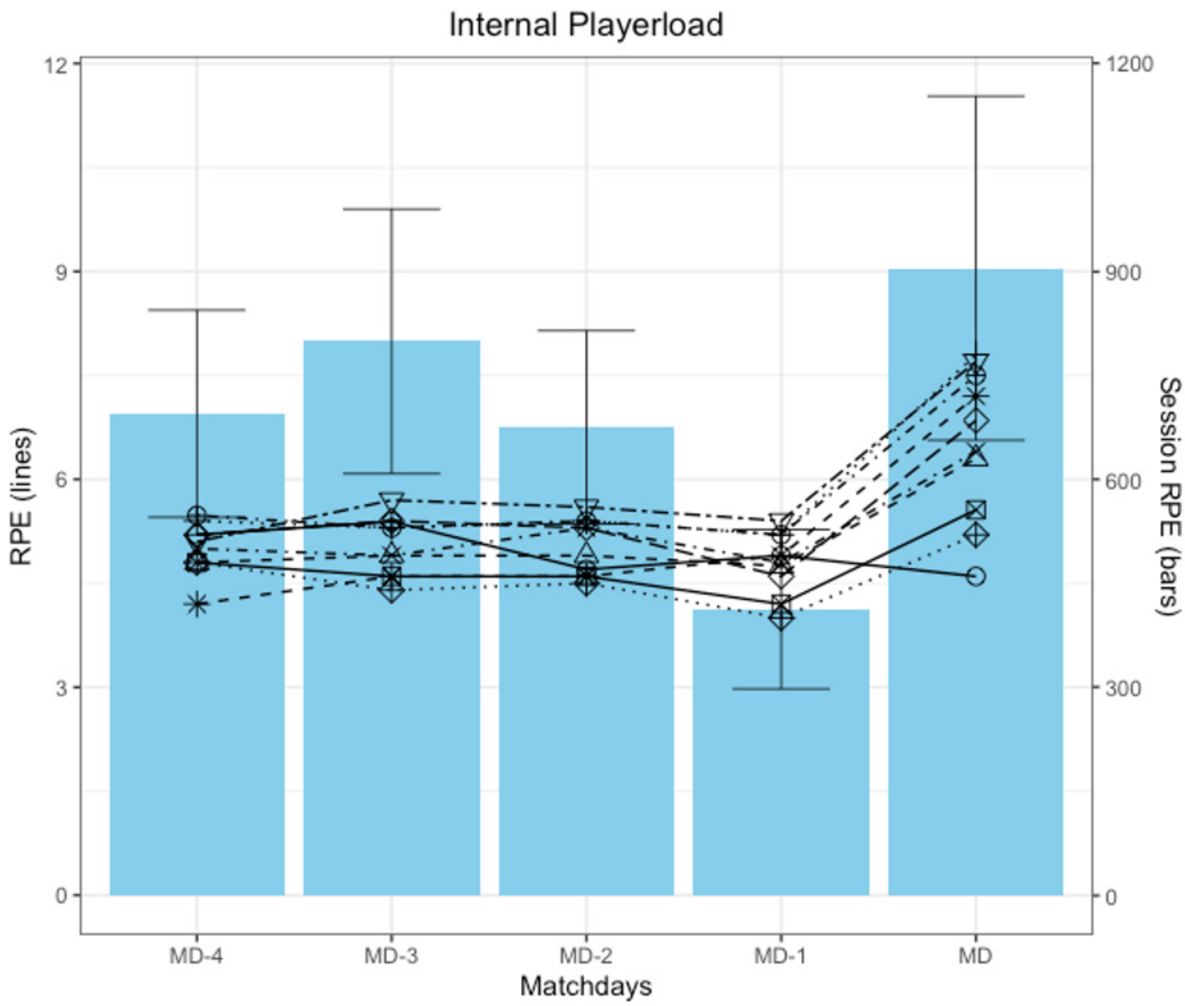

Figure 2. Mean and SD for session RPE over all athletes (bars). Individual data for RPE of all athletes are presented as lines.

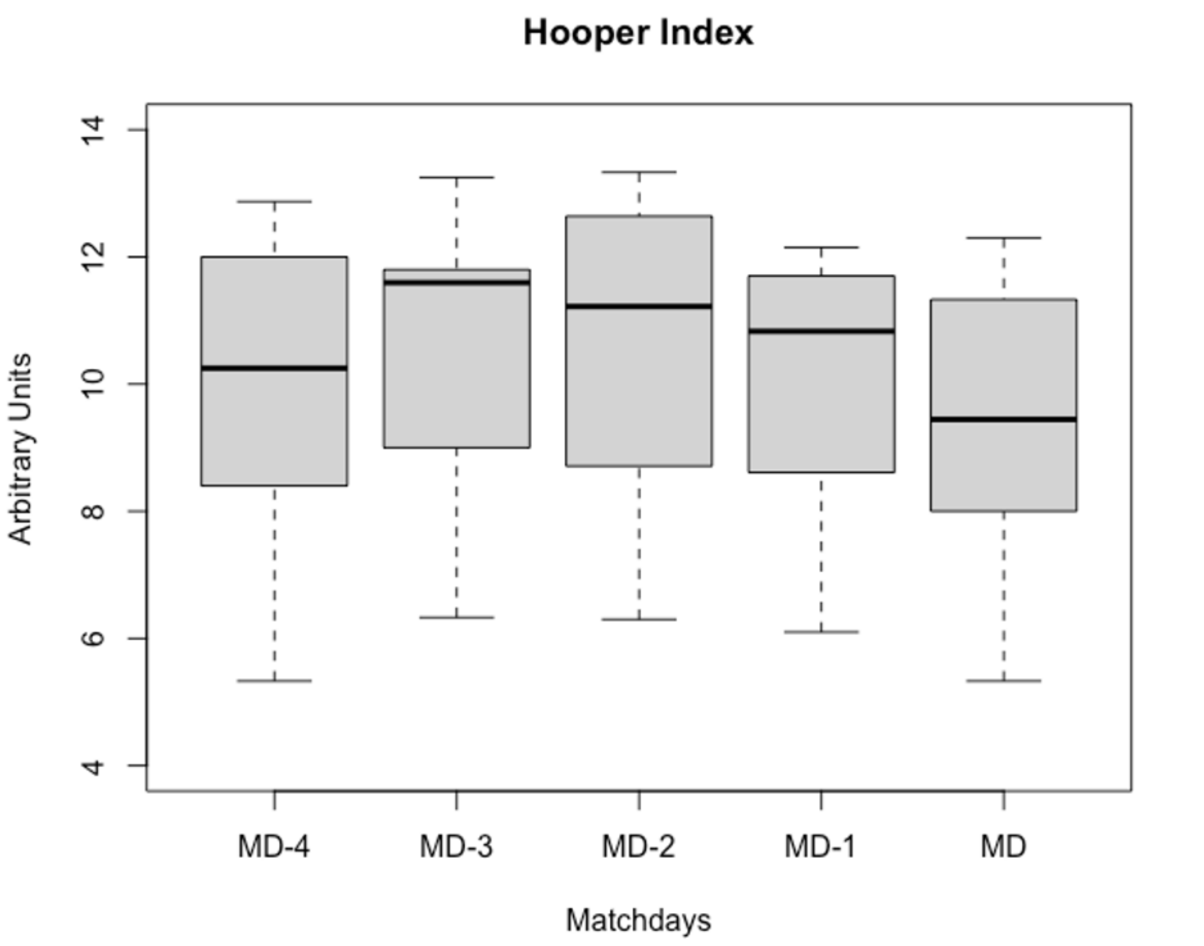

Figure 3. Hooper Index in arbitrary units (sleep, stress, delayed-onset muscle soreness (DOMS), and fatigue) estimated from the Hooper questionnaire.

sufficient recovery time before the upcoming match. This approach is increasingly used in basketball (Garcia et al., 2022; Miloski et al., 2015; Svilar et al., 2019) and has already been applied in other sports (Martin-Garcia et al., 2018; Vachon et al., 2020). In this regard, various investigations suggested that MD-4 and MD-3 were the most suitable days for loading the players through repeated high-intensity actions and game-demanding scenarios (Garcia et al., 2022; Oliva-Lozano et al., 2022). In contrast to MD-4 and MD-3, a large reduction in training volume and reduction in intensity during training sessions should be applied during MD-2 and MD-1. Svilar et al. (2018) proposes a cumulative PL of MD-3, MD-2, and MD-1, at a ratio of approximately 42%, 34%, and 24%, respectively, for appropriate load sharing. Olthof et al. (2021) suggests considering the physical variability of individuals across the seasons, that the training session MD-2 should have less load than MD-3 and MD-4. Regarding MD-1, Petway et al. (2022) reports an acute dose-response relationship between training load and game performance. Consistent with Svilar's recommendation, training MD-1 should be the lightest of the week (Petway et al., 2022).

PL, as an eTL variable, shows significant workload differences between MD-1and MD. A possible reason could be that all practice sessions had the same duration (Forster et al., 2001). For example, a recent study showed that the training load increased with longer microcycles (Clemente et al., 2019). Hurwitz et al. (2022) reported extra repetitions in high-impact drill during practice. Román et al. (2019) mentioned that it is useful to know if the workload has been below or above the real game reference loads, according to individual needs.

However, these findings are not consistent with previous studies on elite basketball players (Svilar et al., 2019, Manzi et al., 2010). Svilar's study covered only three days leading up to a game and reports values on MD-3 (436.6 ± 70.8) MD-2 (358.4 ± 51.1) and MD-1 with the lowest value (253.2 ± 58.7). These findings confirm MD-1 research into short-term tapering in other team sports (Malone et al., 2015). Regarding the PL/min variable, there was a difference only on MD, which showed the highest value. During the week, the PL/min variable, reflecting the intensity of workload, remained relatively constant, with the lowest value at MD-1 (4.7 ± 0.4) and only slightly higher values at MD-4 (4.9 ± 0.3), MD-3 (5 ± 0.4), and MD-2 (5 ± 0.3). Pyne et al. (2009) suggested that training intensity should be maintained for an optimal taper. However, in view of the small PL/min differences in the standard deviations of the individual training days, critical considerations should be applied. A possible reason could be that all practices were scheduled with almost the same drills or the use of group drills (Forster et al., 2001), specifically on MD-2, which shows pretty much the same intensity as MD-3. It is important to know that PL/min is an average value of the intensity of the training session and the variable is affected by the overall duration of the session. Another reason for the change of the variable are interruptions by trainers in which exercises are explained. These interruptions are accompanied by a massive minimization of the variable. Therefore, as it can be seen in figure 2, all training days have almost the same PL/min but do not match MD. Whitehead et al. (2018) recommends match characteristics as a benchmark to understand the most intense periods of competition and for planning appropriate drills replicating or surpassing the intensity of the game. That is why practitioners need to know and should be able to reproduce them (Conte et al., 2015; Tee et al., 2016; Torres-Ronda et al., 2016). In this context, Svilar et al. (2018) pointed out that players may differ in their ability of achieving a higher volume of TL throughout the session, while others work less overall but achieve higher intensities. These different physical demands are measured and monitored either by work done mechanically such as accelerations, decelerations , change of direction (intensity) and distance (volume) or the psycho-physiological effect and perceptual demands such as heart rate or perceived exertion (Fox et al., 2017; Sansone et al., 2020; Schelling & Torres, 2016). Therefore, monitoring volume and intensity during training and competition and reporting data individually appears to be essential (Howatson & Milak, 2009) for designing specific training sessions for the competitive demands of each player.

As an iTL parameter, RPE and session-RPE were analyzed during MD-4, MD-3, MD-2, MD-1, and MD. Significant differences were found between MD-1 and all other days. Related with respect to the RPE data, there could be accumulated fatigue from MD-4 and MD-3, which are the most demanding days, having a direct impact on the next session on MD-2. This would mean that an insufficiently planned decrease in training volume and load might have an impact on MD-1 due to residual fatigue of the previous days. Svilar et al. (2018) report similar results during the week, with only MD-3 to MD-1 being investigated but not MD-4 or MD. On MD, we find the highest RPE (6.7±1.8) and a higher standard deviation compared to the days before the game. These findings differ from the previous literature. Willberg et al. (2021) for example, report a lower RPE (5.1±1.8) value on match days. RPE is strongly associated with cardiorespiratory, metabolic, and neuromuscular measures of exercise intensity (Lea et al., 2021) and perceived exertion is a cognitive state involving neural and biological processes in the brain and influenced by mental factors (McLaren et al., 2022). Thus, an explanation for the small differences in RPE between MD-4 and MD-2 could also be related to a mismatch between the exercise intensity prescribed by the coach and the exercise perceived by players. This finding is consistent with previous research (Staunton et al., 2020) and is also found in other sports (Brink et al., 2017; Marroyo et al., 2014 Rabelo et al., 2016). This underestimation of the workload over a longer period can lead to maladaptive training, insufficient recovery, increased risk of injury, overtraining, and negative changes in psychophysiological state (Heidari et al., 2018; Kenttä & Hassmén, 1998). It seems that coaches misjudge the accumulating effects of volume and intensity over an entire training's session. Also with respect to physical variability of individuals, objective monitoring of the training sessions and matches is more accurate than subjective appraisals.

Another iTL variable, the session – RPE (sRPE), showed the exact same pattern and a strong inter-day relationship – similar to PL, which confirms previous studies (Manzi et al., 2010; Svilar et al., 2018). MD was the most demanding with the highest sRPE. During the training days, MD-3 had the highest value. Only slight differences were found at MD-4 and MD-2. A significant drop in load was observed on MD-1, which supports the tapering concept of training volume decrease. Our study covered four days leading up to a league game and the game itself. sRPE has shown some associations with changes in training outcomes such as fitness and performance (Forster et al., 2001; Jaspers et al., 2017). These associations appear stronger than those with eTL (Impellizzeri et al., 2019), which highlights the importance of internal load quantification. A second finding using sRPE for monitoring iTL is that it is influenced by training volume. These findings correspond to previous studies in basketball (Aoki et al., 2016; Nunes et al., 2014). A possible explanation of higher sRPE in games could be the variability of game intensity, mainly due to the increase in actions requiring changes in direction, accelerations and decelerations, high-speed sprints, and other related specific basketball actions that might lead to a higher mechanical load, which can also be associated with a higher playing time (Montgomery et al., 2010; Pilauga et al., 2015).

Haddad et al. (2013) reported that sRPE was not sensitive enough to identify indicators of athlete self-report measures (ASRM) such as subjective fatigue, soreness (DOMS), stress, and sleep levels. In this context, Hooper & Mackinnon (1995) proposed a self-assessment-based psychometric questionnaire that includes well-being related to sleep, stress, fatigue, and muscle soreness called Hooper Index (HI). Regarding the HI and its categories, our study results indicated DOMS to be significant for MD-3, MD-2, MD-1, and MD. These findings are similar to results of previous studies (Clemente et al., 2020, 2019a; Ferreira et al., 2021; Lukonaitiene et al., 2020). A possible explanation could be that wellness status can be influenced by training factors, like intensification, which can cause psychological disturbances such as fatigue, more muscle soreness, and a worse recovery state (Haddad et al., 2013; Hooper & Mackinnon, 1995). However, basketball players in this study showed very good overall wellness status, with very low DOMS, fatigue, stress, and very good sleep quality (i.e., mean categories' scores around 2). It could be that, in general, this team-training process and players' routines did not represent highly stressful factors. The second suggestion could be a lack of experience with ASRM. That means athletes could try to make a good impression or athletes felt that their coach had some resistance to ASRM so no matter what the ASRM is showing, athletes must perform on the field (Saw et al., 2015). To be more specific, if daily loads are not adjusted according to athletes' ASRM and demands do not follow a planned schedule, athlete compliance may suffer. The present study had some limitations. One of them was the sample size, as only one team was analyzed and there could be possible dependencies on player position. Another limitation is the external load quantification through IMA. There is a lack of information regarding isometric muscle contractions or the physical effort during static position fights and collisions between players, for instance, to map the additional mechanical load in the entire workload. Additionally, our results did not consider contextual factors such as game locations and playing positions, neither in-game technical and tactical performance. Therefore, future studies should assess the fluctuations of weekly training and game load considering these contextual factors.

PRACTICAL APPLICATIONS

Despite these limitations, our study offers some practical applications. Practitioners should consider implementing workload monitoring strategies, taking into account game scheduling during the season. Since several games are played during the season, adequate recovery from the high intensities that games require should be considered. Monitoring can help with good periodization strategies to avoid excessive workload during regular weeks and to prevent non-functional overload and increased risk of injury. It can help to plan for peak workloads and adjust training accordingly. In addition, basketball coaches should monitor player workload in relation to minutes played to receive adequate information on player strain. Training planning should be individualized to avoid exacerbating match loads of players with many minutes played by adding an additional high workload. Successful training load monitoring should occur for two primary reasons: to reduce the risk of injury and to ensure optimal levels of loading and adaptation that result in improved physical and athletic performance.

CONCLUSIONS

Our results suggest, that in a normal week with only one game, it is harder to find the right dosage to prepare for a game. Managing TL in basketball is a complex issue (Capranica & Millard-Stafford, 2011). In game-based sport, it is difficult to design individualized training plans since collective drills are widely used to enhance game-based technical and tactical skills concurrently with fitness components (Dragonea et al., 2018). It may be related to the fact that the requirements of the game are difficult to imitate in training. Basketball players are a specific population characterized by very different anthropometric and physical characteristics. In practice planning, it is important to consider the individual variability between the players. This variability can include psychological factors, individual difference in performance and workload. Furthermore, players differ from each other and show individual game performance profiles (guards, big men, shooters). If this variability is not considered at the individual level, it could have an accumulative effect of workload on match load during a regular week. So, it would be naïve to assume that every player has the same baseline. Therefore, a holistic athlete monitoring strategy can help to provide an appropriate training stimulus in training for players with such diverse characteristics, and it seems reasonable to investigate possible factors that influence player workload. Athlete monitoring should not be seen as limited to either subjective or objective measures. They can both be used to complement each other and help coaches with practice calibration.

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CONFLICTS OF INTEREST

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

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