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Training load, recovery and game performance in semi-professional male basketball: influence of individual characteristics and contextual factors

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ABSTRACT: This study examined the effects of individual characteristics and contextual factors on training load, pre-game recovery and game performance in adult male semi-professional basketball. Fourteen players were monitored, across a whole competitive season, with the session-RPE method to calculate weekly training load, and the Total Quality Recovery Scale to obtain pre-game recovery scores. Additionally, game-related statistics were gathered during official games to calculate the Performance Index Rating (PIR). Individual characteristics and contextual factors were grouped using *k*-means cluster analyses. Separate mixed linear models for repeated measures were performed to evaluate the single and combined (interaction) effects of individual characteristics (playing experience; playing position; playing time) and contextual factors (season phase; recovery cycle; previous game outcome; previous and upcoming opponent level) on weekly training load, pre-game recovery and PIR. Weekly load was higher in guards and medium minute-per-game (MPG) players, and lower for medium-experienced players, before facing high-level opponents, during later season phases and short recovery cycles (all $p < 0.05$). Pre-game recovery was lower in centers and high-experience players ($p < 0.05$). Game performance was better in high-MPG players ($p < 0.05$) and when facing low and medium-level opponents ($p < 0.001$). Interestingly, players performed better in games when the previous week's training load was low ($p = 0.042$). This study suggests that several individual characteristics and contextual factors need to be considered when monitoring training load (playing experience, playing position, playing time, recovery cycle, upcoming opponent level), recovery (playing experience, playing position) and game performance (opponent level, weekly training load, pre-game recovery) in basketball players during the competitive season.

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INTRODUCTION

Monitoring training loads is one of the topics in sports research which has received increased attention in the last years [1]. Monitoring training is essential (i) to obtain quantitative and qualitative information on the exercise performed by an athlete, (ii) to understand individual responses, and (iii) to re-evaluate and modify training plans based on evidence-based and systematic procedures [1, 2]. The ultimate aims of this process are twofold: improving performance capacities to prepare athletes for competition, and avoiding injuries and illnesses [1].

Previous research identified multiple factors which can influence training load in team sports. Firstly, the characteristics of different training modes and contents (e.g., general conditioning, game-based conditioning, offensive/defensive drills) have been shown to carry specific physical, physiological and perceptual loads in basketball [3, 4, 5]. Secondly, the players' individual characteristics can also influence training load. For instance, playing experience has been shown to influence training demands in Australian footballers [6, 7], both studies showing higher loads cumulated by more experienced players. However, no previous study has evaluated the effect of playing experience in basketball. Moreover, other individual characteristics such as playing position and playing time substantially characterize the demands of basketball games. Specifically, backcourt players (e.g. guards) have been shown to perform more high-intensity activities [8, 9] and cover greater distances [10] than frontcourt players (forwards, centers). Regarding playing time, increased demands are placed on more important players (e.g. starters) due to increased playing time compared to less important players [11, 12]. These additional loads deriving from higher playing times are to be carefully managed across a competitive season in order to maintain fitness and avoid fatigue and injuries [1, 12, 19].

While information on competition demands are clearer, only few studies have monitored weekly training load accounting for individual characteristics, specifically playing time [11, 12] and position [13], calling for further research.

Thirdly, contextual factors can also affect the athlete's perception of training and competition demands. Contextual factors have been shown to significantly influence training and competition demands in football [14], rugby [15] and also basketball [16]. Specifically, game location [14], opponent's level [2], game outcome [2, 14, 15], season phase [2] and recovery cycle [15] have shown to affect weekly training loads. Regarding basketball, Fox and colleagues [16] have shown that game location and score-line margin influence game loads. Considering this evidence, the lack of information on the effects of contextual factors on weekly training load in basketball appears meaningful. In fact, the available research in basketball is scarce and has only studied weekly training load considering game schedule [11, 17, 18], playing time [12] and season phase [19].

When monitoring training load, it is recommendable to control for the athletes' psychophysical conditions in order to have information on their status during the season and their responses to training and competition. In this context, the utilization of athlete self-reported measures (e.g., questionnaires on fatigue and recovery) is useful considering their validity in detecting changes in both athletes' conditions [20] and training loads [19, 21]. Studies in basketball have monitored recovery [19] and well-being [11] indexes in conjunction with training load, identifying how these measures reflect variations in training and competition demands. While these studies have considered game schedule [11], playing time [11, 12] and season phase [19], other individual characteristics and contextual factors (e.g. recovery cycle, opponent level, playing position) might influence the athlete' psychophysical conditions. Obtaining such information would offer coaches broader knowledge to plan training schedules across the season.

Lastly, in order to have a comprehensive picture of the training process, the player´s performance in competition should also be controlled for. Studies have analysed game performance in basketball considering individual characteristics [22] and contextual factors [23]. However, to our knowledge only one study involving basketball players has evaluated game performance together with weekly training load [24], and only monitoring training duration, which provides limited information on the training loads actually accumulated by players [25]. In fact, it might be interesting to evaluate performance during games played following high or low weekly training loads, or when players perceive different recovery conditions. Such information might help coaches in designing weekly plans that adequately prepare players to perform in competition.

Therefore, the aim of this study was to identify individual characteristics and contextual factors influencing training load, recovery and performance in basketball players across the competitive phases of the season.

MATERIALS AND METHODS

Study design

This descriptive, longitudinal study was conducted during the 2018/2019 basketball season (September 2018 – May 2019). During the pre-season phase, players familiarized with the monitoring tools used. Following this period, weekly training load, pre-game recovery and game performance data were collected during 27 weeks of the competitive season (including all regular season and play-off games). The study was approved by the Institutional Review Board of the Polytechnic University of Madrid, Spain.

Participants

Fourteen adult male players (age: 25 ± 6 years; height: 188.6 ± 7.3 cm; body mass: 88.2 ± 14.7 kg; playing experience: 15 ± 5 years; position: 5 guards, 6 forwards, 3 centers) from a team competing in a semi-professional league from Spain were recruited for this study. The team weekly schedule featured 3 team-based basketball sessions of 80–120 minutes (which focused on skills development and game-based conditioning), 2 to 3 physical training sessions of 40–80 minutes (metabolic conditioning, strength/power, agility development), and one official game per week. Players who participated in less than 80% of the training sessions scheduled were excluded from the study [19], which led to a total of 237 individual data points obtained for each dependent variable (weekly load, pre-game recovery, game performance). All participants received written and oral information about the study before its commencement, and signed a consent form.

Training load monitoring

After the end of each training session, players reported their rating of perceived exertion (RPE) using the CR-10 scale modified by Foster et al. [26]. This scale is characterized by numerical scores and verbal links (i.e. 0 = rest; 10 = maximal), referring to the athlete's perceived exertion. Each player reported their RPE score independently, via electronic device, between 15 and 30 minutes after the end of the training session. The RPE score was multiplied by the duration of the session to obtain the session RPE (sRPE) load, in arbitrary units (AU). The sRPE method has been previously validated in basketball, showing moderate to very strong associations with physical [13, 27] and cardiovascular demands [17, 27] and satisfactory reliability (ICC: 0.74–0.95) [17, 28]. By summing the loads of all training sessions in a week, excluding game loads, weekly training load was obtained.

Pre-game recovery monitoring

The morning of each game-day players reported their perceived recovery conditions using a modified 10-point [19] Total Quality Recovery (TQR) scale [29]. The TQR scale is closely similar to the RPE scale as it was developed to be used alongside RPE monitoring [19, 29] Following indications by Kenta and Hassmen [29], players were asked to rate their recovery conditions based on physical (e.g. muscle soreness, joint paint) and cognitive (e.g. mood, stress) cues. Higher TQR scores reflect better perceptions of recovery (e.g. 3 = poor recovery; 7 = very good recovery). TQR scores have been previously shown to be significantly related to biomarkers of training stress [30, 31] as well as sRPE loads [19].

Game performance indicator

Game-related statistics were collected during all official team games by a certified basketball coach with experience in basketball statistics and notational analysis. The Performance Index Rating (PIR) was chosen as performance indicator as it is the primary metric used by the Euroleague Basketball league (highest level competition in Europe) (https://www.euroleague.net/main/statistics), and has previously been used in basketball research [32]. PIR was calculated using the following formula:

$$(\text{Points}+\text{Rebounds}+\text{Assists}+\text{Steals}+\text{Blocks}+\text{Fouls Drawn}) - (\text{Missed Field-Goals}+\text{Missed Free-Throws}+\text{Turnovers}+\text{Shots Rejected}+\text{Fouls Committed})$$

To control for playing time, PIR values were normalized according to minutes played (e.g. PIR of 15 obtained during 30 minutes of game play = 0.5).

Individual characteristics and contextual factors

Players were classified according to different individual characteristics. Playing position was defined by the team's head coach, who classified players as guards, forwards or centers [9, 13]. Playing experience was obtained by asking players, before the start of the season, how many years they had been involved in competitive basketball activity (including youth activity). Playing time was defined at the end of the study based on the average minutes played during official games. This categorization was chosen as it appears more detailed compared to the more frequently used labelling of starters and non-starters, since in basketball bench players can accumulate high playing times thanks to the absence of limits for substitutions, and thus play important roles. Separate *k*-means cluster analyses were conducted to classify players according to their experience (high; medium; low) and playing time (high-minutes-per-game, MPG; medium-MPG; and low-MPG).

The following contextual factors were evaluated. Season phases were divided into first round (29/09/2018–19/01/2019), second round (21/01/2019–06/04/2019), and play-offs (15/04/2019–02/06/2019) according to the league schedule. Recovery cycle was intended as the days between two games, and classified as short (< 7 days) or long (≥ 7 days) [15]. Previous game outcome (win or loss) was also evaluated. The opponent level was considered as previous (last game) and upcoming (next game); for this factor, opponent teams were classified using a *k*-means cluster analysis into three categories (high; medium; low) based on the league's ranking at the time the game was played.

Statistical analysis

Separate *k*-means cluster analyses were performed to classify individual characteristics and contextual factors under three categories (high; medium; low) as previously described. Additionally, in order to evaluate their effects on performance in the following game, weekly training load and pre-game recovery were also clustered into three categories (high; medium; low) using separate *k*-means cluster analysis.

Therefore, three separate mixed linear models for repeated measures (weeks) were performed to evaluate the single (main) effects of individual characteristics and contextual factors on three dependent variables: weekly training load, pre-game recovery and PIR. The factors included in the three mixed linear models are presented in Table 1.

Following the main effect analyses, a second mixed linear model for interaction effects was performed for each dependent variable

TABLE 1. Factors included in the main effect analyses.

Weekly training load	Pre-game recovery	Performance Index Rating
Playing position	Playing position	Playing position
Playing experience	Playing experience	Playing experience
Playing time	Playing time	Playing time
Season phase	Season phase	Season phase
Recovery cycle	Recovery cycle	Recovery cycle
Previous game outcome	Previous game outcome	Previous game outcome
Previous opponent level	Previous opponent level	Opponent level
Upcoming opponent level	Upcoming opponent level	Weekly training load (clustered)
	Weekly training load (clustered)	Pre-game recovery (clustered)

considering only those factors which showed a significant main effect in the first model. Analyses were performed using SPSS version 25.0 (IBM, Chicago, IL). Descriptive data are reported as mean ± SD for each variable. Significance was set at $p \leq 0.05$. For mixed linear models, results are reported as F and p values. Post-hoc pairwise comparisons were assessed using the Bonferroni test. Effect sizes were calculated using Cohen's d with the following interpretation: 0.2, trivial; 0.2–0.6, small; 0.6–1.2, moderate; 1.2–2.0, large; and 2.0, very large [33].

RESULTS

Descriptive data (mean and SD) of all variables are presented in Tables 4, 5 and 6.

Table 2 presents the significant main effects found. For weekly training load, no effects of previous game outcome or previous opponent level were found (all $p > 0.05$). Regarding pre-game recovery, no effects were found for season phase, recovery cycle, previous game outcome, previous opponent level, upcoming opponent level or weekly training load (all $p > 0.05$). For PIR, no effects were found for playing experience, playing position, season phase, recovery cycle, or previous game outcome (all $p > 0.05$).

Table 3 presents the interaction effects. Weekly training load was influenced by the combination of player´s experience and position, as well as the interaction between upcoming opponent level and: playing experience; playing time; and season phase (all $p < 0.05$). Pre-game recovery was influenced by the interactions between playing time, experience and position (all $p < 0.05$). Regarding PIR, interactions were found between playing time and weekly training load (all $p < 0.05$), and between weekly training load and pre-game recovery score (all $p < 0.05$).

Pairwise comparisons for weekly training load, pre-game recovery and PIR are presented in Tables 4, 5 and 6, respectively. Medium-experienced players accumulated lower loads than high and low experience teammates (all $p < 0.001$). Guards accumulated greater weekly loads than forwards ($p = 0.001$) and centers ($p = 0.002$). Weekly load was higher in the first season phase compared to the second phase ($p = 0.002$) and play-offs ($p = 0.021$). Regarding pre-game recovery, high experience players reported lower pre-game recovery than medium ($p = 0.024$) and low-experience ($p < 0.001$) players; additionally, centers reported lower TQR scores than guards ($p = 0.007$) and forwards ($p < 0.001$). Game performance was better in high-MPG players than medium-MPG players ($p = 0.046$), when facing low-level opponents compared to high and medium-level teams (all $p < .001$), and when weekly training load was low, compared to high weekly loads ($p = 0.042$).

DISCUSSION

This study aimed to evaluate the influence of individual characteristics and contextual factors on weekly training load, pre-game recovery and game performance in male semi-professional basketball players. In order to have a comprehensive picture of the training process and performance during competition, training loads, perceived players' conditions and performance indicators should be concurrently evaluated. This approach was not identified in the available research. Therefore, this study allows to fill in the information gap about training loads, perceived recovery and game performance according to individual characteristics and contextual factors. In particular, the results of weekly training load showed several significant effects: playing experience; playing position; playing time; season phase; recovery cycle; upcoming opponent level. Additionally, many significant interactions were found between these factors. Regarding pre-game recovery, there were significant effects of all individual characteristics (playing experience, position, importance), while contextual factors did not play a key role. Regarding game performance (PIR), players with higher minutes per game performed better than players with medium MPG; also, players performed better against lower-level opponent teams; very interestingly, PIR was higher when players were exposed to lower training loads during the week leading to the game, with a similar tendency of better game performances when pre-game recovery was higher.

Monitoring training load is essential to prepare training appropriately for competition and avoid injury and illnesses. In this study,

TABLE 2. Significant main effects.

Weekly training load	F	p	Pre-game recovery	F	p	Performance Index Rating	F	p
Playing experience	21.298	**< 0.001**	Playing experience	11.378	**< 0.001**	Playing time	4.499	**0.021**
Playing position	14.133	**< 0.001**	Playing position	6.975	**0.001**	Opponent level	16.41	**< 0.001**
Playing time	7.291	**0.001**	Playing time	3.481	**0.033**	Weekly training load	14.324	**0.003**
Season phase	10.363	**< 0.001**				Pre-game recovery	4.226	**0.036**
Recovery cycle	43.180	**< 0.001**						
Upcoming opponent level	9.510	**< 0.001**						
Playing position	14.133	**< 0.001**						

TABLE 3. Significant interactions.

Weekly training load		p	Pre-game recovery		p	Performance Index Rating		p
p. experience HIGH	phase PLAYOFF	**0.008**	p. experience HIGH	position CENTER	**< 0.001**	p. time HIGH-MPG	opponent level LOW	**< 0.001**
	position GUARD	**0.009**		position FORWARD	**< 0.001**		weekly training load LOW	**0.001**
	recovery cycle SHORT	**0.048**					weekly training load HIGH	**< 0.001**
	upcoming opponent level HIGH	**0.012**	p. experience MEDIUM	p. time HIGH-MPG	**0.047**			
	upcoming opponent level LOW	**0.002**		p. time LOW-MPG	**0.026**	p. time MEDIUM-MPG	opponent level HIGH	**0.01**
				p. time MEDIUM-MPG	**0.028**		opponent level LOW	**0.005**
				position GUARD	**0.019**		weekly training load LOW	**< 0.001**
p. experience MEDIUM	phase PLAYOFF	**< 0.001**					weekly training load HIGH	**< 0.001**
	p. time MEDIUM-MPG	**0.050**					pre-game recovery LOW	**0.035**
	position GUARD	**0.011**					pre-game recovery MEDIUM	**0.001**
	upcoming opponent level LOW	**0.022**						
	upcoming opponent level MEDIUM	**0.013**				p. time LOW-MPG	weekly training load LOW	**< 0.001**
	position FORWARD	**0.003**						
						opponent level HIGH	weekly training load LOW	**< 0.001**
							weekly training load MEDIUM	**0.036**
p. experience LOW	phase SECOND ROUND	**0.008**					weekly training load HIGH	**< 0.001**
	position CENTER	**0.002**						
	recovery cycle SHORT	**0.001**				opponent level MEDIUM	weekly training load LOW	**< 0.001**
							weekly training load MEDIUM	**0.014**
p. time HIGH-MPG	upcoming opponent level HIGH	**0.001**						
						weekly training load HIGH	pre-game recovery LOW	**0.014**
p. time MEDIUM-MPG	upcoming opponent level HIGH	**0.033**						
						weekly training load MEDIUM	pre-game recovery LOW	**< 0.001**
p. time LOW-MPG	upcoming opponent level HIGH	**0.001**					pre-game recovery MEDIUM	**< 0.001**
	upcoming opponent level LOW	**0.011**						
phase FIRST ROUND	upcoming opponent level HIGH	**0.003**				weekly training load LOW	pre-game recovery HIGH	**0.002**
phase SECOND ROUND	upcoming opponent level MEDIUM	**0.001**						
position FORWARD	phase SECOND ROUND	**0.013**						
	upcoming opponent level LOW	**0.030**						

Note: p. = playing

TABLE 4. Pairwise comparisons for weekly training load.

Weekly training load	Mean (± SD)	pairwise comparison	p	ES	
Playing experience					
high	2133 (± 1216)	**high-medium**	**< 0.001**	0.52	**small**
medium	1420 (± 1450)	high-low	1	0.16	trivial
low	2315 (± 1035)	**medium-low**	**< 0.001**	0.70	**moderate**
Playing position					
guard	2388 (± 1549)	**guard-forward**	**0.001**	0.41	**small**
forward	1846 (± 1037)	**guard-center**	**0.002**	0.56	**small**
center	1633 (± 1114)	forward-center	0.572	0.20	trivial
Playing time					
high-MPG	1776 (± 1072)	**high-medium**	**0.002**	0.42	**small**
medium-MPG	2228 (± 1072)	high-low	1	0.09	trivial
low-MPG	1864 (± 927)	**medium-low**	**0.014**	0.36	**small**
Season phase					
first	2168 ± (1057)	**first-second**	**0.002**	0.34	**small**
second	1827 (± 924)	**first-playoff**	**0.021**	0.30	**small**
playoff	1872 (± 904)	second- playoff	1	0.05	trivial
Recovery cycle					
short (< 7d)	1539 (± 1410)	**short-long**	**< 0.001**	0.77	**moderate**
long (≥ 7d)	2373 (± 600)				
Previous game outcome					
win	1866 (± 820)	win-loss		0.21	small
loss	2046 (± 939)				
Previous opponent level					
high	2027 (± 892)	high-medium		0.04	trivial
medium	1987 (± 1074)	high-low		0.19	trivial
low	1853 (± 985)	medium-low		0.13	trivial
Upcoming opponent level					
high	1667 (± 1049)	high-medium	0.08	0.24	small
medium	1905 (± 931)	**high-low**	**< 0.001**	0.61	**moderate**
low	2295 (± 1007)	medium-low	**0.01**	0.40	small

players with medium experience reported lower weekly loads than players with high or low experience. Players with higher experience are typically also of greater age; in fact, in this study we considered only playing experience since it was almost perfectly correlated with age. A recent study involving football players has shown how older players have worse physical performance during matches [34], possibly due to lower physical capacities [35]. However, it is also worthy of consideration that more novice players might accumulate greater training loads due to lower movement efficiency, less developed physical capacities and technical-tactical abilities [7, 35]. Since peak physical performance is typically reached a few years after maturity and declines later [36], it is possible that players in the medium experience group had the most favourable balance between physical capacities and technical-tactical abilities, therefore perceiving training sessions as less demanding.

Regarding playing position, guards accumulated greater weekly loads than forwards and centers. This finding agrees with previous research in basketball. The tactical role of guards is to start the offensive ball possessions and determine the game pace by using continuous accelerations and decelerations [37]. In fact, these high-intensity activities determine the greater physical demands experienced by guards during games compared to frontcourt players (forwards and

TABLE 5. Pairwise comparisons for pre-game recovery.

Pre-game recovery	Mean (± SD)	pairwise comparison	p	ES	
Playing experience					
high	6.2 (± 2.5)	**high-medium**	**0.024**	0.38	**small**
medium	7.3 (± 3.1)	**high-low**	**< 0.001**	0.76	**moderate**
low	7.9 (± 2.1)	medium-low	0.305	0.26	small
Playing position					
guard	7.6 (± 3.3)	guard-forward	1	0.03	trivial
forward	7.5 (± 2.2)	**guard-center**	**0.007**	0.49	**small**
center	6.3 (± 2.1)	**forward-center**	**< 0.001**	0.58	**small**
Playing time					
high-MPG	6.7 (± 2.4)	high-medium		0.27	small
medium-MPG	7.4 (± 2.3)	high-low		0.25	small
low-MPG	7.3 (± 2.0)	medium-low		0.04	trivial
Season phase					
first	7.1 (± 2.0)	first-second		0.10	trivial
second	6.9 (± 2.2)	first-playoff		0.14	trivial
playoff	7.4 (± 2.2)	second- playoff		0.23	small
Recovery cycle					
short (< 7d)	7.0 (± 1.7)	short-long		0.12	trivial
long (≥ 7d)	7.3 (± 2.9)				
Previous game outcome					
win	6.9 (± 2.6)	win-loss		0.23	small
loss	7.4 (± 1.7)				
Previous opponent level					
high	7.5 (± 2.1)	high-medium		0.20	trivial
medium	7.1 (± 2.1)	high-low		0.34	small
low	6.8 (± 2.1)	medium-low		0.14	trivial
Upcoming opponent level					
high	7.2 (± 2.9)	high-medium		0.07	trivial
medium	7.1 (± 2.0)	high-low		0.05	trivial
low	7.1 (± 2.0)	medium-low		0.02	trivial
Weekly training load					
high	6.9 (± 1.6)	high-medium		0.09	trivial
medium	7.1 (± 1.4)	high-low		0.09	trivial
low	7.1 (± 2.0)	medium-low		0.02	trivial

centers) [8, 9, 10] and also during training sessions, as found in this study. Interestingly, these previous studies [8, 9, 10] agreeing with our findings involved adult players; differently, studies involving collegiate athletes [38, 39] did not detect differences in training loads between playing positions. Considering that collegiate sport is a transitional phase between youth and adult basketball, in this setting the players' tasks on court might be less defined and more fluid across playing positions, therefore explaining the differences between previous studies.

Regarding playing time, medium-MPG players reported higher training loads than either high-MPG or low-MPG players. This finding might be explained by a protective strategy used by coaches during the weekly training sessions, aimed at preserving the conditions of the players most used in competition (and possibly most important). On the other hand, it is possible that low-MPG players were less involved in ball drills and scrimmage-type drills, which coaches use during training to accurately prepare game scenarios. Additionally,

TABLE 6. Pairwise comparisons for Performance Index Rating

Performance Index Rating	Mean (± SD)	pairwise comparison	p	ES	
Playing experience					
high	0.25 ± (0.66)	high-medium		0.12	trivial
medium	0.35 (± 0.90)	high-low		0.20	trivial
low	0.37 (± 0.57)	medium-low		0.03	trivial
Playing position					
guard	0.34 (± 0.84)	guard-forward		0.13	trivial
forward	0.24 ± 0.63)	guard-center		0.05	trivial
center	0.38 (± 0.69)	forward-center		0.21	small
Playing time					
high-MPG	0.44 (± 0.64)	**high-medium**	**0.046**	0.32	**small**
medium-MPG	0.24 (± 0.59)	high-low	0.203	0.25	small
low-MPG	0.29 (± 0.60)	medium-low	1	0.07	trivial
Season phase					
first	0.40 (± 0.68)	first-second		0.22	small
second	0.26 (± 0.59)	first-playoff		0.17	trivial
playoff	0.30 (± 0.52)	second- playoff		0.07	trivial
Recovery cycle					
short (< 7d)	0.27 (± 0.40)	short-long		0.16	trivial
long (≥ 7d)	0.38 (± 0.93)				
Previous game outcome					
win	0.37 (± 0.67)	win-loss		0.17	trivial
loss	0.27 (± 0.57)				
Opponent level					
high	0.19 (± 0.64)	high-medium	1	0.03	trivial
medium	0.21 (± 0.57)	**high-low**	**< 0.001**	0.59	**small**
low	0.56 (± 0.60)	**medium-low**	**< 0.001**	0.60	**moderate**
Weekly training load					
high	0.27 (± 0.36)	high-medium	0.958	0.21	small
medium	0.34 (± 0.28)	**high-low**	**0.042**	0.42	**small**
low	0.52 (± 0.27)	medium-low	0.16	0.23	small
Pre-game recovery					
high	0.43 (± 0.28)	high-medium		0.1	trivial
medium	0.40 (± 0.40)	high-low		0.48	small
low	0.30 (± 0.30)	medium-low		0.31	small

as they are less employed during competition, low-MPG players might perceive training as less hard thanks to the lower fatigue cumulated over multiple games. Altogether, our findings raise critical considerations, suggesting coaches to accurately quantify the utilization of players during both training and games, especially considering the different game loads to which players can be exposed during the season [11, 12].

Season phase was also influential in this study, with greater training loads registered in the first round compared to the second round and play-offs. During later phases, competitive games have a different "specific weight", as they are decisive for classification and trophies [19]. Therefore, possibly by expecting higher demands during second-round and play-off games, coaches reduced the load of training sessions during these phases. In fact, this loading strategy in later phases might be appropriate considering that fatigue cumulates during the course of a season [19, 40].

Results for recovery cycle and upcoming opponent level reflect how coaches prepare training plans in view of competition. In this study, lower weekly loads were registered during short recovery cycles. With fewer days in between two games, training loads were decreased to compensate for the reduced time available for recovery, as also found in a previous study on rugby [15]. Regarding the upcoming opponent level, this study found higher weekly loads when the next opponent was of low level, compared to high and medium level opponents. Therefore, coaches in this study increased weekly training loads before facing weaker opponents, possibly expecting lower game demands [41] or also by having greater confidence in their likelihood of winning. Our findings agree with a recent study involving football players, which reported greater external loads in the week before facing a low-level opponent [2].

Differently, contextual factors of the previous game (game outcome and previous opponent level) did not show effects on weekly training loads. Regarding game outcome, previous literature shows contrasting results. Studies in football showed increased weekly loads following losses [2, 14] while oppositely, lower loads were registered in rugby after losses [15]. These discrepancies regarding the effects of game outcome on training load might be explained by psychosocial factors (e.g. coaching style; evaluation of results and subsequent adaptations of training plans; social constructs within different sports) [42] which might have been specific to the coaching staffs involved in each study [2, 14, 15], including this one. Regarding the previous opponent's level, the absence of differences suggests that coaches in this study had a more prospective approach, favouring the upcoming game factors when designing training.

Additionally, several interaction effects were found for weekly load. Mentioning the most interesting, the interaction between high-MPG and high-level upcoming opponent confirms the previously described hypothesis of preservation of important players before facing strong opponents. Differently , as high-experience guards and low-experience centers appear to accumulate very high weekly loads, they should be carefully monitored in order to avoid negative outcomes (i.e. fatigue, injury).

Analyses of pre-game recovery showed that only individual characteristics and no contextual factors had significant effects. Specifically, high-experience players reported lower TQR scores, possibly explained by their higher age and reduced physical and recovery capacities [36]. Along these lines, lower physical and recovery capacities might also explain why centers reported lower recovery scores than guards and forwards. Accordingly, previous studies profiling basketball players reported lower metabolic capacities in centers compared to guards [37, 43] and forwards [37]. Additionally, the interaction between high experience and centers position suggests that this specific group should be carefully monitored for them to recover optimally before games; oppositely, medium-experience guards reported the highest TQR scores, which suggest their favourable recovery capacity [37, 43] and compliance to training loads. Altogether, these interactions between playing experience and position further confirm the importance of age, physical and anthropometric characteristics for performance and recovery in sports [34, 43]. Lastly, there was a tendency for lower TQR scores in high-MPG players. While there was no significant difference in pairwise comparisons, the significant main effect and the lower average scores of this group allude to a cumulative fatigue effect due to their greater utilization during competitions [11, 12].

By contrast, no contextual factor influenced pre-game recovery; furthermore, not even higher weekly loads influenced pre-game recovery. It might have been expected that in later season phases or shorter recovery cycles players might have perceived lower recovery conditions. However, our findings suggest that coaches modulated appropriately training loads according to the season phase and recovery cycle, allowing players to reach the game-day in good recovery conditions. Similarly, a previous study involving female basketball players also reported no changes in TQR scores in later season phases [19].

To the best of our knowledge, this was the first study in basketball evaluating game performance together with training load and perceived recovery. The importance of game-related statistics for success in basketball has been previously documented [23, 44]. Our results showed that high-MPG players performed better than medium-MPG players; interestingly, players with medium playing times were also the ones reporting higher weekly loads across the season. The PIR was also higher when playing against low-level opponents compared to both medium and high-level opponents. Altogether, this study found that i) even if PIR was normalized per minutes played, players who were given more minutes on court accumulated better statistics, suggesting that the most effective players belonged to the high-MPG group; and ii) competition against higher-ranked teams are harder and indeed, overall, players registered more negative statistics (e.g. turnovers, missed shots) and fewer positive indicators (e.g. shots made, assists) during these games.

Importantly, players in this study performed better in games when exposed to low training loads in the week leading to the game, compared to weeks with high loads. To the best of our knowledge, this is the first study showing the impact of weekly training load on game performance of basketball players, which further confirms the importance of monitoring training to achieve success in competition. Similarly, there was a tendency for higher PIR when players perceived higher recovery conditions before games. Furthermore, the interaction effects between high weekly load and low pre-game recovery, and low weekly load and high recovery conditions carry important practical worth, suggesting that the interplay between training load and recovery might have a dose-response effect on game performance.

CONCLUSIONS

This study identified several aspects that can influence training load, recovery and game performance in basketball players. When designing training schedules, individual characteristics and contextual factors should be taken into account, paying particular attention to those circumstances in which players accumulate high loads (guards, high-experience, medium-MPG, early season phase, and their combinations) or low loads (low-MPG; high-level upcoming opponent). Similarly, high-experienced, high-MPG and center players exhibited the lowest recovery scores before games; therefore, specific conditioning and recovery strategies should be designed for these groups. Notably, high weekly loads negatively impacted game performance, independently and in combination with pre-game recovery. Therefore, before games, training loads should not be high and optimal recovery conditions have to be ensured.

Concluding, we recommend practitioners to monitor training load, recovery and performance and concurrently consider individual characteristics and contextual factors as they are interconnected. This monitoring framework can offer detailed information which cannot be obtained when looking at training and performance separately.

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Conflict of interest declaration

No conflicts of interest were reported by the authors.

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