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Fluctuations of Jump Height in Male Basketball Players: Analysis of a Competitive Season

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ABSTRACT

International Journal of Exercise Science 17(4): 887-901, 2024. The present study aimed to determine whether neuromuscular fatigue monitored through countermovement jump height was a reliable and helpful marker for monitoring acute (session) and chronic (between sessions/periods of the season) fatigue throughout an entire basketball season. A longitudinal observational study analyzed the neuromuscular performance (i.e., through countermovement jump) during a basketball season. Fourteen semiprofessional male basketball players participated in the study between September 2021 and May 2022 (34 weeks, 102 practices, and 1574 jumps analyzed). Upon waking up, they completed an online wellness questionnaire. Before practices began, players performed three countermovement jumps on a contact platform after a structured warm-up, repeating the protocol at the end of each practice. Ten minutes after finishing such practice, they also reported perceived exertion's muscular and cardiovascular ratings. The preseason was the period of the season with the lowest absolute countermovement jump height levels (2.06 to 2.50 cm; d = 1.92 to 2.74, very large, $p < 0.02$). Average pre-session jumps were very largely higher on Wednesdays (0.62 cm, 95% CI = 0.29 – 0.95, $p = 0.0095$, $d = 2.09$) and Fridays (0.62 cm, 95% CI = 0.06 – 0.88, $p = 0.06$, $d = 1.43$) compared to Mondays. The countermovement jump is a valuable marker for assessing fatigue in semiprofessional basketball players. Games played on weekends mainly and consistently affected Monday's jumping performance, showing the lowest average values. Finally, preseason values were lower than those observed for the rest of the season.

KEY WORDS: Team sports, vertical jump, CMJ, periodization, training load

INTRODUCTION

Basketball is an intermittent court-based team sport characterized by intense and short actions interspersed with extended periods of low to moderate activity and recovery (1). These efforts include high-intensity actions with and without the ball, such as changes of direction, lateral movements, jumps, and landings (2). If stress and fatigue produced by such efforts (i.e., training and competition) are not adequately balanced with sufficient recovery, male athletes can be exposed to a higher risk of reduced performance (23). Fatigue could be described as the reduced capacity to obtain performance, limiting physical and cognitive functions due to the interaction between physical and perceived fatigue in female and male athletes (8). Central and peripheral fatigue of the nervous system and the ability of the contractile properties of the muscle to perform over time are the most relevant factors related to performance fatigability (9). Moreover, fatigue can be divided into two types according to the moment it appears: short-term fatigue, typically of metabolic origin, with the effects decreasing after five minutes (19), and long-term fatigue, with a central, peripheral, and neuromuscular origin in female and male athletes (41). This second type of fatigue can be present for more than 48 hours and appears when the ability to produce force or power deteriorates in male athletes (29). Thus, using a scientific rationale to control fatigue and individualize loads, using a variable related to performance impairment and physiological responses could help inform decisions during the training in male athletes (16).

Based on this, using the vertical jump and, more specifically, the countermovement jump (CMJ)(17) as a fatigue monitoring tool is widespread and well-accepted among elite players (8). Furthermore, it is a valid and reliable method, potentially valuable for detecting and quantifying fatigue under ecological conditions in female and male athletes (8). Thus, its use to evaluate neuromuscular fatigue when researching players' recovery processes after regular and congested competition periods has become popular (8,10–12,39). An indicator of the session volume and intensity to reduce physical strain and the injury risk resulting from insufficient neuromuscular control could be obtained by monitoring this activity/recovery relationship in female athletes (39). Additionally, this simple and non-fatiguing test can monitor training sessions physiologically without the need to measure concentrations of ammonia or blood lactate (12) due to its near-perfect relationships with CMJ height loss in male athletes (26). Eight to ten percent jump height losses correspond to 70-80 µmol ·l-1 and 8-10 mmol ·l-1 of ammonia and lactate in the blood, representing the onset of metabolic instability in male athletes (15). These data can help practitioners to monitor and manage induced neuromuscular fatigue during a male training session (35).

Furthermore, to assess internal load holistically and ecologically, the current literature has studied the use of the Rate of Perceived Exertion (RPE) and the Rate of Session Perceived Exertion (sRPE) in different sports. Specifically, in basketball, sRPE has proven to be a valid method to quantify internal load in professional and semiprofessional male players (36). At the same time, it can be instrumental and practical for the coaching staff to monitor and control internal load to design basketball training frequency strategies in female athletes (31). Moreover, the differential RPE (muscular and respiratory) can provide a detailed quantification of more specific internal load during training activities commonplace in male team sports (22). In addition, self-ratings of wellness to evaluate fatigue, stress, sleep, and muscle soreness successfully predict overtraining syndrome (14). Thus, including the abovementioned variables (i.e., sRPE and wellness) might help better understand basketball practice fatigue prompted through the internal load.

Although the CMJ test has been considered a suitable, non-invasive, and sensitive method for measuring and monitoring neuromuscular fatigue in male team sports (10–12,34), to the best of our knowledge, there is no study where CMJ height has been analyzed before and after every single training session during an entire basketball season. Therefore, the study aimed to determine whether neuromuscular fatigue monitored through countermovement jump height was a reliable and helpful marker for monitoring acute fatigue (pre- and post-session), short-term chronic fatigue (between sessions), and long-term chronic fatigue (between periods of the season). The secondary aim was to explore the differences in sRPE and wellness scores during the training week and the season. The CMJ height was hypothesized to differ between every session, training week, and season period.

METHODS

Participants

Fourteen male basketball players (mean ± SD; age: 22.6 ± 3.5 years; height: 190.6 ± 6.5 cm; wingspan: 194.5 ± 9.3 cm, and body mass: 85.1 ± 9.6 kg) competing in the Spanish 4th tier league ("Liga EBA") participated in the study between September 2021 and May 2022. The experience of the players in the study competing at the 3rd and 4th tier of the Spanish Basketball Federation (FEB) was 3.36 ± 2.24 years (range 1-8 years). The sample size was adjusted to account for the number of players in the team. This limits the use of certain statistical procedures, but it is a common and necessary practice in studies involving team sport athletes. It helps to gain insight into performance in populations with similar training and competition conditions, eliminating confounding factors (1, 7, 13, 31, 34, 39, 40). The study followed the principles of the Ethical Issues Relating to Scientific Discovery in Exercise Science (27), and players were informed about the procedures, agreed to participate, and provided written consent. The study was approved by the Research Ethics Committee of the University of Vic-Central University of Catalonia (registration number: 168/2021).

Protocol

This longitudinal observational study analyzed the neuromuscular performance (i.e., through CMJ) during an entire basketball season (34 weeks and 102 practices) before and after each practice. Players trained three days per week during the preseason and in-season periods, with a standard training week structure, Monday, Wednesday and Friday; detailed information on the weekly structure and the strength periodization are presented in Table 1 and Table 2, respectively. Training sessions were performed during evenings (8 pm) as the team was semiprofessional and half the players were studying or working during the day.

Players were required to answer the wellness questionnaire 5-10 minutes after waking up every training day. Players rated five categories (fatigue, sleep quality, general muscle soreness, stress levels, and mood) from 1 (very bad) to 5 (very good)—the sum of the five items results in the "Wellness score" (23). The first week of the preseason was used to familiarize the players with the questionnaire.

Before every single practice started, a 12-min standardized warm-up using several different running patterns (dynamic arm movements, hops, shuffling, long strides, backward movements, side cuts, and front turns), foam roller self-myofascial release (40-50'' per muscle group: rectus femoris, hamstrings, calves, adductors and glutes), static and dynamic joint mobility, and neuromuscular activation exercises (squats, deadlifts, and lunges, ten repetitions each exercise) followed by three submaximal CMJ was implemented. After the warm-up, the

Table 1. Training week

	Monday	Wednesday	Friday	Weekend
Testing	Warm-up + 3 CMJs	Warm-up + 3 CMJs	Warm-up + 3 CMJs	Competition
Off-court 60′	Individual injury prevention (3-5 exercises) Strength: 9 exercises in 3 blocks of 3 sets (fundamental, complementary, and compensatory)	Individual injury prevention (3-5 exercises) Strength: 9 exercises in 3 blocks of 3 sets (fundamental, complementary, and compensatory)	-	
On court 90′	30-45′ Shots and individual technique 20′ Defensive play (2v2-3v3-4v4) 25′ 5v5 (games to 9 points)	15′ Shots 15′ Offensive play (3v2) 20′ Defensive play (2v2-3v3-4v4) 20′ Offensive play (5v5, 5v5+1court, 5v5+2, 5v5+3, 5v5+4) 20′ 5v5 (games to 9 points)	15′ Specific warm-up 20′ Shots 15′ Offensive play (5v0) 20-25′ Game plan (5v5, 5v5 +1 5v5 +2) 10-15′ 5v5 (game to 9 points)	
Testing	3 CMJs	3 CMJs	3 CMJs	

CMJ: countermovement jump

Table 2. Periodization for strength

PRESEASON	COMPETITIVE 1	CHRISTMAS BREAK	COMPETITIVE 2
Week 1 12 reps @50-60% 1RM RIR >6 **Weeks 2-3** 12 reps @75% 1RM RIR 3-4 **Weeks 4-5** 6 reps @80-85% 1RM RIR 1-2 **Week 6** 6 reps @60% 1RM RIR >6	**Weeks 7-18** 10 reps @60-75% 1RM RIR 3-4	**Weeks 19-21** 6 reps @80-85% 1RM RIR 1-2	**Weeks 22-34** 10 reps @60-75% 1RM RIR 3-4

1RM: one repetition maximum; REPS: repetitions; RIR: repetitions in reserve

pre-CMJ was performed using a contact mat (7) (Chronojump, Boscosystem®, Barcelona, Spain) with an accuracy of 50 ms (0.29 cm) to determine the jumping height. This platform has been validated to evaluate vertical jumps (3). Most of the players (10 out of 14) performed CMJ once a week during the previous season, and the rest were used to perform CMJ in their previous clubs. Although players were already familiarized with the jumping procedures, the first day of the preseason was used as a familiarization session, which followed the same structure described for all the sessions. On the second day, the within-day reliability (TEM and CV) was measured between the 3 repetitions for pre-session CMJ. Participants were required to bend their knees at approximately 90º angle and perform a maximal vertical jump with their hands fixed on the hips. They were also instructed to keep their bodies upright throughout the jump and to land with their knees fully extended. Any jump perceived to deviate from the required instructions was not considered for the subsequent analysis and was repeated. Three trials were allowed, and the average value was used in the following analyses (5). A 10-second passive recovery was provided between jumps. The exact process for the post-CMJ was repeated just at the end of the session (Figure 1).

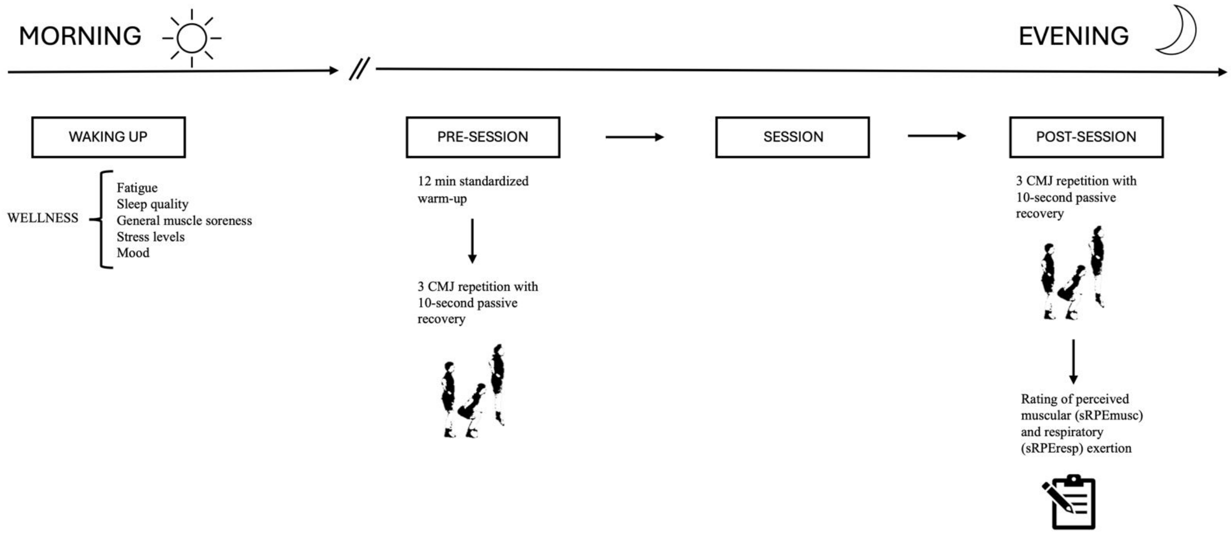

Figure 1. Protocol timeline (CMJ: countermovement jump).

Approximately ten minutes after the completion of each training session, a rating of perceived muscular (sRPEmusc) and respiratory (sRPEresp) exertion was requested from each participant using the 0–10-point Borg's category RPE scale, modified by McLaren (22). A Spanish translation of this scale was utilized. Each player answered two simple questions, always asked by the same staff member and in the following order: "How intense was the session on your chest?" and "How intense was the session on your legs?" The RPE questions were completed without the presence of other players, and they could not see other participants' values to avoid misinterpretation and teammates' influence (25).

Statistical analyses

Descriptive statistics are reported as mean ± standard deviation (SD). Data were analyzed using linear mixed models (LMM) and generalized linear mixed models (GLMM) to account for missing data and repeated measures.

A one-way ANOVA was first applied to examine absolute reliability (intraclass correlation coefficient, ICC). To assess the typical error of measurement (TEM), expressed as a coefficient of variation (CV), a specific spreadsheet was used (Internet Society for Sport Science, Will G. Hopkins, Reliability from consecutive pair of trials (2015), In Internet: www.sportsci.org (January 2023). For interpretation, ICC values were >0.9 excellent, 0.9–0.75 good, 0.75–0.5 moderate, and <0.5 poor (18), and CV values were considered acceptable if <10% (6). The minimal detectable change (MDC) 95% CI was calculated. A CV of less than 5 % was set as the a priori criterion for reliability. It has been suggested in team sports that the smallest worthwhile change (SWC) for elite athletes can be calculated as 0.2 multiplied by the between-subject SD ($SWC_{0.2}$) of the particular test, based on Cohen's ES principle (13). Furthermore, the SWC to detect a moderate or large effect was determined by multiplying the between-subject standard deviation by 0.6 ($SWC_{0.6}$) and 1.2 ($SWC_{1.2}$), respectively. If the TEM was smaller than the SWC, the test was rated as "good"; if the TEM was like the SWC, an "OK" rating was given. However, if the TEM was considerably higher than the SWC, the test was rated as "marginal"(13).

Primary analyses included separate LMM to test the effects on the jumping height (CMJ) of 1) pre- and post-session; 2) day of the week (Monday, Wednesday, Friday); and 3) period of the season (preseason, competition 1, Christmas break, competition 2); which were entered as fixed effects, while each player was entered as a random effect into each model. The interaction effects between pre- and post-session jumping height and 4) day of the week; and 5) period of the season were also performed. F scores and eta-squared (eta^2) were used to report the magnitude of the fixed effect in the models, and interpreted eta^2 as: < 0.01 = *negligible*; 0.01-0.06 = *small*; 0.06-0.14 = *medium*; ≥ 0.14 = *large*.

Secondary analyses included separate GLMM to explore the effects of 1) the day of the week (Monday, Wednesday, Friday) and 2) the period of the season (preseason, competition 1, Christmas break, competition 3) on the sRPE and wellness. All assumptions were met, and the normality of the residuals was assessed using the Kolmogorov-Smirnov test. Chi-squared (chi^2) and Phi were used to report the magnitude of the fixed effect in the models, and interpreted Phi as: < 0.1 = *negligible*; 0.1-0.3 = *small*; 0.3-0.5 = *medium*; ≥ 0.5 = *large*.

When significant differences were found in the analyses, post-hocs were performed using Holm's correction for multiple comparisons. Estimates of 95% confidence intervals (CIs) were calculated. The t statistics (LMM) were converted into Cohen's *d* to report the magnitude of the differences and were interpreted as: <0.20 = *trivial*; 0.20-0.59 = *small*; 0.60-1.19 = *moderate*; 1.20-1.99 = *large*; and >2.00 = *very large.* Significance was set at p < 0.05 for all tests. Analyses were conducted using the JASP package (Version 0.16.4, JASP Team (2022) [Computer software]).

RESULTS

In total, 1574 jumps (41.57 ± 5.55) were analyzed. Intra-session reliability was excellent for the CMJ jump height (ICC 3,1 = 0.97 [95%CI 0.92 – 0.99]), with the TEM, CV, and SWC reported in Table 3.

Table 3. Reliability measures for the CMJ jump height.

	Trial 1	Trial 2	Trial 3	Mean	TEM (95% CL)	CV (95% CL)	MDC	$SWC_{0.2}$	$SWC_{0.6}$	$SWC_{1.2}$
CMJ	38.9 ± 4.5 cm	38.4 ± 4.7 cm	38.4 ± 4.7 cm	38.5 ± 4.7 cm	0.84 cm (0.6 – 1.3)	2.2% (1.6 – 3.5)	2.3 cm (6.1%)	0.9 cm (2.4%)	2.8 cm (7.3%)	5.6 cm (14.5%)

CL: confidence limit; CMJ: countermovement jump; CV: coefficient of variation; MDC: minimal detectable change; TEM: typical error of the measurement; SWC: smallest worthwhile change

Primary analyses: CMJ height - The summary of the CMJ comparisons between 1) session (pre vs. post), 2) day of the week (Mon-Fri), and 3) period of the season (preseason, competition-1, Christmas break, competition-2) are reported in Table 4.

Table 4. Estimates for CMJ height

		Session	Estimate (cm)	95%CI (cm)	
Season period	Preseason	Pre	39.69	37.08	42.30
		Post	39.47	36.77	42.18
	Competitive 1	Pre	**41.48** *	38.91	44.04
		Post	**42.09** *	39.32	44.85
	Christmas break	Pre	**41.45** *	38.33	44.58
		Post	**41.80** *	38.38	45.23
	Competitive 2	Pre	**42.08** *	38.92	45.25
		Post	**42.04** *	38.66	45.42
Day of the week	Monday	Pre	40.98	38.52	43.43
		Post	41.4	38.71	44.1
	Wednesday	Pre	**41.77** #	39.30	44.24
		Post	41.86	39.23	44.5
	Friday	Pre	**41.6** #	38.99	44.22
		Post	41.74	39.00	44.48

CI: confidence interval; CMJ: countermovement jump. Notes: *Different from Preseason; # Different from Mon.

Jump height LMM reported a significant effect on the day of the week (F = 7.52, p = 0.0037, eta^2 = 0.428, *large*) and period of the season (F = 8.72, p = 0.002, eta^2 = 0.669, *large*) but not for the moment of the session (F = 0.99, p = 0.34, eta^2 = 0.069, *medium*).

Specifically, pairwise comparisons showed that Wednesday (0.62 cm, 95%CI = 0.29 – 0.95. p = 0.0095, d = 2.09, *very large effects*) and Friday (0.47 cm, 95%CI = 0.06 – 0.88. p = 0.06, d = 1.43, *very large effect*) had greater pre-session jumping height compared to Monday, showing no between-days differences at post-session (see Table 5). Preseason was the period of the season with the lowest CMJ jumping height compared to the rest of the periods (difference from 2.06 to 2.5 cm; d = 1.92 to 2.74, *very large,* see Table 6).

Table 5. Between-day changes in CMJ height (short-term chronic fatigue)

Weekday	Estimate (cm)	Lower 95%CI (cm)	Upper 95%CI (cm)	p	d	Lower 95%CI	Upper 95%CI
Mon vs. Wed	**0.62**	0.25	0.99	**0.0095**	**2.09**	**0.84**	**3.35**
Mon vs. Fri	**0.47**	0.06	0.88	**0.06**	**1.43**	**0.18**	**2.69**
Wed vs. Fri	-0.15	-0.58	0.27	0.45	-0.44	-1.72	0.80

CI: confidence interval; CMJ: countermovement jump

Secondary analyses: RPE and Wellness - The summary of the RPE and Wellness comparisons between the moment of 1) season (preseason, competition-1, Christmas break, competition-2), and 2) week (Mon-Fri) are reported in Table 7 and Table 8.

Table 6. Between season period changes in CMJ height (long-term chronic fatigue)

Season period	Estimate (cm)	Lower 95%CI (cm)	Upper 95%CI (cm)	*p*	*d*	Lower 95%CI	Upper 95%CI
Preseason vs. Competition 1	**2.22**	1.24	3.21	**0.0019**	**2.74**	**1.53**	**3.96**
Preseason vs. Christmas	**2.06**	0.74	3.39	**0.02**	**1.92**	**0.69**	**3.16**
Preseason vs. Competition 2	**2.5**	1.1	3.89	**0.0098**	**2.15**	**0.95**	**3.35**
Competition 1 vs. Christmas	-0.16	-1.03	0.71	1	-0.25	-1.58	1.09
Competition 1 vs. Competition 2	0.28	-0.79	1.34	1	0.31	-0.88	1.49
Christmas vs. Competition 2	0.44	-0.64	1.51	1	0.51	-0.74	1.75

CI: confidence interval; CMJ: countermovement jump

Table 7. Estimates for perceptual outcomes related to the period of the season.

	Season period	Estimate (AU)	95%CI	
sRPEmusc	Preseason	**910.65** *#	861.85	959.44
	Competitive 1	852.51	797.56	907.47
	Christmas break	736.9	654.73	819.07
	Competitive 2	**928.19** *#	879.00	977.38
sRPEresp	Preseason	**846.09** *	784.1	908.09
	Competitive 1	766.51	703.33	829.69
	Christmas break	722.32	606.96	837.68
	Competitive 2	814.61	760.86	868.35
Wellness	Preseason	17.46	17.00	17.92
	Competitive 1	16.98	16.23	17.74
	Christmas break	18.5	17.08	19.91
	Competitive 2	**17.17** #	16.39	17.95

AU: arbitrary units; CI: confidence interval; sRPEmusc: rating of perceived muscular exertion; sRPEresp: rating of perceived respiratory exertion. Notes: *Different from Comp1 ($p < 0.05$); # different from Christmas break ($p < 0.05$)

For the secondary analyses, RPEmusc and sRPEresp LMM reported a significant effect on the day of the week ($chi^2 = 53.62$, $p < 0.001$, Phi = 0.191, *small*; $chi^2 = 50.63$, $p < 0.001$, Phi = 0.185, *small*; respectively) and period of the season ($chi^2 = 19.23$, $p < 0.001$, phi = 0.11, *small*; $chi^2 = 12.43$, $p = 0.006$, Phi = 0.09, *small*; respectively). Specifically, pairwise comparisons showed that all the days of the week differed, with Wednesday being the day with the greatest sRPE ($p < 0.001$, d = 0.94, *medium effect*) compared to Monday. Friday was the day with the lowest sRPE compared to Monday ($p < 0.001$, $d = 4.52$, *very large effect*) and Wednesday ($p < 0.001$, $d = 6.55$, *very large effect*). Preseason and Comp2 reported higher sRPEmusc ($p < 0.01$, d from 0.71 to 1.34, *medium to large effects*) than Comp1 and Christmas break. Furthermore, for the sRPEresp, the preseason was the only season period higher than Comp 1 ($p < 0.001$, $d = 1.29$, *large effect*).

Analyses of the wellness scores reported a significant effect on the day of the week ($chi^2 = 11.10$, $p = 0.004$, Phi = 0.087, *negligible*) and the period of the season ($chi^2 = 8.65$, $p < 0.03$, Phi = 0.07, *negligible*). Pairwise comparisons showed lower Wednesday wellness scores than Monday ($p =$

0.02, *d* = 0.70, *medium effect*) and Friday (*p* = 0.007, *d* = 0.81, *medium effect*). For the season period, Christmas Break achieved higher wellness scores than Comp2 (*p* = 0.05, *d* = 1.22, *medium effect*).

Table 8. Estimates for perceptual outcomes related to the day of the week.

	Weekday	Estimate (AU)	Lower 95%CI	Upper 95%CI
sRPEmusc	Monday	**980.99** #	927.08	1034.91
	Wednesday	**1031.5** *#	978.09	1084.91
	Friday	**660.45** *	624.5	696.4
sRPEresp	Monday	**874.82** #	812.89	936.75
	Wednesday	**918.49** *#	859.04	977.94
	Friday	**604.7** *	558.2	651.19
Wellness	Monday	17.33	16.58	18.07
	Wednesday	**16.88** *#	16.23	17.53
	Friday	17.4	16.82	17.98

AU: arbitrary units; sRPEmusc: CI: confidence interval; rating of perceived muscular exertion; sRPEresp: rating of perceived respiratory exertion. Notes: *Different from Mon; # different from Fri

DISCUSSION

The main aim of this study was to investigate how male basketball training influences jumping performance and whether CMJ height changes existed between pre- and post-session, between days of the week, and between season periods. To the authors' knowledge, no research is currently available to analyze CMJ height before and after every training session during a basketball season. According to the results, and similar to other authors' findings (28), the preseason was the period with the lowest CMJ height values, which could be attributed to the training regimen designed to prepare players for the competition. However, in contrast to those where longer preparatory periods (12 weeks) with overloading and tapering phases were used, the preseason is short (6 weeks) and intense, consisting solely of overloading phases. Therefore, the players accumulated fatigue, resulting in reduced physical performance. Moreover, at an adult level, the objective of the preseason is to progressively enhance players' performance until its conclusion and sustain it throughout the season, which may elucidate the obtained results. Furthermore, as was also observed by Malone and colleagues (21), in the pre-session, higher jumping heights were achieved on Wednesday (*d* = 2.09, very large) and Friday (*d* = 1.43, very large) compared to Monday throughout the entire season. This is likely due to the players being fatigued and possibly less predisposed to perform optimally on the first day of the week, following one or two days off. Players aim to recover and be in good condition for the next game. The preseason period showed the greatest sRPEmusc and sRPEresp values for the whole season and a higher sRPEmusc for the Comp2 period. Wellness scores were lower on Wednesdays and during the last competition period (Comp2) than during the Christmas Break.

According to the results obtained, the preseason was the period of the season with the lowest CMJ height values compared to the rest of the periods (2.06 to 2.50 cm; *d* = 1.92 to 2.74, very large), which could be related to the higher load faced during the preseason and positive training effect into the first competitive period, the more trained, the better results. Moreover, when analyzing the training week results, these showed substantially lower pre-training CMJ values on Monday than the rest of the week. In this regard, Gathertcole and colleagues (12) reported that CMJ was impaired after (0-h) a high-intensity running fatiguing protocol compared to baseline values when analyzing college-level team sport athletes. According to the study results, although some variables improved at 24h, some participants took a more extended period (72h) to achieve baseline results, considering they were still fatigued. Moreover, long-term neuromuscular (41), central, and peripheral origin fatigue can occur for more than 48 hours (29). This effect can also be observed in this study, where the pre-training jumps on Monday were significantly worse than those on Wednesday and Friday because of those 48-72h post-game, with some players still fatigued. The same conclusion was reached by McLean and colleagues' study (23), where rugby players' flight time and relative CMJ power were significantly reduced in the 48-h post-game training week. Thus, neuromuscular performance (i.e., CMJ height) needs more than 24-48h to recover baseline values.

Gathercole et al. (12) obtained a coefficient of variation (CV) in the CMJ of <5% to assess the results, suggesting that the CMJ test can produce highly consistent results. In the present study, we observed similar results, with a 2.18% intra-session CV, which allows us to consider the data consistently. Moreover, according to Ribeiro and colleagues, the CV of the CMJ is a relevant variable to justify player and team performance during games (34). Lower CV values were related to better and more successful individual performance in team games. Higher weekly load and wellness values were related to lower CV (14). Therefore, weekly CMJ variation analysis is crucial in synthesizing the balance in the weekly training load, which has implications for players' preparation (14).

As a part of the secondary aim of the study, sRPE was analyzed. It was established that all days of the week differed, with Wednesday being the day with the highest sRPE ($p < 0.001$, medium effect) compared to Monday. Friday had the lowest sRPE ($p < 0.001$, very large effects) compared to Monday and Wednesday. These differences could be partially explained because Monday's load, gameday +2 (MD+2), is lower and has a regenerative component. Friday is MD-1, and the session volume was lower than the other two training sessions. Moreover, it was also observed that the variations between sRPEmusc and sRPEresp were minimal and had a similar tendency. Similar findings were obtained by Los Arcos and colleagues (20), who observed small magnitude differences between sRPEmusc and sRPEresp in soccer players, so the practical relevance of evaluating both scores may be questioned. As pointed out in previous studies, contextual variables also influence players when reporting RPE. In a team with only one competition per week and such a defined weekly structure, the differences observed in RPE reporting the last day of training before the game may have been influenced by "job security"(4). Furthermore, it was also observed that preseason and Comp2 were the periods of the season with higher sRPEmusc ($p < 0.01$, medium to large effects) compared to Comp1 and Christmas holidays. Preseason physical demands tend to be high, and in Comp2, players perceived accumulated fatigue throughout the competition period. This was consistent with Piedra and colleagues'(30) findings, who observed that an increase in sRPE and a greater number of accelerations and decelerations might be associated with increased neuromuscular fatigue detected through the CMJ test. Moreover, this was related to sRPE and jump loss in the preseason, where a greater volume of work was performed, and the lowest jump height was observed. This games the results of a previous study in which elite basketball players, March and April (i.e., Comp2), showed the most catabolic or stressed hormonal state (low testosterone/cortisol values and high cortisol) (37). Thus, monitoring RPE after a good familiarization and methodological process might help coaches manage and prevent the excessive stress from the training load.

This second analysis also considered wellness and showed that Wednesday's scores were lower than Mondays and Fridays ($p < 0.05$, medium effects). This variation may be related to the fact that the wellness questionnaire considers players' mood, and they all knew in advance that Wednesday sessions were the highest intensity of the training week. Moreover, those sessions ended later than the other two, at 11 pm, after a working day, which could also affect their mood negatively and consequently the overall wellness score. Ribeiro et al. (34) showed that weekly monitoring of sRPE and wellness improves training load and fatigue management. Vallés-Ortega et al. (40) demonstrated a relationship between the post-game performance evaluation questionnaire with the CMJ height reached and the total playing time experienced during games. These results also showed how using internal and external load indicators reflects the fatigue recovery pattern in basketball during a high-competitive density period (31). Regarding the season period, wellness scores were only lower between the Christmas Break and Comp2 ($p = 0.05$, medium effect). These values could be related to the high levels of sRPEmusc reported in this period. We should also consider the final moments of the season, where competitive stress may affect the player's state. However, these perception values, which could seem negative, were not related to a worse CMJ jump in this competition period. McLean and colleagues (23) showed that players had higher neuromuscular fatigue in a 7-day training week with a higher relative training load than in a 9-day training week. It was, most likely, because of an inadequate training dose. Considering that the volume and intensity throughout the training weeks were not intentionally modified, the perception of intensity (sRPEmusc) was increased; this may be due to a worse perception of the same intensity as the season progresses. Thus, we can hypothesize that if the training intensity had been maintained but the volume had been lowered, jumping would have improved in the Comp2 period.

The present study shows a profile of the variability in jumping performance experienced by a semiprofessional male basketball team during an entire competitive season. It was observed that the preseason was the period with the lowest average CMJ values, probably due to the specific training demands of this period, and that players need more preparation before the competitive period. It was also observed that although the last competition presented high sRPE demands and reduced wellness, players could maintain their CMJ levels. Moreover, CMJ height is unaffected by the session's content, presenting non-significant pre- and post-session changes. On the first day of the training week, CMJ values were not fully recovered, probably due to the previous game demands. However, no changes in CMJ values were observed during the rest of the week, showing good chronic adaptability to the regular schedule and recovery.

The present study has limitations. First, it was conducted on a team of semi-professional male players, meaning the sample size may not be optimal. However, several reliable assessment tools and relevant data points were included in the analyses to improve its design. Additionally, since the study used an observational design, it was not intended to be generalized to other similar situations. Instead, it aimed to explain the observed responses of the players in the analyzed team (38). To improve ecology and ease of use, CMJ was assessed using contact platforms. When using contact platforms, one potential issue is that they may overestimate jump height compared to other methods of collecting data on these motor actions. Despite this, the device used in our study has been validated in several studies, showing better performance than similar systems (32,33). Therefore, this methodology should be valid when conducting a study to assess differences and changes in individuals tested under the same conditions throughout a season because, in any case, its measurement errors are systematic and not random. It should also be noted that if the overestimation of the jump height obtained through contact platforms is considered a relevant methodological problem, the net impulse through inverse dynamics can be calculated when collecting the body mass daily. These measurements can be used in future studies using the same technology; however, when differences are evaluated, this problem, again systematic, may not be relevant (24). Although validated and considered a reliable tool to assess flight time, contact platforms do not allow the observation of variations in jump strategy from jump to jump or the study of force applied in every action. Although it can be challenging to move heavy and fragile equipment with a team, it is evident that incorporating force platforms with similar objectives in future pieces of research would add methodological value to the obtained results. Half of the players in the study only played basketball, while the rest had other professional or academic duties. This difference may have affected players' recovery, readiness, and performance. The total minutes played per player and sRPE and CMJ values from games were not collected. Only internal load subjective measures were gathered. Considering the variability in external load during team sports training and competition, monitoring external load variables using accelerometry, post-session RPE, and the following day wellness state during a whole season and their relationship with CMJ performance would have been interesting. Finally, these data cannot be extrapolated to professional, grassroots, or female basketball players due to their characteristics. Additionally, future studies should be conducted on female athletes in similar basketball studies to determine if the responses follow the same trend and enable comparisons.

In conclusion CMJ values show relevant variations depending on the period of the season, proving to be an interesting and highly ecological indicator for assessing local neuromuscular fatigue in semiprofessional basketball players. Surprisingly, CMJ height is unaffected by the session's content, presenting non-significant pre- and post-session changes. However, CMJ is revealed as an interesting marker to assess chronic player adaptation (average CMJ values are lower in the preseason than in-season), as well as for controlling acute fatigue (in our participants, there was a tendency to experience lower values on the first day of the training week than during the rest of the week). Based on our results, coaches and practitioners can use our procedures to establish a simple, ecological, and valid methodology to control the adaptation to the training load. Thus, promoting recovery and providing quality-based training loads to maintain physical fitness during the competitive season seems a pivotal strategy to support the physical fitness needed to compete during an extended competition period.

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