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# Perceived Training Load, Muscle Soreness, Stress, Fatigue, and Sleep Quality in Professional Basketball: A Full Season Study

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This study aimed to compare the perceived training load (session-RPE) and wellness status (muscle soreness, stress, fatigue, and sleep quality) within and between regular (one-match) and congested (two matches) weeks. Fifteen professional basketball players from a European First league club participated in this study. Wellness status (Hooper's questionnaire) and perceived training loads (session-RPE) were measured for each training session and matches over a full season. Regular weeks presented moderately greater session-RPE than congested weeks (p = 0.201; d = 2.15, moderate effect). Both regular and congested weeks presented a decrease in perceived training load before matches, which was accompanied by improved wellness status on a match day. Congested weeks presented moderately lower sleep quality (p = 0.421; d = 1.320, moderate effect) and moderately greater fatigue (p = 0.468; d = 1.401, moderate effect) than regular weeks. Regular and congested weeks presented minimum differences for DOMS and stress. Lower wellness in congested weeks may be associated to an accumulative effect of training and match loads. Tapering phases before matches seem to play an important role for improving athletes' wellness and preventing overtraining.

*Key words*: training monitoring, load, well-being, basketball, congested fixture.

## Introduction

The individualization of a training process depends on the appropriate assessment of athletes' physical and physiological status (Borresen and Lambert, 2009; Mikolajec et al., 2012, 2017; Michalczyk et al. 2015). While the external load is an absolute measure of work performed by athletes during training and competition (e.g., distances, accelerations), the internal load represents the biological responses to the stimulus promoted by external loads (e.g., heart rate, RPE) (Bourdon et al., 2017). In basketball, players may cover 4 to 5 km in a 40-min game and perform 700-1000 movements that change every 2 s (Abdelkrim et al., 2007; Erculj et al., 2008; Klusemann et al., 2013; Michalczyk et al., 2018).

Lactate concentrations may vary between 4 and 6 mmol/L with a peak concentration of up to 12 mmol/L. The heart rate (HR) remains above 85% of the maximum during 75% of game time (Boone and Bourgois, 2013; McInnes et al., 1995). These data suggest high external and internal loads during basketball play.

Despite the well-known physical and physiological impact of basketball matches on players, there are few studies dedicated to analyze

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the load on basketball training sessions (Manzi et al., 2010; Scanlan et al., 2014; Horička, and Šimonek, 2019). Analysis of training loads over the week provides information on coaches' methodological options for controlling training loads and avoiding overreaching (Coutinho et al., 2015) and overtraining (Haddad et al., 2013; Hooper and Mackinnon, 1995). For example, Manzi et al. (2010) observed a tapering phase before matches regardless of the number of matches in a week (i.e., one or two) within an elite professional team analyzed over 12 weeks (40 training sessions). Although the physical and physiological impact of regular and congested weeks (weeks with 2 or more games) has been well-documented in soccer (Folgado et al., 2015; Lago-Peñas et al., 2011; Rey et al., 2010), to the best of our knowledge, only Manzi et al. (2010) analyzed load distribution over a training period in basketball. The analysis of internal loads may help coaches understand athletes' responses to training and competition and better manage the external load.

The internal load is usually assessed by heart rate responses, blood lactate concentration, hormonal concentrations, and ratings of perceived exertion (RPEs) (Halson, 2014). The analysis of internal loads measured by psychophysiological variables such as RPEs might be interesting due to its potential to integrate different types of stimuli, as well as its ease of use (Foster et al., 2001) and low cost. The session-RPE has been shown to be significantly correlated to heart rate responses (Edwards' training load) (Manzi et al., 2010) and to external loads measured by accelerometers (Scanlan et al., 2014). Also evidence about high levels of correlation between changes in the RPE and heart rate during a season-long period were recently found in soccer (Kelly et al., 2016). Also in soccer, the session-RPE was largely associated with player loads (sum of triaxial accelerations) and the Edwards method (that represents the training impulse based on the heart rate) (Casamichana et al., 2013).

In addition, training and competition processes may represent stressful factors for athletes and influence their wellness status. Basketball players have presented increased levels of stress and decreased immunoglobulin A during the competitive phase (Moreira et al., 2008). Studies have also found relationships between monotony of training and training strain (Anderson et al., 2003). These data suggest that training and competition loads can impact athletes' wellness status (Haddad et al., 2013; Mielgo-Ayuso et al., 2017), which influences sports performance. Wellness status 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 and Mackinnon, 1995). The analysis of both internal loads and wellness status may help coaches understand athletes' tolerance to the training process (Gabbett et al., 2017) and better adjust external loads.

Considering the above mentioned issues, literature on internal training loads and athletes' wellness status during basketball training sessions over a season is scarce. Analysis of training load distribution over the week according to the number of matches may provide important information about training periodization in professional basketball. Therefore, the aim of this study was to analyze the perceived training load and wellness status over a basketball season and compare these variables between regular and congested weeks in a professional male basketball team.

## Methods

### *Participants*

Fifteen professional basketball players from an European first league club (27.1 ± 5.2 years old; 195.3 ± 9.9 cm; 97.2 ± 13.1 kg; 7.6 ± 5.6 years of experience in elite basketball) participated in this study. The ethical standards of the Declaration of Helsinki for studies with humans were followed.

### *Experimental Approach*

This study followed a descriptive longitudinal approach. Researchers did not interfere in any training plans or other coaches' responsibilities. Inferential analysis tested for possible differences in perceived internal loads (session-RPE) and wellness status (Hoover questionnaire) between training sessions and matches in regular and congested weeks. Training sessions were classified based on their proximity to match (M), from 1 to 4 days before M (M-1 to M-4). Training sessions that occurred on a match day were codified as M-0. Regular weeks presented only one official match in a 7-day period, while

congested weeks had at least two official matches (some weeks presented two consecutive matches).

The perceived internal load and wellness status were daily assessed during 235 training sessions and 69 matches over 42 weeks (16 regular and 26 congested) from August 2016 to June 2017 (Table 1), using the session-RPE and the Hooper questionnaire. Only data from players who presented medical clearance for training at the beginning of the week and participated in at least 80% of all training sessions were included in the analysis.

### Instruments

Participants were familiarized with both the CR-10 and the Hooper questionnaire in a dedicated session about the procedures. They classified their effort from 1 (very light activity) to 10 (maximal exertion) according to the CR-10 Borg scale (Borg, 1998) approximately 30 minutes after each training session or match. Ratings were multiplied by session/matches total duration (in minutes) (Foster et al., 2001), resulting in session-RPEs (perception of the session load).

The Hooper questionnaire (Hooper and Mackinnon, 1995) of four categories (delayed onset muscle soreness – DOMS; stress, fatigue, and sleep) was rated approximately 30 min before each training session or match. Each category presents 7 classifications. For DOMS, stress, and fatigue levels, 1 means very, very low and 7 means very, very high. For sleep quality, 1 means very, very good and 7 means very, very bad (Clemente et al., 2017). The sum of the four categories results in the Hooper index (Haddad et al., 2013). Lower indexes indicate better wellness.

The CR-10 and Hooper questionnaire were rated individually using a computer tablet (Microsoft Surface Pro 3, USA) with an application specifically designed for these two scales. This approach reduced the possibility of hearing or observing other ratings and increased answers' accuracy (Malone et al., 2015).

### Statistical Procedures

The results were expressed as means (M) ± standard deviation (SD). A mixed ANOVA was used to identify interactions between within-subjects factor (training sessions over the week) and between-subjects factor (training sessions in regular vs. congested weeks) for the dependent variables. The partial eta squared ($\eta^2_P$) effect size (ES) was used for mixed ANOVA and classified as

no effect (ES < 0.04), minimum effect (0.04 < ES < 0.25), moderate effect (0.25 < ES < 0.64), or strong effect (ES > 0.64) (Ferguson, 2009). The Tukey's test was used in ANOVA as a post-hoc method. Independent t tests and Cohen's *d* effect sizes were used for pairwise comparisons between regular and congested weeks. Cohen's *d* was classified as no effect (*d* < 0.41), minimum effect (0.41 < *d* < 1.15), moderate effect (1.15 < *d* < 2.70), or strong effect (*d* > 2.70) (Ferguson, 2009). All statistical analyses were carried out using SPSS statistical analysis software (SPSS version 23.0, Chicago, USA). The level of statistical significance was set at $p \leq 0.05$.

## Results

The session-RPE and Hooper index of each training session and matches in regular and congested weeks are presented in Figure 1. Between-subjects factor in the mixed ANOVA revealed that regular weeks had moderately greater (but not significant) session-RPEs than congested weeks (*p* = 0.201; *d* = 2.15, *moderate effect*). No significant differences were found for Hooper indexes between regular or congested weeks (*p* = 0.870; *d* = 0.27, *no effect*).

Comparisons between training sessions and matches revealed differences in session-RPEs in both regular (*p* = 0.001; $\eta^2_P$ = 0.619, *moderate effect*) and congested weeks (*p* = 0.001; $\eta^2_P$ = 0.761, *strong effect*). Pairwise comparisons (Figure 1) indicated that matches presented significantly greater values of session-RPEs than training sessions on M-4, M-1, and M-0 in both regular and congested weeks, while M-3 and M-2 did not differ from M in any week type. Except for M-0, the perceived load was not different between training sessions in regular weeks, while M-4 and M-1 were lower than M-3 and M-2 in congested weeks. For the Hooper index, M and M-0 presented the lowest values, regardless of the type of week.

Regarding each Hooper's category, moderate, but not significant differences were found between regular and congested weeks for sleep quality (*p* = 0.421; *d* = 1.320, *moderate effect*) and fatigue (*p* = 0.468; *d* = 1.401, *moderate effect*). Fatigue was moderately greater and sleep quality was moderately worse in congested weeks. Minimum differences were found between regular and congested weeks for DOMS (*p* = 0.136; *d* = 0.410, *minimum effect*) and stress (*p* = 0.967; *d* =0.001, *no effect*).

**Table 1**

*Total number of weeks, regular weeks, congested weeks, training sessions, and matches over a basketball season.*
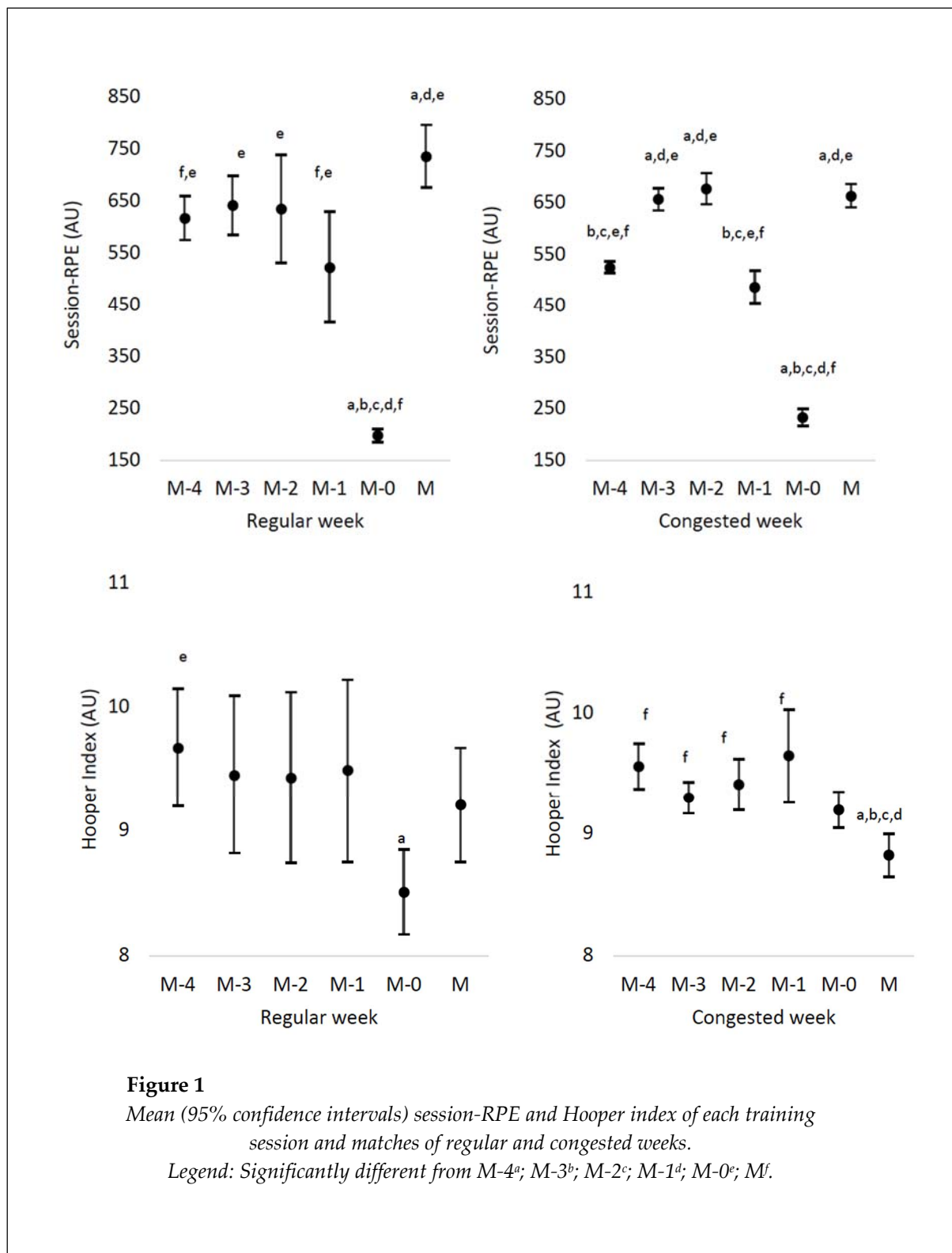
| | August | September | October | November | December | January | February | March | April | May | June |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total weeks | 1 | 5 | 4 | 4 | 5 | 4 | 4 | 5 | 4 | 4 | 2 |
| Regular weeks | 1 | 3 | 1 | 0 | 3 | 0 | 1 | 2 | 3 | 1 | 1 |
| Congested weeks | 0 | 2 | 3 | 4 | 2 | 4 | 3 | 3 | 1 | 3 | 1 |
| Sessions | 3 | 35 | 26 | 21 | 26 | 19 | 22 | 28 | 22 | 22 | 11 |
| Matches | 0 | 8 | 7 | 8 | 7 | 8 | 7 | 9 | 5 | 7 | 3 |

**Table 2**

*Mean (95% confidence intervals) DOMS, fatigue, stress, and sleep quality levels in regular and congested weeks.*

| | M-4 | M-3 | M-2 | M-1 | M-0 | M |
|---|---|---|---|---|---|---|
| *Regular weeks* | | | | | | |
| DOMS | 2.56 [2.36;2.76] | 2.67[e] [2.55;2.78] | 2.75 [2.47;3.03] | 2.56 [2.36;2.76] | 2.29[b] [2.19;2.38] | 2.52 [2.39;2.65] |
| Fatigue | 2.70 [2.52;2.88] | 2.61[e] [2.46;2.77] | 2.62 [2.40;2.84] | 2.66[e] [2.45;2.87] | 2.30[b,d] [2.20;2.40] | 2.49 [2.37;2.61] |
| Stress | 1.83[c] [1.68;1.99] | 1.72[e] [1.55;1.89] | 1.79 [1.58;1.99] | 1.81 [1.59;2.03] | 1.72 [1.62;1.82] | 1.77 [1.63;1.91] |
| Sleep | 2.60 [2.44;2.76] | 2.49 [2.24;2.74] | 2.37 [2.18;2.57] | 2.45 [2.14;2.76] | 2.29 [2.15;2.43] | 2.47 [2.30;2.65] |
| *Congested weeks* | | | | | | |
| DOMS | 2.49[f] [2.45;2.53] | 2.50[f] [2.46;2.55] | 2.52[f] [2.43;2.61] | 2.54[f] [2.45;2.64] | 2.49[f] [2.45;2.52] | 2.33[a,b,c,d,e] [2.27;2.40] |
| Fatigue | 2.69[e,f] [2.64;2.75] | 2.60 [2.54;2.66] | 2.62 [2.56;2.69] | 2.71[e,f] [2.59;2.84] | 2.51[a,d] [2.45;2.57] | 2.49[a,d] [2.42;2.56] |
| Stress | 1.79[b] [1.75;1.84] | 1.70[a,f] [1.66;1.73] | 1.77 [1.72;1.83] | 1.81 [1.73;1.89] | 1.77 [1.72;1.82] | 1.79[b] [1.74;1.84] |
| Sleep | 2.67[b,e,f] [2.61;2.74] | 2.50[a,f] [2.44;2.55] | 2.49[f] [2.41;2.58] | 2.58 [2.36;2.80] | 2.49[a,f] [2.41;2.56] | 2.28[a,b,c,e] [2.22;2.34] |

*Legend: Significant different from M-4[a]; M-3[b]; M-2[c]; M-1[d]; M-0[e]; M[f]*

**Figure 1**
*Mean (95% confidence intervals) session-RPE and Hooper index of each training
session and matches of regular and congested weeks.
Legend: Significantly different from M-4[a]; M-3[b]; M-2[c]; M-1[d]; M-0[e]; M[f].*

Comparisons between training sessions and matches in regular weeks revealed differences for DOMS ($p = 0.014$; $\eta^2_P = 0.181$, *minimum effect*) and fatigue ($p = 0.003$; $\eta^2_P = 0.227$, *minimum effect*), but not for sleep quality ($p=0.321$; $\eta^2_P = 0.079$, *minimum effect*) and stress ($p = 0.405$; $\eta^2_P = 0.050$, *minimum effect*). In congested weeks, DOMS ($p = 0.001$; $\eta^2_P = 0.089$, *minimum effect*), sleep quality ($p = 0.015$; $\eta^2_P = 0.087$, *minimum effect*), and fatigue ($p = 0.004$; $\eta^2_P = 0.093$, *minimum effect*) were significantly

different between training days and matches. No significant differences were found for stress ($p = 0.059$; $\eta^2_P = 0.050$, *minimum effect*).

Significant differences were found between training sessions and matches in both regular and congested weeks (Table 2). Fatigue and stress were the greatest on M-4 and M-1 in both regular and congested weeks. Sleep quality was the worst on M-4 in both regular and congested weeks. All categories tended to decrease in M-0 and M in both week types, except for stress in congested weeks.

## Discussion

This study aimed to compare the perceived training load (internal load) and wellness status between training sessions and matches in regular and congested weeks. Results indicated higher internal loads during training sessions that occurred two or three days before a match. There was a load decrease (tapering phase) in the last two training sessions before a match (day before and match day) in both regular and congested weeks, which was accompanied by an increase in wellness status on a match day. Congested weeks also presented lower internal loads four days before matches, probably to allow players' recovery from the previous game. Congested weeks presented moderately greater levels of fatigue and moderately lower sleep quality than regular weeks, despite moderately lower perceived loads. Fatigue and stress were highest on the fourth and last day before matches in both week types. In general, Hooper's categories indicated good mean levels, with very low DOMS, stress, and fatigue and very good sleep.

This study results corroborate with Manzi et al. (2010), who reported the use of a tapering strategy before matches in professional basketball, with lower session-RPEs on the day before a match regardless of the number of matches within the week. Although Manzi et al. (2010) found no differences in the weekly perceived training load between one-match and two-match weeks they reported a higher perceived load in no-match weeks. The tapering phases before matches may have decreased the overall week training load, supporting the moderately lower weekly perceived training load in this study congested weeks (two tapering phases). This would suggest that congested weeks may need some adjustments in training loads particularly on two or three days

before matches, especially for bench players, who tend to experience a lower match load and performance decrease throughout the season (Caterisano et al., 1997). Indeed, Manzi et al. (2010) showed higher (although not significant) loads in some training sessions (approximately, 800 a.u.) compared to matches (approximately, 600 a.u.), even within congested weeks. However, this recommendation should be treated with some caution, since congested weeks presented moderately higher fatigue levels than regular weeks in this study. Moreover, Manzi et al. (2010) and the present study did not evaluate the external (absolute) training load, which has been shown to present only a moderate correlation ($r = 0.49$) with the perceived training load (session-RPE) in basketball training (Scanlan et al., 2014). The impact of external and perceived loads' decreases before matches on players performance over a basketball season remains to be investigated.

Regarding the Hooper index and its categories, this study results indicated higher fatigue and lower sleep quality in congested weeks, despite its moderately lower perceived load. These data suggest an accumulative effect of training and match loads on wellness status over congested weeks. Ispirlidis et al. (2008) reported significant decreases in performance and biological alterations up to 72 hours after soccer matches, which corroborates with the highest fatigue and stress levels on M-4 and M-1 in both regular and congested weeks (a few days after a match or heavier training). However, basketball players in this study showed very good overall wellness status, with very low DOMS, fatigue, and stress and very good sleep quality (i.e., mean categories' scores around 2) in both week types and training sessions and matches. This suggests that, in general, this team training process and players routine did not represent highly stressful factors. Although wellness status can be influenced by extra-training factors (Haddad et al., 2013; Hooper and Mackinnon, 1995), the tapering phases before matches may have contributed to improve players' overall wellness, since the load decrease on the day before a match was accompanied by improvements in the players' Hooper index, DOMS, fatigue, and sleep quality on a match day. Due to differences between sports (soccer vs. basketball), future studies should investigate the impact of one or two matches per week – with their

respective tapering phases – on basketball players performance, as well as the relationship between wellness status and sport performance.

Finally, the visual inspection of session-RPE and Hooper index graphs indicated a decrease in perceived training loads when Hooper indexes were higher (poorer wellness), especially in congested weeks. This pattern may have contributed to the good levels of wellness in the basketball team investigated. Since this research design did not interfere in coaches' decisions throughout the training process, we do not know whether loads were daily adjusted according to athletes' wellness ratings or whether they followed a planned schedule. Future studies should investigate the use of individual rating cutoff points and their impact on athletes' performance to provide coaches with variables for determining when to decrease or increase each athlete's training load (Claudino et al., 2012). The individualization of external training loads according to athletes' psychophysiological

responses would help improve performance and prevent overtraining.

## Conclusions

Congested weeks may present lower perceived loads than regular weeks, despite poorer wellness status over a professional basketball season. This decrease in wellness may be associated to an accumulative effect of training and match loads on players' fatigue in congested weeks. Tapering phases before matches may play an important role for improving athletes' wellness and, therefore, prevent overtraining. Future studies should investigate the impact of tapering phases before matches on sport performance over a basketball season. Furthermore, investigations on the use of individual cutoff points according to athletes' wellness ratings could provide coaches with variables for determining when to decrease or increase each athlete's training load.

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