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Relationships between type and duration of training and well-being status of volleyball athletes

Relações entre tipo e duração do treinamento e status de bem-estar de atletas de voleibol

Ricardo Franco Lima[1,2]
https://orcid.org/0000-0003-3552-7534
Ana Filipa Silva[1,3,2]
https://orcid.org/0000-0002-1772-1272
José Afonso[4]
https://orcid.org/0000-0002-2038-393X
Rui Silva[1,2]
https://orcid.org/0000-0003-3380-864X
Henrique de Oliveira Castro[5]
https://orcid.org/0000-0002-0545-164X
Filipe Manuel Clemente[1,2,6]
https://orcid.org/0000-0001-9813-2842

[1] Escola Superior Desporto e Lazer, Instituto Politécnico de Viana do Castelo. Viana do Castelo, Portugal.
[2] Research Center in Sports Performance, Recreation, Innovation and Technology (SPRINT). Melgaço, Portugal.
[3] The Research Centre in Sports Sciences. Health Sciences and Human Development (CIDESD). Vila Real, Portugal.
[4] Centre for Research, Education, Innovation and Intervention in Sport. Faculty of Sport. University of Porto. Porto, Portugal.
[5] Universidade Federal de Mato Grosso, Departamento de Educação Física, Cuiabá, Brazil.
[6] Instituto de Telecomunicações. Delegação da Covilhã. Lisboa, Portugal.

Abstract – The purpose of this study was to describe weekly variations in the type and duration of training, as well as wellness-related parameters, in elite volleyball players. Twenty-four youth elite volleyball players from the French national team (age: 17.8 ± 1.0 y.o.) were monitored daily, and the type of training, training duration, participation in matches, and wellness status were measured over 22 weeks. Volleyball training duration varied from 100 to 510 minutes per week, while strength and conditioning training duration varied from 97 to 262 minutes per week. Fatigue levels varied from 1.5 to 2.8 A.U., and delayed onset muscle soreness (DOMS) varied from 1.5 to 2.5 A.U. Large positive correlation were found between sleep and match duration (r = 0.64) and between stress and weekly volume (r = 0.52). Additionally, moderate positive correlation were found between fatigue and match duration (r = 0.36); between sleep and weekly volume (r = 0.35); between DOMS and match duration (r = 0.43); between stress and strength training (r = 0.42), volleyball training (r = 0.35), and match duration (r = 0.47). The present study revealed natural variations in training volume across the season and moderate dependency between weekly training/match durations and wellness status.

Key words: Aerobic training; Performance; Strength training; Training load; Wellness.

Resumo – *O objetivo deste estudo foi descrever as variações semanais no tipo e duração do treinamento, bem como parâmetros relacionados ao bem-estar, em jogadores de elite de voleibol. Vinte e quarto jovens jogadores de elite de voleibol da seleção Francesa (idade: 17,8 ± 1,0 anos) foram monitorados diariamente, e o tipo de treinamento, a duração do treinamento, a participação em partidas e o status de bem-estar foram medidos durante 22 semanas. A duração do treinamento de voleibol variou de 100 a 510 minutos por semana, enquanto a duração do treinamento de força e condicionamento variou de 97 a 262 minutos por semana. Os níveis de fadiga variaram de 1,5 a 2,8 A.U., e a dor muscular tardia (DMT) variou de 1,5 a 2,5 A.U. Correlação positiva grande foi encontrada entre sono e duração do jogo (r = 0,64) e entre estresse e volume semanal (r = 0,52). Além disso, uma correlação positiva moderada foi encontrada entre fadiga e duração da partida (r = 0,36), entre sono e volume semanal (r = 0,35), entre DMT e duração da partida (r = 0,43), entre estresse e treinamento de força (r = 0,42), treinamento de voleibol (r = 0,35), e duração da partida (r = 0,47). O presente estudo revelou variações naturais no volume de treinamento ao longo da temporada e dependência moderada entre treinamento semanal/duração da partida e status de bem-estar.*

Palavras-chave: *Treinamento aeróbico; Desempenho; Treinamento de força; Carga de treinamento; Bem-estar.*

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Corresponding author
Ricardo Franco Lima.
Escola Superior Desporto e Lazer, Instituto Politécnico de Viana do Castelo
Rua Escola Industrial e Comercial de Nun'Álvares, 4900-347, Viana do Castelo, Portugal.
E-mail: ricardo.lima@esdl.ipvc.pt

INTRODUCTION

The practice of monitoring training sessions is invaluable to coaches when planning a competitive season and adapting the workload during training sessions and weeks to prepare players for competition[1,2]. Furthermore, monitoring the load of athletes provides information about their biological and physical stress levels, and allows coaches to assess workloads so that injuries can be avoided[3]. Training workload has been investigated in different sports with the aim of assessing and monitoring external and internal load[3,4]. Internal and external load are the main variables of interest when monitoring workload during training sessions and competition moments[5,6]. Because of the specificity of each sport, the demands vary, and, consequently, the methods used to assess training sessions need to be adjusted accordingly[7]. As a case in point, volleyball is an intermittent sport involving short bursts of high-intensity effort interspersed with longer periods of low intensity[8]. In this sense, monitoring training workload should be intuitive and should be intended to provide efficient data analysis and interpretation while enabling efficient reporting of simple yet scientifically valid feedback[9].

Moreover, it is known that internal training load in volleyball is sometimes greater during the preparatory mesocycle than during the competitive mesocycle[10]. In fact, a general conditioning and hypertrophy training regimen, along with specific volleyball conditioning, is deemed necessary in the preparatory mesocycle for the development of lower-body strength, agility, and speed performance in volleyball players[11]. For that reason, recent studies that have assessed internal load—namely, the wellness status of elite male volleyball players—have revealed the usefulness of combining players' repeated perception effort (RPE) and well-being (Hooper index) to provide information about the impact of training and competition on players[1,6,12,13]. Regarding the wellness status of players during training sessions[14], a study revealed that volleyball training sessions cause meaningful changes in the physiological and perceptual measures of fatigue and muscle soreness from the second training session of the week until the last training day of the week.

The previous facts signify the importance of monitoring internal load during different types of strength and conditioning in training sessions, as well as monitoring players' wellness status to provide athletes and coaches with important information[9,15]. There is a lack of evidence about the distribution of the duration of training sessions and matches and these factors' relationships with well-being, especially in young players. However, using the duration of training sessions and matches as indicators of training volume could help coaches to identify critical periods of the season, mainly if those parameters are closely related to variations in well-being.

Thus, the purpose of this study was: (i) to analyze weekly variations in training duration (organized by type of training, namely, volleyball-specific training and strength and conditioning training) and match duration; (ii) to analyze weekly variations in well-being parameters; and (iii) to analyze the relationships of training and match duration with well-being variables.

METHODS

Participants

Twenty-four youth elite volleyball players from the French national team participated in this study (age: 17.8 ± 1.0 years old; height: 193.9 ± 0.02 cm; body mass: 75.04 ± 8.21 kg). The wellness status of the players was monitored daily. Moreover, the duration was recorded for each training session and match. The following inclusion criteria were applied: (i) participation in the majority of training sessions (at least 80% of all sessions); (ii) missing no more than one consecutive week of training (due to injury, for example); and (iii) medical clearance at the beginning of each microcycle to participate in training without any limitations. The study was approved by the local institute's research ethics committee.

Experimental approach and procedures

A correlational study design was implemented. Training data were collected during the first half of a season, thus spanning 22 weeks. As this is a descriptive, correlational study, all training programs were planned by the coach and his staff according to the preparatory and competitive period of the team. The players responded to the Hooper questionnaire daily. The questionnaire consisted of four categories of items (delayed onset muscle soreness [DOMS], sleep quality, fatigue, and stress). The questionnaires were applied in the morning, 30 minutes before the first training session of the week. All players were accustomed to the daily procedures used in this research as part of their habitual training routine.

The training and match durations were recorded separately by the same researcher throughout the study period. Each training session was classified either as volleyball training (field-based training sessions), strength training (resistance training in the weight room), aerobic training (cardiorespiratory training performed in the weight room) and other training (any other training performed in the weight room, [e.g., stretching, recovery]). The sum of the duration of all weight room training activities (strength, aerobic, and other) was considered as strength and conditioning training duration. Warm-up and cool-down exercises were included when measuring the duration of all training sessions. The duration of play during matches was recorded for each player. The training and match durations were classified as dependent variables.

Hooper questionnaire

The Hooper questionnaire (adjusted to a 7-point scale)[16] was used. On the scale, a value of 1 means 'very, very low,' and a value of 7 means 'very, very high' for stress, fatigue, and DOMS levels; for sleep quality, 1 means 'very, very bad' and 7 means 'very, very good.' The questionnaire was used because it is easy to use, involves no cost, and is non-invasive. Furthermore, it is a promising option for tracking fatigue, sleep, stress, and soreness during a sports season[17-19].

The players were familiarized with the questionnaire and the scale before the study began. Approximately 30 minutes before the training session, each player was asked to rate their perception of the quantity of fatigue, stress, and DOMS, as well as the quality of their sleep during the previous week. Responses were given individually to prevent players from hearing the scores of their teammates.

Statistical procedures

Descriptive statistics of training duration were presented in the form of mean and standard deviation. The normality and homogeneity of the sample was tested and observed by using the Kolmogorov-Smirnov test and the Levene test, respectively, for a $p > 0.05$. After confirmation of the assumptions of normality and homogeneity of the sample, correlation coefficients between training duration and well-being measures were determined by using the Pearson r (r). The following thresholds were used to classify the magnitude of correlations[20]: [0.0-0.1], trivial correlation; [0.1-0.3], small correlation; [0.3-0.5], moderate correlation; [0.5-0.7], large correlation; [0.7-0.9], very large correlation; and >0.9, nearly perfect correlation. The statistical procedures were executed in the SPSS software (version 24.0, IBM, USA) for a $p \leq 0.05$.

RESULTS

Descriptive values of weekly duration (min) of volleyball training, strength and conditioning and match can be found in Figure 1. The highest volleyball training durations were reached on weeks 10 (520 min) and 12 (510 min) and the lowest duration was reached on week 19 of ~100 min. The highest strength and conditioning duration was reached on week 2 of 262 min and the lowest duration was reached on week 19 of 97 min. Finally, the highest match duration was reached on week 17 of 1053 min and the lowest duration reached 38 min on week 6, although there were no matches in weeks 1, 2 and 5. A fluctuation pattern in the duration distribution is quite noticeable, in which a decrease in the overall load can be observed in weeks 11 and 19 with a mean duration value of ~200 min for week 11 and of ~100 min for week 19. In the first weeks (1 to 9) of the season it was observed that strength and condition duration remained high compared to volleyball training, however a shift on durations was observed from week 10, in which volleyball training assumed a more relevant role, although both remained similar throughout the season.

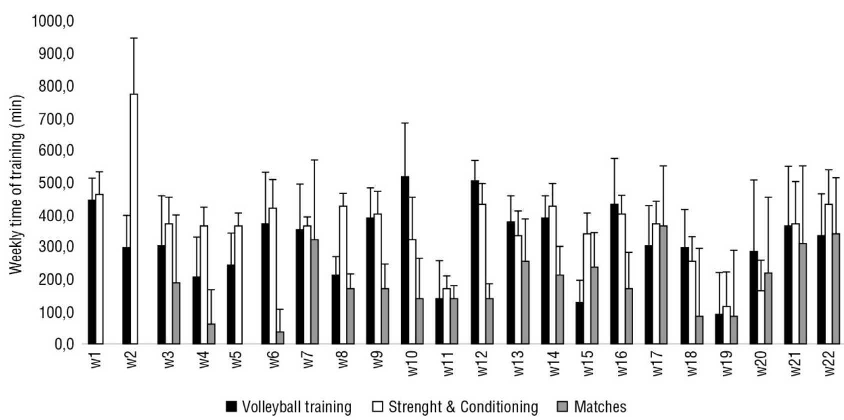

Figure 1. Weekly duration (min) of volleyball training, strength and conditioning and match.

A specific analysis to the duration of strength and aerobic training (included in the strength and conditioning training volume) can be found in Figure 2. Strength training reached the highest durations on weeks 12, 14 and 17 of ~300 min and the lowest duration on week 15 of ~50 min, while the highest aerobic training duration was reached on week 2 of ~400 min and the lowest duration on weeks 3, 10, 11, 13, 17, 18 and 21 of ~0 to 50 min. Higher durations of aerobic training were observed in the first 2 weeks of the season with a significant drop from week 3 and maintaining lower durations from week 4 to week 22. On the other hand, for strength training, it was observed a 4-week mesocycle pattern (3 weeks of loading following 1 week of unloading) from the beginning until the end of the season.

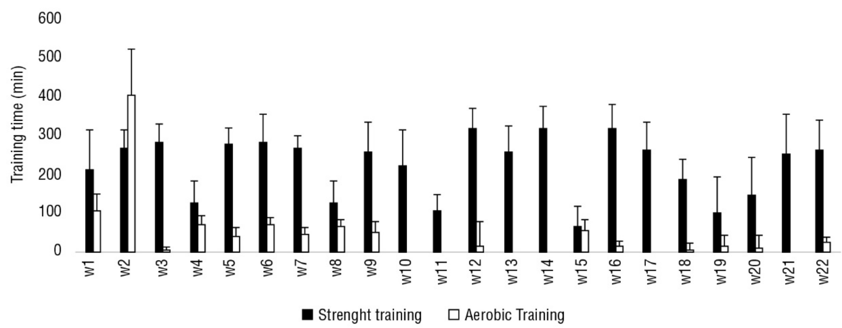

Figure 2. Weekly duration (min) of strength training and aerobic training.

The accumulated duration of training and match can be found in Figure 3. The highest training/match duration was reached in weeks 2, 12 and 22 of ~1.100 min and the lowest duration was observed in week 19 of ~250 min. In the first 3 weeks of the season it was observed higher durations between ~850 to 1.100 min following a slight decrease in weeks 4 and 5 to ~600 min. From week 6 it was observed a 5 to 6-week mesocycle with higher durations following 1 week of unloading (i.e. smaller durations), in which an unloading phase was observed in weeks 11 and 19 similarly to the observed in Figure 1.

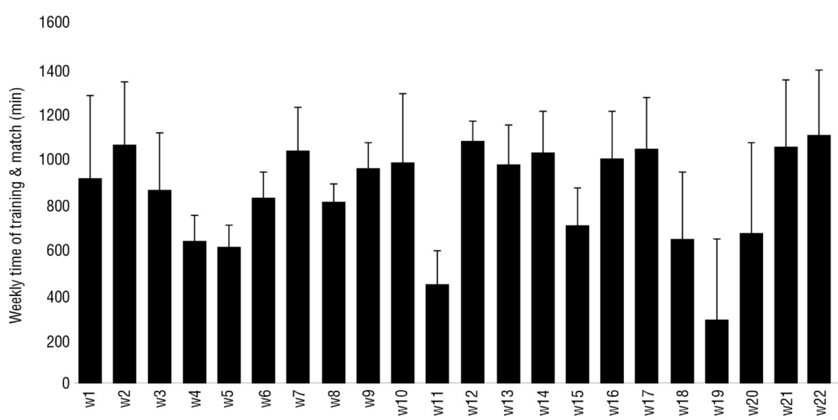

Figure 3. Total weekly duration (min) in training and match.

Mean of fatigue, sleep, DOMS and stress scores in each week of the analyzed period can be found in the Figure 4. The highest fatigue levels felt by athletes were reached in week 20 of ~2.8 AU from the Hooper scale and the lowest levels were reached in week 10 of ~1.5 AU. For sleep variable, the highest values were found in week 17 of ~2.2 AU and the lowest values were found in week 10 of ~1.4 AU. Relatively to delayed onset muscle soreness (DOMS), the highest values were found in week 18 of ~2.5 AU, and the lowest values of ~1.5 AU in week 5. Finally, for stress variable, the highest values were found in weeks 6 and 17 of ~1.5 AU and the lowest values were found in weeks 4 and 5 of ~1.0 AU. It was found that from week 5 to week 14 (10 weeks period) the fatigue, sleep and DOMS variables have a progressive increase during 5 weeks dropping in the 6th week from weeks 5 to 9 and from weeks 10 to 14, following a relatively consistent values until the end of the 22-week period. While for stress variable, it was found consistent values from the beginning to the end of the 22 weeks period analyzed.

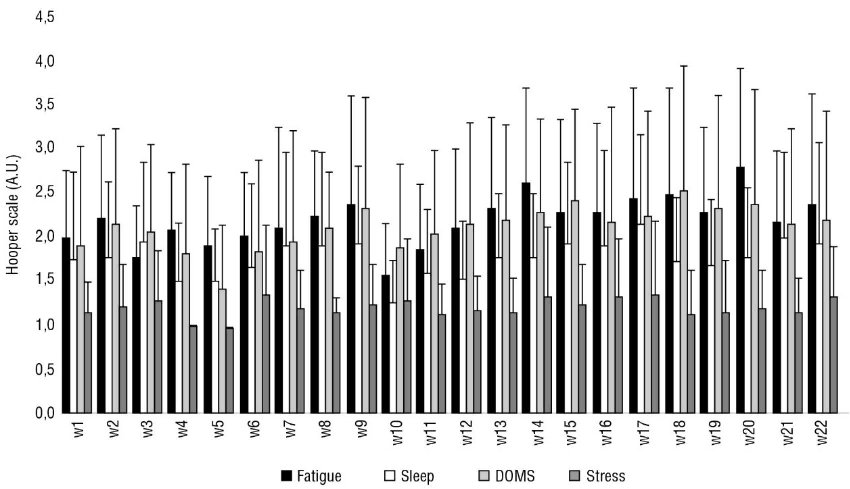

Figure 4. Mean of fatigue, sleep, DOMS and stress scores in each week of the analyzed period.

Correlations between well-being variables and training duration were tested and can be found in Table 1. Large positive correlation coefficients were found between sleep and match duration (r = 0.64[0.3;0.84]) and between stress and weekly volume (r = 0.52[0.13;0.77]). Moderate positive correlation coefficients were found between fatigue and match duration (r = 0.36[0.07;0.68]), between sleep and weekly volume (r = 0.35[-0.08;0.67]), between DOMS and match duration (r = 0.43[0.01;0.72]) and between stress and strength training (r = 0.42[0.0;0.71]), volleyball training (r = 0.35[-0.08;0.67]) and match duration (r = 0.47[0.06;0.74]).

Table 1. Correlation coefficients between well-being measures and training duration.

	Strength training (min)	Aerobic Training (min)	S&C (min)	Volleyball Training (min)	Matches (min)	Weekly volume (min)
Fatigue (A.U.)	-0.04	-0.04	-0.09	-0.12	0.36	0.06
	[-0.45;0.39]	[-0.45;0.39]	[0.49;0.34]	[-0.52;0.32]	[0.07;0.68]	[0.37;0.47]
	Trivial	*Trivial*	*Trivial*	*Small*	*Moderate*	*Trivial*
Sleep (A.U.)	0.08	0.01	0.15	-0.12	0.64	0.35
	[-0.35;0.49]	[-0.41;0.43]	[-0.29;0.54] *Small*	[-0.52;0.32]	[0.3;0.84]	[-0.08;0.67]
	Trivial	*Trivial*		*Small*	*Large*	*Moderate*
DOMS(A.U.)	-0.21	-0.12	-0.21	-0.11	0.43	0.04
	[-0.58;0.23]	[-0.52;0.32]	[-0.58;0.23]	[-0.51;0.33]	[0.01;0.72]	[-0.39;0.45]
	Small	*Small*	*Small*	*Small*	*Moderate*	*Trivial*
Stress (A.U.)	0.42	-0.08	0.19	0.35	0.47	0.52
	[0;0.71]	[-0.49;0.35]	[-0.25;0.57]	[-0.08;0.67]	[0.06;0.74]	[0.13;0.77]
	Moderate	*Trivial*	*Small*	*Moderate*	*Moderate*	*Large*

Note: S&C: strength and conditioning; Training load: sum of S&C and volleyball training; Weekly load: sum of training load and matches. DOMS: delayed onset muscle soreness.; A.U.: arbitrary units; min.: minutes.

DISCUSSION

The purposes of this study were to (i) analyze weekly variations in the duration of training sessions and matches; (ii) investigate weekly variations in well-being parameters; and (iii) explore the relationships of training and match duration with well-being variables.

Fluctuations in duration distribution were registered throughout the period of analysis. In the first three weeks, high total duration (training and match combined) and strength and conditioning duration (first two weeks) were observed, clearly characterizing a traditional approach to the preparatory period, as high training volumes were applied at perhaps not-so-high intensities[21]. During the following weeks, aerobic training duration decreased, but strength and volleyball training durations showed a wave-like fluctuation.

An analysis of all the different load variables showed that all components were considered to create a wave to better manage and control all the training loads. Nevertheless, when strength and conditioning training had higher durations, the match and/or specific volleyball training durations decreased and vice-versa. This implies that coaches understand that not all matches present the same degree of difficulty; therefore, they take the opportunity to change their weekly structure accordingly. Especially in the first two weeks of training, strength and conditioning training were high due to their incorporation in the preparatory period, which is mainly characterized as a period of high training volume combined with a focus on fitness development (e.g., endurance, strength, and speed)[22]. In the present study, strength and conditioning training had a longer duration than volleyball training until week 9. This result is in line with the literature[23], including other studies on volleyball[24,25].

The athletes' physical capacity is an important element of success in sports[26]. Strength and conditioning training, which includes strength and aerobic training in the present study, was related to greater load during the first weeks of the season. However, the distribution of these two physical capacities did not stay the same throughout the season. For instance, aerobic capacity registered its highest value in the second week, but its prevalence dropped on week 3 and stayed low from weeks 4 to 22. Although high aerobic capacity is an integral indicator of the functional capacities of all systems involved in supply, transportation, and energetic oxygen transformation (cardiorespiratory capacity and functional muscle capacity to produce ATP in the presence of oxygen)[26], it has been reported that volleyball requires a relatively high anaerobic work capacity[27].

Thus, the increased load of aerobic exercises in the pre-season was intended to increase aerobic capacity. Meanwhile, for all other weeks, the focus shifted to anaerobic capacity. Strength capacity was frequently stimulated throughout the study period, registering a similar pattern of 3:1 (i.e., increased load for three weeks, followed by a decrease the following week). This fluctuation in load, allowed the coach to better manage the workload and prevent athletes from becoming over-fatigued, thus ensure the alternation of loads and allowing for overcompensation.

In weeks 1, 2, and 5, no matches were registered (Figure 1). This is because these were the pre-season weeks. In the first two weeks, the athletes did not have the physical fitness needed to play in perfect conditions, and in the fifth week, they did not have a match so that they could start in a perfect fit the official season after a week of tapering. As is a common strategy at this stage, the games that took place in weeks 3 and 4 were probably friendly preparation games, encouraging team engagement and coordination. In fact, during the training program, a considerable amount of time should be devoted to drills that improve the players' ability to play as one cohesive unit[28].

Nevertheless, in volleyball training and match load, the same concern with maintaining a load fluctuation seems to be evident, as the largest loads were spread out (weeks 2, 12, and 22). Furthermore, the lowest value for this variable was registered on week 19, which coincided with Christmas and New Year's Eve, thus resulting in frequent disruptions in the training schedule.

Sleep, fatigue, and DOMS increased progressively as the official competition began (weeks 6 to 9), and then consistent values were maintained until week 22. Differently, stress showed higher values at the beginning of the official season (week 6) and in week 17 (which matches with the longest match duration registered and, therefore, could well have been the hardest opponent of the analyzed period). Finally, large positive correlations were found between sleep and match duration ($r = 0.64$) and between stress and weekly duration ($r = 0.52$). Meanwhile, moderate positive correlations were registered between fatigue and match duration ($r = 0.36$), sleep and weekly duration ($r = 0.35$), and DOMS and match duration ($r = 0.43$). Furthermore, stress was correlated with strength training ($r = 0.42$), volleyball training ($r = 0.35$), and match duration ($r = 0.47$). Overall, match duration had moderate to strong correlations with sleep, stress, fatigue, and DOMS, making it the only external variable that was significantly correlated with all wellness variables. Therefore, match duration might be a good indicator of internal load.

Finally, there are some curious aspects of the indirect measures of internal load. Fatigue was the highest in week 20, even though the previous week had the lowest training duration. This finding could indicate that fatigue accumulated across all previous training weeks and is related to the asynchrony of the recovery processes[29,30]. This non-linearity of adaptation and fatigue processes is reinforced by the fact that fatigue was the lowest in week 10, which had one of the highest training durations of the 22 weeks. Incidentally, sleep was low in week 10 but high in weeks 19 and 20. This again points towards the accumulated effects of fatigue towards week 20, as the long sleep times imply a need for recovery. DOMS peaked in week 18, preceding the peak of overall fatigue by approximately two weeks, again underlining the asynchrony of responses to training.

The correlation analysis showed that match duration is perhaps the best measure of external load for inferring internal load, as it was the only measure that presented moderate to strong correlations with all wellness variables. However, since this was an correlational study of a single team, there is no means of comparison. Therefore, these effects are to be interpreted with caution because it is not known whether these correlations are generalizable or reflect an idiosyncrasy of this specific sample. Future studies should analyze an entire season to gain a better understanding of the evolution of the studied parameters throughout a season.

Finally, as a practical approach, the strength of this study revealed how the variations wellness measures could be so important to coaches plan their season. This monitoring could also reveal both individual and team variations regarding wellness measures. In this sense, the simple fact to apply this questionnaires, should add relevant information for coaches to plan their season with different perspective and accordingly to the athletes needs.

CONCLUSION

Regarding the variations of wellness measures, sleep, fatigue and DOMS increased progressively at the beginning of the official season and then remained constant until the end of the study. Thus, it concluded that wellness measures are training-duration-dependent.

COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

Ethical approval was obtained from the local institute's research ethics committee - Scientific Council of Polytechnic of Viana do Castelo and protocol was written following the standards established by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interest to declare.

Author Contributions

Conception and design of the experiment: RFL, AFS, JA, RS, FMC. Realization of the experiments: RFL, AFS, JA, RS, HOC, FMC. Data analysis: RFL, AFS, FMC. Contribution with reagents/research materials/analysis tools: RFL, AFS, JA, RS, HOC, FMC. Article Writing: RFL, AFS, JA, RS, HOC, FMC. All authors read and approved the final version of the manuscript.

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