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ORIGINAL ARTICLE

Training Loads and Jump Performance of Volleyball Athletes during a Microcycle

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Abstract

The present study analyzed the behavior of internal loads through the session rating of perceived exertion (RPE) method and its monotony and strain indicators, as well as the external loads through vertical jump monitoring, during two training weeks of the preparatory phase of athletes from the Brazilian under-19 volleyball team. The sample consisted of 17 athletes (18.2 ± 0.4 years, 88.8 ± 11.7 kg and 198.5 ± 8.2 cm). During the period assessed, the first week consisted of five training days and one recovery day, and the second week consisted of four training days and three recovery days. Daily training loads (TL) and weekly TL were monitored using the session RPE method. Monotony and strain were weekly assessed. Jump performance was evaluated during tactical training, in which the number of vertical jumps and mean jump height were collected. Data were evaluated by comparing weeks 1 and 2 that made up the microcycle, using the paired t test for normal data and the Wilcoxon test for non-normal data, with a significance level of $\alpha \leq 0.05$. No significant differences were found in the comparison between the TL of week 1 and week 2 of the microcycle ($p = 0.125$), while the monotony and strain indicators had higher means in week 1. The total number of jumps performed was the same in weeks 1 and 2, but the mean number of jumps performed per training session was higher in week 2 ($p = 0.012$), and the mean jump height was greater in week 1 ($p = 0.008$). We conclude that the microcycle was balanced for the number and height of jumps, leading to equal TL values between weeks.

Keywords

Collective sports, Performance, Periodization, Training

Introduction

High-performance athletes have their routines composed of hours of daily training to meet the physical demands at competition moments (Horta, et al. 2017; Milanez, et al. 2011) [1,2] in which the highest values of weekly training loads are found in the preparatory period when compared to the competitive period (Andrade, et al. 2021; Aoki, et al. 2017; Horta, et al. 2019) [3-5]. Thus, training planning and control of internal and external loads imposed on athletes (Reynoso, et al. 2016) [6] can avoid acute and/or chronic fatigue situations (Arazi, et al. 2012; Lombardi, et al. 2011) [7,8] maximizing adaptive responses.

The main method for monitoring volleyball internal loads is the session rating of perceived exertion (RPE) method (Andrade, et al. 2021; Aoki, et al. 2017; Horta, et al. 2017) [3,5,1], because sports that prioritize strength and power in their practices need analysis

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tools for training loads, which are capable of measuring the intensity of efforts (Foster, et al. 2001) [9]. One of the main external loads to be monitored in volleyball is the jump performance through the number of vertical jumps and vertical jump height of athletes, as this gesture appears as the main performance criterion (Lombardi, et al. 2011; Wagner, et al. 2009) [8,10] performed with large volumes and intensities (Horta, et al. 2019) [11]. Data show that volleyball athletes can jump up to 114.95 ± 6.93 jumps per training session, with a mean height of 54.47 ± 8.95 cm (Cardoso, et al. 2021) [12].

Training internal loads of professional volleyball athletes range from 1388 ± 111 AU (Berriel, et al. 2021) [13] to 6000 AU (Horta, et al. 2019) [11] in the preparatory phase. But Berriel, et al. (2021) [13] showed that weekly loads between 1388 ± 111 AU and 3852 ± 149 AU are capable of improving jump performance (squat jump - SJ, counter movement jump - CMJ and counter movement jump with arms - CMJa) and aerobic capacity of volleyball athletes. Monotony and strain indicators bring additional information for monitoring training routines, with results on oscillation and magnitude of loads applied in different training sessions for a given period (Foster, et al. 2017; Freitas, et al. 2015) [14,15]. High monotony and strain indicators suggest that there was an inadequate distribution of training loads related to the volume applied during the week, which can lead to a drop in performance, fatigue, injuries and even the overtraining syndrome (Foster, et al. 2017; Freitas, et al. 2015) [14,15].

In this way, the objective of the present study was to analyze the internal loads behavior through the session RPE method and its monotony and strain indicators, as well as the external loads, through the monitoring of vertical jumps during two training weeks of the preparatory period of athletes from the Brazilian under-19 volleyball team.

Material and Method

Subjects

The sample was intentional, comprising 17 athletes from the Brazilian under-19 volleyball team, with mean age of 18.2 ± 0.4 years, mean body mass of 88.8 ± 11.7 kg and mean height of 198.5 ± 8.2 cm. All athletes of the sample were selected by the Brazilian Volleyball Confederation to participate in the under-19 team.

Prior to participating in the study, the athletes read and signed the free and informed consent form, which contained all the information relevant to the study. The research project was approved by the Research Ethics Committee of the XXXXX (number: XXXXXX). This study complies with the Code of Ethics of the World Medical Association (Declaration of Helsinki), published in the British Medical Journal (July 18th, 1964).

Procedures

The training period evaluated was the third microcycle of the preparatory phase of the Brazilian under-19 men's volleyball team for the World Championship. At this stage, the athletes' training routines consisted of two daily workouts, with technical and strength training in the morning and tactical training in the afternoon. The first training week consisted of five training days and one recovery day, while week 2 consisted of four training days and three recovery days.

Internal loads were monitored in all training performed (morning and afternoon) and external loads were monitored through the jump performance in the tactical training performed in the afternoon.

Internal load

RPE assessment was conducted by means of the CR-10 Scale Borg (Borg, 1990) [16] and used to evaluate the training loads through the session RPE method proposed (Foster, 1998) [17] at the end of training, the athletes were asked to answer the following question: What is your perception of effort for today's training? They should mark their answer on the scale. Scale indices range from 0 to 10, where 0 equals no effort and 10 equals maximum effort. The athletes were previously familiarized with the use of scales.

Training loads were monitored by the session RPE (sRPE) method, which is given by the product of the values observed by the RPE scale and the training time (in minutes) of each session, which corresponds to the training load (TL) of the session. For daily TL values, the TL of the morning and afternoon sessions were summed. Weekly TL was the result of the sum of daily TL. TL results are expressed in arbitrary units (AU).

Monotony and strain

To obtain the monotony, mean daily training loads were calculated, including the recovery days, to compose the mean weekly training loads and the respective standard deviation. The calculation of monotony was given by the ratio of mean weekly training loads by its standard deviation. Values above 2 AU were considered a reflection of little oscillation of training loads.

Strain was calculated through the product of total weekly training load (sum of the daily training loads of each week) by the monotony of the corresponding week. The maximum suggested reference value for the total load (strain) is 10,000 AU. High indices of total load (strain) suggest that there was an inadequate distribution of the training loads related to the volume applied in the week (Foster, 1998) [17].

External load

Vertical jump performance was used to monitor external loads, through the number of vertical jumps and the mean jump height obtained during tactical training. For data acquisition, an inertial measurement unit tool (VERT, Florida, USA) was used, inserted in an elastic band at the height of the athletes' waist. This tool captures the mean height of vertical jumps and the number of vertical jumps performed (MacDonald, et al. 2017) [18]. The collected data was immediately transferred to a smartphone via Bluetooth. The methodology for capturing these variables was carried out in accordance with the study of MacDonald, et al. (2017) [18]. All vertical jump patterns that composed the training were captured for the external load analysis.

Statistical analysis

Descriptive statistics was used to present data in mean and standard deviation. Data normality was verified through the Shapiro-Wilk test.

Weekly training load, monotony and total load (strain) data were grouped by week 1 and week 2, analyzed using paired t-test.

Jump performance was evaluated through the total number of jumps in the week, number of jumps performed in training sessions and jump heights performed in training sessions. For the total number of jumps in the week, all jumps performed during week 1 and week 2 were summed and compared using the paired t test. For the number of jumps performed in training sessions and jump height, the means of weeks 1 and 2 were calculated and compared using the paired t test for normal data and the Wilcoxon test for non-normal data.

The significance level adopted was $\alpha \leq 0.05$. Statistical tests were performed using SPSS software version 22.0 (IBM, Chicago, USA).

For effect size analysis, Cohen's d coefficient was used, in which an effect size of < 0.19 was considered insignificant, 0.20-0.49 small, 0.50-0.79 medium, 0.80-1, 29 large and > 1.30 very large (Espirito-Santo & Daniel, 2015) [19].

Results

No significant differences were found in the comparison between the TL of weeks 1 and 2 (p = 0.125). On the other hand, there was a significant difference for monotony and strain indicators when comparing week 1 and 2, as shown in table 1 below.

Daily TL showed a undulatory character in the two weeks evaluated, with significant differences between training days (p = 0.000). Training days of the first training week were Tuesday: 1367 ± 123 AU, Wednesday: 1217 ± 139 AU, Thursday: 909 ± 92 AU, Friday: 783 ± 103 AU and Saturday: 1068 ± 156 AU. In the second week, training loads were Monday: 1317 ± 145 AU, Tuesday: 1005 ± 117 AU, Wednesday: 1100 ± 131 AU and Thursday: 1247 ± 128 AU.

The behavior of daily TL and TL of weeks 1 and 2 can be observed in the figure 1 below.

No significant differences were found for the total number of jumps in the week between the two training weeks, but when comparing the mean number of jumps performed per training session, week 2 presented higher means compared to week 1 (p = 0.012). Mean jump height was greater in week 1 compared to week 2, with a significant difference (p = 0.008).

Evaluating the ES of jump performance between weeks 1 and 2, total number of jumps of the week and jump height showed a small ES, while the mean number of jumps per session presented a medium ES (Table 2).

Table 1: Weekly training load, monotony and strain data presented in mean ± standard deviation (DP), p value and effect size (ES) of training weeks 1 and 2.

VARIABLES	"N"	WEEK 1	WEEK 2	p	ES
		Mean ± SD	**Mean ± SD**		
Weekly training load (AU)	**17**	5345 ± 1685	4671 ± 1877	0.125	0.37
Monotony (AU)	17	1.518 ± 0.19	0.93 ± 1.25	0.004*	0.67
Total load (Strain) (AU)	17	6471.9 ± 2834.0	4707.2 ± 2057.7	0.007*	0.70

*: Significant when p value ≤ 0.05; "N": Number of athletes evaluated; AU: Arbitrary Units

Table 2: Data on total number of jumps of the week, mean number of jumps per session and jump height performed in training sessions of weeks 1 and week 2 presented as mean ± standard deviation (SD), p value and effect size (ES).

VARIABLES	"N"	WEEK 1	WEEK 2	p	ES
		Mean ± DP	**Mean ± DP**		
Total number of jumps of the week	15	328.00 ± 117.02	364.40 ± 143.33	0.220	0.26
Mean number of jumps	15	81.34 ± 15.99	99.70 ± 26.77	0.012*	0.77
Jump height (cm)	15	55.64 ± 8.52	49.17 ± 15.72	0.008*	0.47

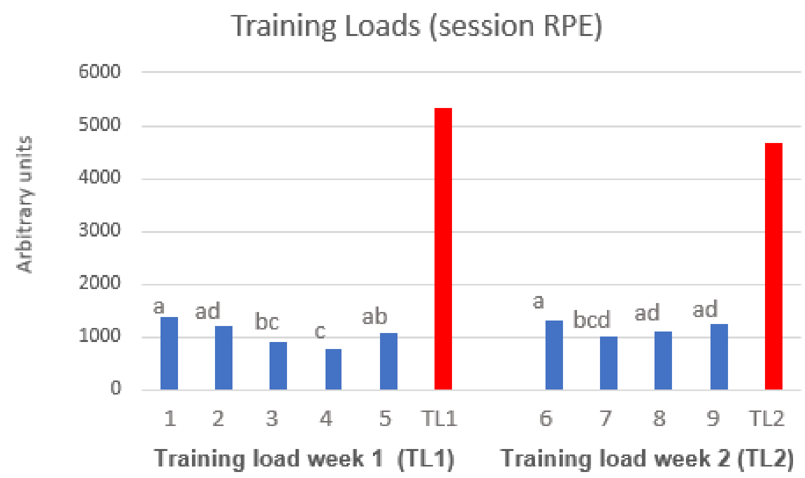

Figure 1: Mean values of daily training loads and total weekly training load for week 1 (TL1) and week 2 (TL2), evaluated using the session rating of perceived exertion method, expressed in arbitrary units (AU).

Discussion

The aim of the present study was to analyze the behavior of internal loads through the session RPE method and its indicators of monotony and strain, as well as external loads, through the monitoring of vertical jumps during two training weeks of the preparatory period of athletes from the Brazilian under-19 volleyball team.

The main findings show high weekly training loads in the two weeks evaluated, but without significant differences between weeks. Monotony and total load (strain) indicators were greater in week 1 compared to week 2, but the values were within the ideal range for both indicators in both weeks. Jump performance was similar for the total number of jumps performed in both weeks, but with a greater mean number of jumps per session in week 2 than in week 1, while mean jump height was greater in week 1.

We can observe that the organization of training loads by the team's technical commission was balanced. Training loads of the weeks did not show significant differences, although week 1 was composed of five training days and week 2 was composed of 4 training days. Mean values of weekly training loads (week 1: 5345 ± 1685 AU and week 2: 4671 ± 1877 AU) were similar to the findings (Horta, et al. 2019) [5] that assessed volleyball athletes and showed a mean load for the preparatory period between 3000 and 6000 AU. On the other hand, (de Freitas, et al. 2019) [20] showed a mean weekly load of 2354 ± 492 AU for professional volleyball athletes evaluated in the second week of the preparatory phase, a lower value than that showed in our study, wherein it is possible that the training sessions had not reached such high loads compared to the third microcycle of the preparatory phase evaluated in our study.

Debien et al. (Debien, et al. 2018) [21] also presented lower weekly training loads than those found in our study, evaluating 36 training weeks of professional volleyball athletes, showing a mean weekly training load of 3733 ± 1228 AU evaluated in the second half of the preparatory phase. Such difference may be related to the fact that the under-19 team has a shorter preparatory phase period (12 weeks), which may lead athletes to the need of adapting to high training loads in a short period of time, targeting the competitive period. But Berriel et al. (Berriel, et al. 2021) [13] assessing a training period of 10 weeks, showed a weekly training load ranging from 1388 ± 111 AU and 3852 ± 149 AU, which are capable of improving jump performance (SJ, CMJ, CMJa) and aerobic capacity, important skills for volleyball athletes.

Our findings corroborate with (Aoki et al., 2017) [4] who showed that under-19 athletes have training loads very similar to the demands of adult volleyball teams, and the high loads found in our study are compared to moments of intensification of training loads, which is probably related to the preparatory period stage evaluated.

Training with undulatory loads has been showing improvements in physical fitness, recovery rates and lower injury rates when compared to non-undulatory loads (Costa, et al. 2019) [22]. The daily training loads of the period evaluated showed an undulatory character. This behavior can also be observed through the monotony and total load (strain) indicators that bring information about the magnitude and distribution of the weekly training loads, which are within the appropriate values.

We can observe through the monotony and total load (strain) values that, despite showing significant differences between weeks 1 and 2, the mean values of monotony (week 1: 1.518 ± 0.19 - week 2: 0.93 ± 1. 25) and total load (strain) (week 1: 6471.9 ± 2834.0 - week 2: 4707.2 ± 2057.7) were within the reference values considered ideal for these indicators. Monotony values above 2.0 AU reflect little oscillation of training loads and values up to 10000 AU are suggested for the total load (strain).

Evaluating male volleyball players, (Freitas, et al. 2015; Horta, et al. 2019) [15,5] found monotony values up to 1.4 ± 0.1 AU and 1.47 ± 0.10 AU, very similar to those found in our study, and total load (strain) values of 2802.7 ± 580.7 AU and 954 ± 203 AU, which are below our findings. (Debien, et al. 2018) [21] evaluating preparatory and competitive periods, showed values very similar to our findings for both indicators, with monotony values between 1.13 ± 0.20 and 1.32 ± 0.09 and total load (strain) values between 4092 ± 1250 and 6214 ± 1197 AU. Despite the differences found in the studies (Debien, et al. 2018; Freitas, et al. 2015; Horta, et al. 2019) [21,15,5] these studies showed well-distributed loads, with values within the ideal range for these indicators, as well as our findings.

Vertical jumps are one of the best options to evaluate external loads applied to volleyball athletes in training and competition periods, as they are used in serving, attacking, setting and blocking actions, performed in large volumes and intensities (Sattler, et al. 2012) [23].

Evaluating the total number of jumps performed in the weeks assessed, we found a mean of 328.00 ± 117.02 jumps in week 1 and 364.40 ± 143.33 jumps in week 2, statistically equal values, which shows that in week 1, with five days of training, the number of jumps was similar to week 2, with four days of training. Thus, the mean number of jumps per daily session showed significant differences between weeks 1 and 2 ($p = 0.012$) with a mean number of jumps of 81.34 ± 15.99 per session in week 1 and a mean of 99.70 ± 26.77 jumps per session in week 2.

The number of jumps per session in week 1 is close to the findings (Cardoso, et al. 2021) [12] who show a mean jump volume of 79.25 ± 34.37 in training, evaluating a male volleyball team in Brazil, while (Horta, et al. 2017) [1] presented a mean number of 87.2 ± 37.9 jumps performed in training, values above those found in week 1 and below those found in week 2.

While the lowest mean number of jumps per session was found in week 1, the mean jump height was higher in week 1 (55.64 ± 8.52 cm) when compared to week 2 (49.17 ± 15.72 cm) ($p = 0.008$), which shows a certain balance between volume and intensity in the weeks. (Cardoso, et al. 2021) [21] evaluated mean jump height in training using VERT, the same tool used in the present study, and found a mean of 54.47 ± 8.95 cm, close to the values showed in week 1. We did not find other studies evaluating jump height during training, but we observed that the means found in our study are close to the jump performance in maximum tests, in which (Berriel, et al. 2021) [13] showed a mean of 56.9 ± 5.4 cm for the CMJ after the preparatory phase, while (Horta, Bara Filho, et al., 2019) [11] showed 46.94 ± 5.92 cm for the same jump. Maffiuletti et al., Trakkovic et al., Debien et al. (Debien, et al. 2018; Maffiuletti, et al. 2002; Trajkovic, et al. 2012) [21,24,25] found mean CMJa values of 47.9 ± 5.7 cm, 48.1 ± 6 cm and 48.21 ± 4.95 cm respectively, and (Aoki, et al. 2017) [4] evaluating under-19 Brazilian athletes, show the highest values in maximum tests in the CMJa, 51.1 ± 6.8 cm.

It should be noted that the sample comprises athletes selected to participate in the Brazilian under-19 team. These athletes are submitted to a rigorous selection process, and among the physical performance tests, vertical jump performance is much highlighted. In addition, their performances are constantly being observed, which can explain the greater mean jump height of the week 1 in comparison to the study (Cardoso, et al. 2021) [12] and the similar weekly values found in maximum performance tests of CMJ and CMJa of professional athletes. Despite the differences found in jump performance between the two weeks, regarding number of jumps and jump height per training session, the weekly training loads did not show significant differences between the two weeks, contrary to the findings (Pisa, et al. 2022) [26], who showed that training sessions with a greater number of jumps resulted in higher training load values.

As practical applications, we show the importance of monitoring internal training loads. Also, the session RPE method is an easy and simple method to be applied in sports, bringing a series of important information on the magnitude of loads applied daily, weekly and over the course of a season, which are complemented by monotony and strain indicators, providing information about load distributions. In addition, real-time monitoring of jumps in volleyball practice is extremely important, as the jump volume of athletes can be adjusted according to the specific objectives of the teams, positions on court, and return after injuries, among others.

Conclusion

Thus, we can observe that during the microcycle evaluated, comprising the two training weeks, there was a balance between the number of jumps performed in training sessions and the jump heights, in which the week with the highest number of jumps performed per session showed the lower jump heights, and in the week in which fewer jumps were performed per session, higher jump heights were achieved. Jump behavior, in addition to the other variables that made up the technical and muscle strength training, led to equal training loads between weeks, in which the daily training loads had a undulatory nature, as evidenced by the monotony and total load (strain) indicators that were within the ideal values, showing the ability of the coaching staff to organize the training.

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