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Original Article (short paper)

Monitoring training load in beach volleyball players: a case study with an Olympic team

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Abstract — Aim: Describe and compare training load dynamics of two Olympic beach volleyball players. **Methods:** Two Olympic beach volleyball players participated in this study (specialist defender and blocker: both aged 34 years, holding 14 years of competitive experience, height: 1.74 m and 1.81 m, weight: 69 kg and 65 kg, respectively). Internal training load (ITL), total weekly training load (TWTL), monotony and strain were obtained through the session rating of perceived exertion (session-RPE) for three training mesocycles (10 weeks). Lower limb explosive power was assessed through the counter movement jump (CMJ). **Results:** Mean ITL, TWTL, monotony and strain during the 10-week period were: 370 ± 156; 1997 ± 838; 2.7 ± 1.3; 5621 ± 1802 arbitrary units (AU) (Defender) and 414 ± 153; 2392 ± 892; 2.7 ± 1.1; 6894 ± 3747 (AU) (Blocker). Mean of CMJ height was 47.0 ± 1.3 and 40.3 ± 1.6 cm, for the defender and blocker, respectively. The defender player presented higher ITL in the second (effect size (ES) = 0.90; 92/5/3, *likely*) and in the third (ES = 0.91; 94/4/2, *likely*) mesocycles when compared to the first. Monotony raised from the first to the third mesocycle (ES = 2.91; 98/1/1, *very likely*). Blocker's ITL was higher in the third mesocycle than the first (ES = 1.42. 98/1/1, *very likely*) and in the second (ES = 1.49; 98/1/1, *likely*). **Conclusion:** ITL magnitude increased from the first to the third mesocycle, in both players.

Keywords: workload, recovery, performance.

Introduction

Beach Volleyball (BV) is a team sport characterized by its intermittent nature, demanding frequent shifting between short periods of maximal efforts (attack) and longer periods of submaximal efforts (positioning to serve/receive)[1]. Speed and muscle power are capacities influencing success achievement in this sport, due to the fast and skilled court movements interspersed with frequent explosive vertical jumps[2]. Additionally, some studies[1,3] have reported differences in physical demands (e.g. number of jumps per set) when considering the player's role (defense and blocker specialist). These are relevant and determinant factors to attain high expertise and victories during the matches[4].

Elite sports environment is characterized by the progressively higher demands imposed on athletes. Hence, coaches and practitioners seek for monitoring tools that provide useful variables for planning training sessions, optimizing performance gains and providing competitive benefits[5].

In high-level BV, finely monitored training periods are necessary to improve performance, with effective stimuli being offered while avoiding injury and illness, such as upper respiratory tract infections[6,7]. An imbalance between loading and recovery may lead to an acute fatigue condition, which can evolve to overreaching and overtraining[6,8]. Additionally, there is evidence suggesting that an athlete experiencing sudden changes in the weekly training load will be at higher risk of performance decrement and injury[5,9]. In this sense, monitoring and controlling training loads can help in the prevention of maladaptations and injury/illness[10].

A recent study with professional football players[11] has showed that the ratio between the load applied during a certain week (acute load) and the mean of the previous four weeks (chronic load)[12], ranging between >1.00 and <1.25, was connected to lower injury risk. Therefore, training load monitoring has been seen as a relevant factor determining success in sports, as it provides insights on the training process, allowing valuable feedback to be given to the athletes, as related to performance and fatigue changes[12-14].

Impellizzeri, Rampinini, Marcora[15] have proposed the quantification of internal training loads (ITL), which relate to each athlete's physiological and psychological changes resulting from the application of an external load, e.g. session duration, frequency, training type[5,16]. The quantification of ITL using session-rating of perceived exertion and heart rate-derived training impulses has been used and validated in several sport disciplines, football[17,18], futsal[19], taekwondo[20], rugby[6], basketball[21] and volleyball[22]. One of the advantages of quantifying ITL by using session-RPE is that it is valid across several training modes (strength, interval training, technical-tactical training), besides being significantly correlated with changes in fitness and performance during training periods[23]. In volleyball, session-RPE is sensitive to detect changes in external training loading[22] and displays agreement between coaches and players[24].

Despite the great amount of research conducted in various sports, no studies have been found on ITL monitoring of elite level BV players during a specific training period. The aim of our study was to describe training loads undertaken by a BV Olympic team during a training period leading up to their participation in the 2016 Olympic Games.

Methods

A Case Study

Two Olympic BV players (a defender and a blocker: both aged 34 years. and holding 14 years of competitive experience, height

1.74 m and 1.81 m, weight 69 kg and 65 kg, respectively) participated voluntarily in this study. Data collection was carried out during the 2015/2016 Brazilian Beach Volleyball Open Circuit, where they had been twice medalists. In 2016/2017 they had won three tournaments and currently (2017/2018 season) are ranked in the first position of the Fédération Internationale de Volleyball (FIVB). Data collection was part of the professional team routines in which players had been frequently assessed across the season. Therefore, the normal ethics committee clearance was not required[25]. Nevertheless, to ensure the team players' confidentiality, all identifying information on the athletes was removed before data analysis.

Monitoring the Internal Training Load

Monitoring of daily ITL was performed for 10 weeks and divided into three mesocycles (first: general preparation period in January/February; second: specific preparation period in March; third: competitive period in April) meeting the main objectives pre-set by the team's technical staff (Table 1). During the follow-up period, the players played five games in Niterói/Rio de Janeiro (first mesocycle), four games in Maceió/Alagoas (second mesocycle), and seven games in Vitória/Espírito Santo in the third mesocycle, totaling 16 games. Daily ITL was established by the product between the chosen value of RPE scale[26,27] and the duration of training session in minutes[26]. Each player answered a question, 30 minutes after each training session, "How (hard) was your training?", indicating the answer on RPE scale from 0 to 10[10]. The double–shift training days provided a daily ITL, whose result was obtained by the sum of the two sessions. Besides daily ITL, also the total weekly training load (TWTL) was estimated by adding up each week's seven ITL. Monotony was obtained by the ratio between the mean and the standard deviation of each week's daily ITL, and strain through the multiplication of the TWTL result by monotony. These variables were expressed in arbitrary units (AU)[10,28].

Lower limbs explosive power (EP) has been assessed through the adapted countermovement jump (CMJ). Jumps were carried out with the upper limbs aid, where the athletes performed the blocking motor gesture. Tests were conducted on a jumping platform (Contact platform kit, Chronojump Boscosystem®). Each player performed three jumps with one minute interval in-between, and the highest jump has been registered (cm). Assessments were conducted at the beginning (Monday) of each one of the 10 week training period.

Statistical Analysis

Descriptive statistics was used in data analysis (means and standard deviation). The 10-week training coefficient of variation (CV) was estimated. Changes in the variables ITL, monotony, strain and explosive power (EP) between the mesocycles were analysed using standardized differences or effect size (ES). The Hopkins scale (www.sportsci.org/resource/stats) was used for their interpretation: 0-0.2 trivial, > 0.2-0.6 small, > 0.6-1.2 moderate, > 1.2-2.0 large, and > 2.0 very large[29]. The probability of finding differences between the variables was solved by assessing them qualitatively through the scale: < 1%, almost certainly not; 1-5%, very unlikely; 5-25%, unlikely; 25-75%, possible; 75-95%, likely; 95-99%, very likely; > 99%, almost certain. When the results of both categories (better and poorer) were > 5%, the true (unknown) effect was classified as unclear[30].

Results

Table I presents the number of weeks, main training abilities, number of games, main objectives, number of games of each mesocycle, means and their standard deviation of duration of sessions (physical, conditioning, tactical-technical), TWTL, monotony and strain of each player's mesocycle. Table 1 presents blocker and defender players' TWTL 10 training weeks. The CV of mean of 10 training weeks was 42.7% and 37.3%, for defender and blocker, respectively.

Table I - Description of each volleyball player's training weeks, main training abilities, number of games and training variables.

	Defender			Blocker		
Mesocycles	**First**	**Second**	**Third**	**First**	**Second**	**Third**
Training weeks	4	3	3	4	3	3
Main training abilities	ER, TT, H	TT, PO, AC	TT, PO	ER, TT, H	TT, PO, AC	TT, PO
Number of games	5	4	11	5	4	11
Physical (min)	121.8±51.5	72.5±38.9	53.3±4.2	140.0±42.4	116.7±10.6	138.3±3.5
Strength training (min)	177.5±89.7	146.7±55.1	98.3±2.9	115.5±51.9	92.5±5.8	52.0±70.8
Tactical-technical (min)	218.8±218.8	184.7±97.6	206.7±136.1	217.5±83.5	184.7±97.6	246.7±133.2
Total time (min)	518.0	403.8	358.0	473.0	393.8	437.0

Explosive force (cm)	46.4±0.9	46.3±1.5	48.0±1.1	39.7±0.3	40.6±1.9	40.6±0.8
TWTL (AU)	2061.3±759.3	2041.7±1196.5	1750.0±875.0	2163.0±945.8	1854.7±938.1	2591.7±971.2
Monotony (AU)	2.3±0.3	3.7±1.7	4.1±1.0	2.7±0.3	3.5±1.8	3.7±1.1
Strain (AU)	4678.3±1703.7	5919.1±1716.1	6579.5±2008	5563.9±2056.8	5375.8±934.7	10186.4±5720.2

Legend: SR: strength - resistance; TT: tactical-technical; H: hypertrophy; PO: power; AC: aerobic capacity; TWTL: total weekly training load

Figure 1 displays the total weekly training load average and variation in the EP across the 10 weeks analyzed for defender (A) and blocker (B). EP mean was 47cm and 40cm, for the defender and blocker, respectively.

Figure 1. Total weekly training load (TWTL) and explosive power (CMJ) during the 10 analyzed weeks for defender (A) and blocker (B).

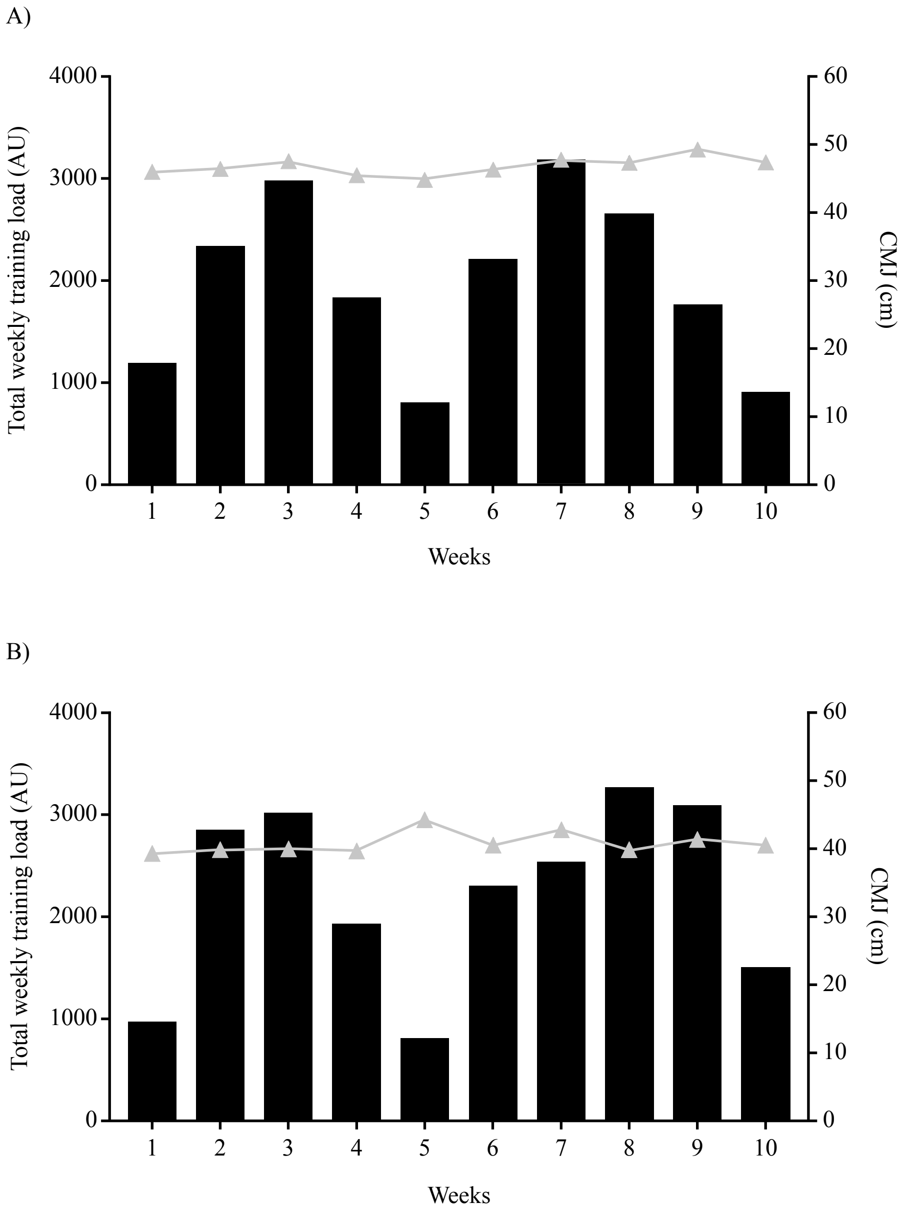

Figure 2 presents both defender (A) and blocker (B) ITL and monotony of each week. ITL mean, represented by the dotted line, was 414 AU (defender) and 370 AU (blocker). Figure 3 presents the training strain of each week for defender (A) and blocker (B). The strain means, represented by the dotted line, were 5621 AU (defender) and 6894 AU (blocker).

Table II illustrates defender and blocker's comparisons among variables (ITL, monotony, strain and EP) between mesocycles, as well as standard means, effect size and qualitative odd. The defender showed ITL in the 2nd and 3rd mesocycles substantially greater when compared to the 1st mesocycle. Additionally, the defender presented greater monotony in the 3rd mesocycle when comparing to 1st. Blocker presented a significantly greater 3rd mesocycle when compared to 1st and 2nd.

Figure 2. Defender (A) and blocker (B) Internal training load (ITL) mean assessed through session RPE and each week's monotony.

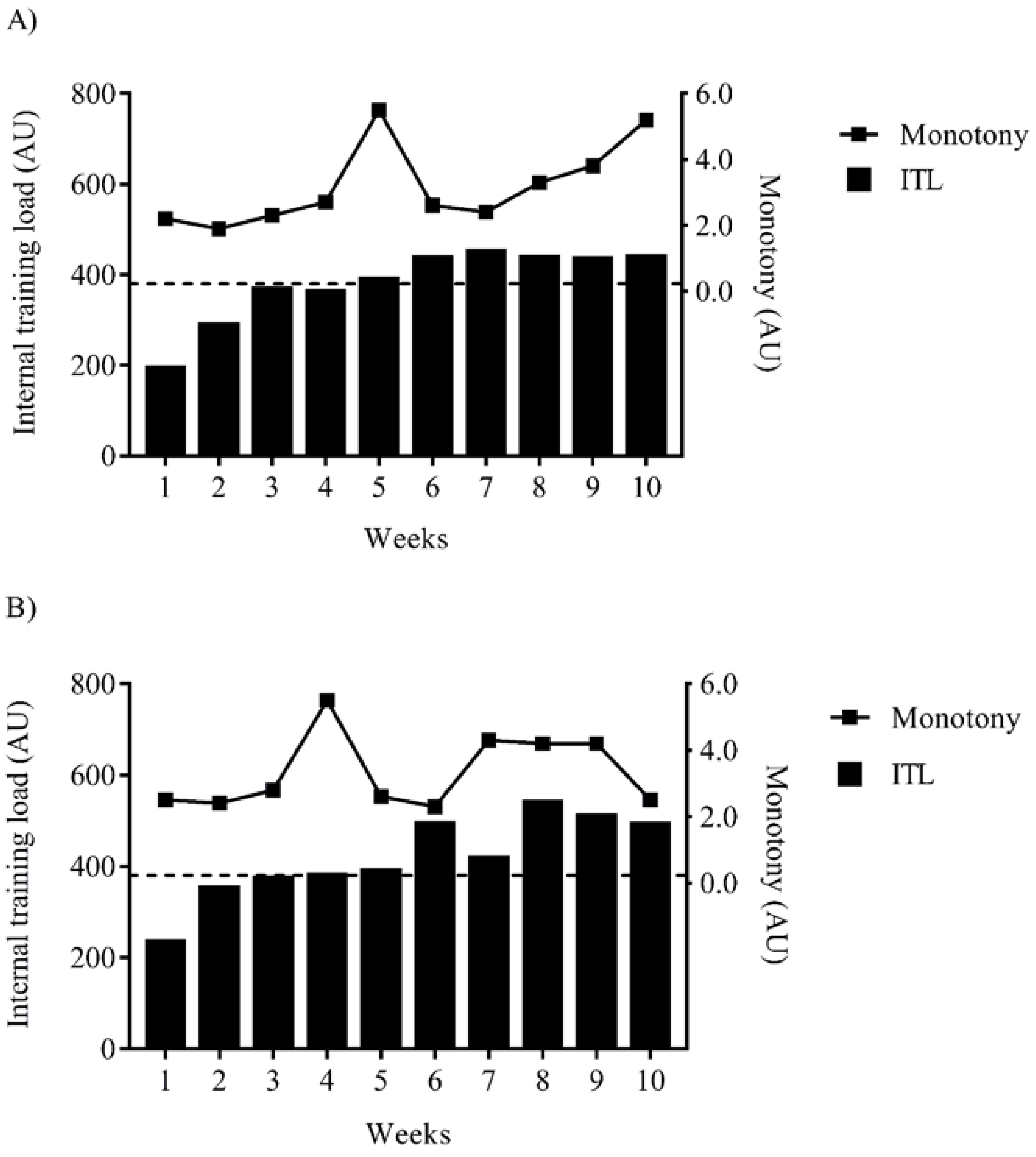

Figure 3. Each training week strain average represented by the dotted line for defender (A) and blocker (B).

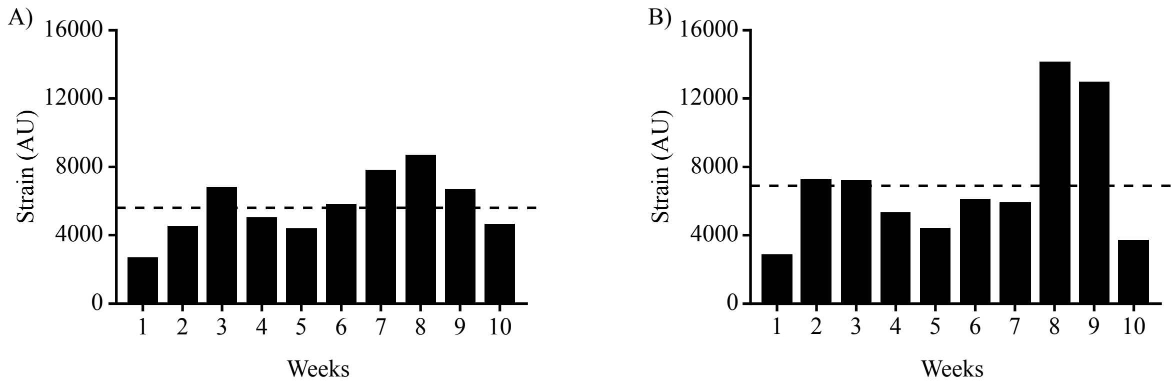

Table II. Standardized mean difference (SMD), 90% CI (confidence interval), magnitude of effect size and probabilities of comparison among 1st, 2nd and 3rd mesocycles for each player's position training variables.

		Mesocycles		
	Variables	**1x2**	**1x3**	**2x3**
Defender	Internal training load	0.90 (0,00;1,79) Moderate 92/5/3 likely	0.97 (011;1.82) Moderate 94/4/2 likely	0.21 (-0.75;1.18) Small 52/32/17 unclear
	Monotony	1.83 (-2.19;5.85) Large 82/4/14 unclear	2.91 (1.10;4.71) Very Large 98/1/1 very likely	0.27 (-0.81;1.35) Small 56/27/17 unclear
	Strain	0.48 (-0.54;1.50) Small 71/18/11 unclear	0.67 (-0.39;1.72) Moderate 80/12/8 unclear	0.20 (-0,95;1.34) Trivial 50/26/24 unclear
	Explosive power	- 0.04 (-1.93;1.85) Trivial 39/18/43 unclear	1.39 (-0.10;1.85) Large 92/3/4 likely	0.66 (-0.30;1.62) Moderate 83/11/6 unclear
Blocker	Internal training load	0.78 (-0.14;1.70) Moderate 88/7/4 likely	1.42 (0.54;2.30) Large 98/1/1 very likely	1.49 (0.58;2.40) Large 98/1/1 very likely
	Monotony	1.31 (-4.44;7.05) Large 69/5/26 unclear	2.06 (-1.76;5.88) Very large 85/3/11 unclear	0.13(-0,80;1.105) Trivial 43/33/23 unclear
	Strain	0.03 (-0.83;0.89) Trivial 35/35/30 unclear	0.84 (-1.06;2.74) Moderate 76/10/14 unclear	1.52 (-2.57;5.61) Large 78/5/17 unclear
	Explosive power	6.38 (-0.60;13.35) Very large 94/1/6 unclear	2.10 (-0.99;5.18) Very large 89/3/8 unclear	-0.60 (-1.64;0.45) Small 8/11/81 unclear

Discussion

Monitoring ITL through session-RPE provides valuable and indirect information related to athlete's physiological stress. This is the first study monitoring ITL, TWTL, monotony and strain in BV athletes. The current study has observed a greater defender's ITL during the second and third mesocycles when compared to the first. Moreover, blocker has shown an ITL substantially greater in the third mesocycle when compared to the first and second.

Our findings are in agreement with those reported by Bouaziz et al.[6] who had reported an increasing in ITL from first to second mesocycle in rugby athletes, and it is possible that its magnitude might result from different objectives within each mesocycle. Commonly, the first mesocycle corresponds to a pre-season, a period of time with training sessions with strength-endurance, hypertrophy and tactical-technical characteristics[31]. The second mesocycle comprises power, aerobic capacity, and tactical-technical training[31]. Different objectives of training sessions encompass distinct relationships between volume and intensity that lead to different perceived exertions[10]. Additionally, it is known that other factors might directly affect ITL, such as travels, full competition calendar and daily life stress[5,7]. However, this research has not quantified such variables. Therefore, further research is needed in the BV scope to investigate them.

Daily ITL behaviour can differ from one modality to another, due to different physiological, environmental and players' expertise demands[10]. For instance, we can quote football, a contact sport, which alternates high intensity moments (e.g., shots, jumps, changing direction) with low and longer intensity periods (jogging or walking)[32]. BV has no contact among the players and it is characterized by its intermittent nature, fluctuating randomly from brief periods of maximal or near maximal activity to longer periods of moderate and low intensity activity[33]. Hence, each sport demands impact upon athletes' different stimuli and responses, resulting in different ITL awareness[10]. Accordingly, ITL magnitude differences among various modalities highlight the importance of monitoring training load in different sports, competitions and also among the athletes of the same modality, even though when these play distinct roles during a game or tournament[32,34,35].

CV of TWTL has been presented as an important variable promoting the positive adaptations to the training process[5,7]. In relation to TWTL magnitude through a certain period, Freitas, Miloski, Bara-Filho[35] reported that the CV of TWTL of a volleyball team, for 22 training weeks, was 16%, a result that differs from our investigation, where the CV presented 42.7 and 37.3%, blocker and defender, respectively. A possible explanation to the high variation observed in the current investigation, can be the lack of ITL monitoring in the games during the assessment period, thus leading to low TWTL values in weeks with a great number of games. Buchheit *et al.*[18] also reported a high CV (66%) in professional football players for two weeks. Blanch and Gabbett[9] sustained that meaningful oscillations in the training load during a short time period can be an injury triggering risk factor. When the training load added to the games played in a certain week (heavy load) is greater than the medium of the last four weeks (chronic load), the athlete will be more exposed to non-functional overreaching and overtraining, which can be connected to the occurrence of more severe injuries[5,9,11,36].

According to player's role (blocker vs. defender specialist), blocker's TWTL was greater (Δ=41% difference) than defender's on the third mesocycle. Concomitantly, with a large ITL on the third mesocycle, which was the period with the greatest match number (Table 1), the blocker performed more jumps than the defender during a set[1,3]. These factors together could have contributed to the larger TWTL experienced by the blocker compared to defender specialist.

Besides the internal load variables, also lower limbs EP has been assessed, throughout 10 weeks (Figure 1). Lower limb EP with countermovement is a determinant ability in BV, as this task demands repeated jumps during the game[2]. The current study presented no substantial differences in EP among the mesocycles (Table 2), suggesting that EP was not sensitive to the different training loads. Freitas, Nakamura, Miloski, Samulski, Bara-Filho[22] have obtained the same findings when conducting an intense training with professional volleyball athletes. Authors have shown that even after an increasing period in intensity, EP has not been significantly altered. Nonetheless, two investigations with futsal players[19,37] have demonstrated a noteworthy increasing of lower limb EP after training.

Monotony is related to training load oscillation in a determined time period, and some investigators suggest values over 2.0 AU, that is, low variation between the applied loads, hence, not favouring the promotion of positive adaptations[28]. The current study has found values over 2.0 AU (Table 1), which can be explained by the co-existence of the training period and the competition of the Brazilian Open Circuit of Beach Volleyball. Indeed, the third mesocycle presented the highest monotony rate, with more games (7 matches), which elicits extra training sessions with restoring characteristics. Miloski, Freitas and Filho[38] demonstrated in a study comprising futsal players, that the mesocycle with the highest number of games had been the period with more restoring sessions when compared to mesocycles with low game number. Corroborating our findings, Freitas, Nakamura, Miloski, Samulski, Bara-Filho[22] observed mean values of monotony between 1.52 and 3.15 AU in a professional volleyball players' training mesocycle.

Strain is characterized by the general stress triggered by the weekly training[28]. Among the three mesocycles under investigation, no substantial differences have been found in our investigation (Table 2). Similar values to ours have been found (Figure 3) in Crossfit[39], volleyball[22] and futsal athletes[38]. The high value of strain might be connected to the incidence of upper respiratory tract infection and injuries[28]. Notwithstanding, further research is necessary to test this connection in BV.

The current investigation has described the training load of an Olympic BV team. Important information has been found on ITL dynamics throughout a training period. However, the use of this method envisages the use of other methods to training control, as the more information is available to coaches and conditioning coaches, the more accurate the training prescription and the solving of negative adaptations will be. The present research has some limitations, lacking game and competition stress analysis, recovery rate between sessions, which can affect ITL awareness. These limitations suggest further research to monitor ITL during training and competitions, daily stress, travels and their connection with athletes' adaptive responses.

Conclusion

The internal load monitoring (session-RPE) during the training period enables better external load adjustment according to player's role (defender and blocker specialist), allowing suitable recovery periods and, consequently, performance improvement.

The current investigation presents the internal load monitoring of defender and blocker specialist and its comparison among the training period mesocycles. We could notice a substantial internal load increasing from the first to the third mesocycle, in both players. Coaches should monitor and adjust training load according to players role and their team competitive calendar, targeting performance peak during the most important competitions.

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