©Journal of Sports Science and Medicine (2014) **13**, 571-579
http://www.jssm.org

Research article

Sensitivity of Physiological and Psychological Markers to Training Load Intensification in Volleyball Players

Victor H. Freitas [1]✉, Fabio Y. Nakamura [1], Bernardo Miloski [2], Dietmar Samulski [3] and Mauricio G. Bara-Filho [4]

[1] Departamento de Educação Física, Universidade Estadual de Londrina, Londrina, Brazil; [2] Escola de Educação Física e Esporte, Universidade de São Paulo, São Paulo, Brazil; [3] Escola de Educação Física, Fisioterapia e Terapia Ocupacional da Universidade Federal de Minas Gerais – MG, Brazil; [4] Faculdade de Educação Física e Desportos, Universidade Federal de Juiz de Fora – MG, Brazil

Abstract

The aim of this study was to test the sensitivity of; performance in the countermovement vertical Jump (CMJ); the Recovery and Stress Questionnaire for Athletes (RESTQ-Sport); the Total Quality Recovery Scale (TQR) and the creatine kinase (CK) to the deliberate intensification of volleyball training loads. For this purpose 8 athletes underwent a training period (FP) of 11 days of deliberate training load (TL) intensification followed by a second period (SP) of 14 days of reduction of loads (IT group). A further 8 athletes continued training with normal TL (NT group). Both groups were tested before the FP (baseline), after the FP and after the SP. The TL evaluated using the session rating of perceived exertion method (session-RPE) was higher after the FP compared to the SP, and higher in the IT group, compared to the NT group. The CMJ did not change in either group ($p > 0.05$). In the IT group, the RESTQ-Sport was altered after the FP compared to both the baseline and the SP ($p < 0.05$), while no change was observed in the NT group. In the IT group, the CK increased and the TQR decreased after the FP compared to both the baseline and after the SP and were higher and lower, respectively, than the NT group ($p < 0.05$). The results suggest that performance in the CMJ is not a sensitive variable to the fatigue caused by intensification of training loads during a pre-competitive period in volleyball, whereas CK, TQR and RESTQ-Sport were shown to be sensitive measures.

Key words: Team sport, rating of perceived exertion, physical training, overtraining, performance.

Introduction

Volleyball is characterized as an intermittent sport, with frequent high-intensity actions, involving explosive bursts, short body displacements and numerous jumps (Sheppard et al., 2007). One of the main physical abilities required in this modality is lower limb muscle power, expressed by the numerous jumps performed during the games, which are important both for the attacking and blocking actions (Sheppard et al., 2007; 2008; 2009). Some studies have reported positive changes in the ability of performing vertical jumps during a competitive season (Hakkinen, 1993), as well as during the years of training in the transition from the junior to the senior category (Sheppard et al., 2012). Besides this, a greater ability to perform serving and blocking actions has been suggested as a discriminating factor between the more successful teams, who win championships, and the less successful ones (Sheppard et al., 2009). It is noteworthy that in modern volleyball, most players serve using jumps in order to have higher vertical amplitude in contact with the ball, thereby increasing the power of the action. Therefore, a well-planned pre-competitive period is essential to ensure that the athletes enter the competitive period with an optimal performance in this and other abilities.

Volleyball, like other team sports, presents a calendar with a short pre-competitive period and a long competitive period. Thus, during the pre-competitive period, intensification of the training load is a frequently used strategy aimed at preparing the athletes to face the demands of a long competitive period and adapt rapidly (Coutts et al., 2007a; Coutts and Reaburn, 2008). Such a strategy requires careful control of training loads, since the application of excessive loads and insufficient recovery may induce negative adaptations to training, leading the athlete to non-functional overreaching or overtraining (Borresen and Lambert, 2009; Foster et al., 2001; Kentta and Hassmen, 1998). Appropriate load control, in turn, is based on accurate quantification and frequent monitoring of performance and psychophysiological changes resulting from the balance between the stress and recovery (Borresen and Lambert, 2009; Coutts et al., 2007d; Coutts and Reaburn, 2008).

In this sense, the session rating of perceived exertion (session-RPE) method (Foster, 1998; Foster et al., 2001) is presented as a simple low cost strategy, validated to quantify the internal training load in several sports (Foster, 1998; Foster et al., 2001; Coutts and Reaburn, 2008; Coutts et al., 2007b; 2007d; Impellizzeri et al., 2004; Milanez et al., 2011), including volleyball (Bara Filho et al., 2013), and has been shown to be consistent with the manipulation of external load.

Among the numerous jumps performed in volleyball games (Sheppard et al., 2007), a substantial percentage are performed with a countermovement, implying a rapid eccentric phase leveraging the concentric phase of the jump. Thus, the countermovement vertical jump test (CMJ) is frequently used to evaluate performance in this modality (Sheppard et al., 2008; 2009; 2012). Fatigue caused by exhaustive exercises, especially those involving stretch-shortening cycle, implies a loss in neuromuscular function (Horita et al., 1999; Komi, 2000). The reduced performance in the CMJ, which is related to the magnitude of muscle damage and neuromuscular fatigue, may

Received: 22 November 2013 / Accepted: 02 April 2014 / Published (online): 01 September 2014

persist for several days (Komi, 2000; Horita et al., 1999). A study by Delextrat et al. (2012) reported a decrease in the CMJ height on the third day of a regular training week in basketball players. In rugby athletes, Coutts et al. (2007a) showed a reduction in CMJ performance after a pre-competitive period with intensified training loads. Johnston et al. (2013) also identified impaired muscular function during the performance in the CMJ in response to an intense period of rugby fixtures. Thus, the CMJ appears to be a sensitive index of the fatigue occasioned by the intensification of training load, especially in sports like volleyball, in which the stretch-shortening cycle is repeated hundreds of times a week. However, the sensitivity of CMJ to the fatigue caused by the intensification of training has not yet been tested in volleyball.

Questionnaires are also shown to be valid, simple and practical strategies for monitoring the effects of training loads (Kentta and Hassmen, 1998). Among them, the Recovery and Stress Questionnaire for Athletes (RESTQ-Sport) (Costa and Samulski, 2005; Kellmann and Kallus, 2001) is capable of simultaneously monitoring the stress and recovery in response to team sports training (Coutts and Reaburn, 2008; di Fronso et al., 2013; Noce et al., 2011), whilst also being sensitive for monitoring the effects of training loads during periods of intensification and to identify/predict overreaching (Coutts and Reaburn, 2008; Coutts et al., 2007d; Gonzalez-Boto et al., 2008; Nederhof et al., 2008). Another tool that is thought to be equally sensitive to the effects of training loads is the Total Quality Recovery Scale – TQR – (Kentta and Hassmen, 1998), used to monitor the state of the psychophysiological recovery of athletes (Brink et al., 2010; Suzuki et al., 2006).

Serum creatine kinase (CK) is a biochemical marker widely used in sports science as a diagnostic parameter for quantifying the degree of muscle damage (Brancaccio et al., 2010; Hartmann and Mester, 2000) or changes in the permeability of the muscle cell membrane (Goodman et al., 1997). Studies show a sharp rise in CK levels after prolonged high intensity exercises (Nederhof et al., 2008; Waskiewicz et al., 2012), after exercises with a large eccentric component (Snieckus et al., 2012), as well as in response to a period of intensified training (Coutts et al., 2007a; 2007b). In addition, in soccer players, an increase above the 90th percentile of CK found in the athletes' plasma, during a competition, is suggested to detect fatigue and muscle overload (Lazarim et al., 2009).

The sensitivity of the aforementioned performance, psychological and biochemical markers in monitoring the overload effects of training in athletes of various sports leads us to the hypothesis that these markers will present the same sensitivity for monitoring the effects of training load intensification during a pre-competitive period in volleyball. Nevertheless, this has not yet been investigated in previous studies and is justified based on the perceived need of coaches and trainers to monitor biological signs of excessive internal training loads. Thus, the aim of this study was to test the sensitivity of CMJ performance, RESTQ-Sport, TQR and CK to deliberate intensification of training load during the pre-competitive period on high-level volleyball players.

Methods

Experimental approach to the problem

The present study involved a mesocycle of 25 days preparation of a high-level volleyball team (adult team competing in the 1st division of Brazilian volleyball – Brazilian Men's Volleyball Super League) for a state competition, in which the team was among the 4 finalists. The beginning of the investigated period corresponded to the seventh mesocycle of the team season, with competitions at national and state level.

In order to assess the sensitivity of the markers to the intensification of training loads, a proportion of the players were submitted to deliberate intensification of training load (IT group). The training load was deliberately intensified for 11 days (first period – FP) and reduced afterwards for 14 days (second period – SP). Another group continued training with normal (i.e., habitual) training (NT group) load. This group was used as the "control". Performances in the CMJ, RESTQ-Sport, and the CK were evaluated at three different moments: on the first day of training, considered as baseline, after FP and after SP. The TQR was evaluated at the beginning and end of each microcycle.

Subjects

Sixteen male athletes belonging to a high-level Brazilian volleyball team participated in the study. The team's technical staff planned the training in order to test the effect of intensification of training loads on performance indicators. Accordingly, the coach presented a list of the eight athletes who had more potential to be starters in the championship. These athletes composed the IT group. These players were 23.37 ± 2.94 years old, 88.18 ± 5.26 kg, 1.95 ± 0.06 m with a 7.80 ± 2.13% fat percentage. A group of eight players with lower chances of being starters (non-starters) was submitted to the training that is habitually planned in the pre-competitive period of the investigated team, composing the NT group. These athletes were 19.75 ± 1.48 years old, 77.52 ± 11.51 kg, 1.88 ± 0.07 m with a 9.07 ± 2.71% fat percentage. Hence, we emphasize that this study was not a randomized controlled trial, because the randomization of players into the groups would not have been in the interests of the team, and so, it would be counterproductive to its goals. Nevertheless, we consider the experimental design adequate to describe the longitudinal effects of short-term overload in volleyball, having, as a reference, a group of players training normally.

The study was approved by the local Ethics Committee (Cep/Ufjf, notion nº 278/2010) and all participants were briefed in the test procedures before signing a consent form expressing their willingness to participate in the study. The exclusion criterion was the occurrence of a mioarticular limitation which would cause withdrawal from the training, although no athlete fulfilled this criterion during the study.

Procedures

Before starting the pre-competitive mesocycle, a microcycle with a total weekly training load of 971.16 ± 287.22

arbitrary units (AU) was applied, followed by 72 hours with no training, which is considered a light load. The training load was quantified by means of the session-RPE method (Foster, 1998; Foster et al., 2001). The training mesocycle comprised of 25 days and was divided into 4 microcycles, in which in the first 3 there were 7 days of training and in the last, 4 days. The TQR scale was applied on the first and last day of training of each microcycle (days, 1, 6, 8, 13, 15, 20, 22 and 26) before starting the training session for the day. The same mesocycle was also divided into 2 periods: FP of 11 days of training, of which 7 days belonged to the first and 4 days to the second microcycle, and SP of 14 days, of which 3 days belonged to the second, 7 days to the third and 4 days to the forth microcycle. The performance in the CMJ, the responses to RESTQ-Sport and the CK were evaluated on days 1 (baseline), 12 (after FP) and 26 (after SP), between 1:30 and 2:30 pm, before initiating the training session of the day. The training content applied to the IT and NTgroups is described in Table 1.

Quantification of training load: The training load was quantified on a daily basis by means of the session rating of perceived exertion (session-RPE) method (Foster, 1998; Foster et al., 2001). Thirty minutes after the end of each training session, the athletes answered the question: *"How was your workout?"*, demonstrating their answer on the 10 point RPE scale (Foster et al., 2001), regarding the entire training session. We calculated the product of the demonstrated values from the RPE scale and the training duration in minutes of each training session, thereby expressing the internal load of the training session (TL). On the days with 2 training sessions, the TLs were summed to quantify the daily TL (DTL). The total weekly training load (TWTL), monotony and strain were calculated after each microcycle, as well as after FP and SP. The TWTL was calculated by summing the DTLs, the monotony was calculated by means of the ratio between the average and the standard deviation of the DTL of each microcycle, and the strain was calculated by the product of the TWTL and the monotony (Foster, 1998). The athletes had been familiarized with the method for a period of 5 months prior to the beginning of this study.

Countermovement vertical jump test (CMJ): To evaluate the power of the lower limbs the countermovement vertical jump test was performed on a contact mat (*Cefise*®, Brazil). The CMJ was performed with an arm swing and starting in the upright position using the stretch-shortening cycle, flexing the knee until ~90º (Bosco, 1994). The test results were obtained using the Jump System software (*Cefise*®, Brazil). The athletes performed three jumps and the highest one was retained for analysis. The interval between jumps was 1 minute. The intraclass correlation coefficients of the CMJ tests performed at different moments were 0.95, 0.97 and 0.96, respectively. A previous warm up was oriented by the physical trainer with 3 minutes of light-intensity running and 2 minutes of unilateral jumping around the court.

Recovery and Stress Questionnaire for Athletes (RESTQ-Sport): To evaluate the stress and the recovery related to the activities in the previous 3 days and 3 nights, the Portuguese version (Costa and Samulski, 2005) of the RESTQ-Sport (Kellmann and Kallus, 2001) was used. This questionnaire is composed of 76 questions consisting of a series of statements, with responses on a Likert scale from 0 (never) to 6 (always). The questions are divided into 19 scales, of which 7 scales are related to general stress, 5 to general recovery, 3 to the stress in

Table 1. Training load description.

	IT Group				NT Group			
Micro	**Physical**	**Technical**	**Tactical**	**Matches**	**Physical**	**Technical**	**Tactical**	**Matches**
1	4 X WT (HYP); 2 X AC; 2 X CA; 2 X AG	3 X P; 5 X S; 2 X D; 2 X A; 1 X B	3 X AA; 2 X ABD; 1 X ACA	0	3 X WT (HYP); 1 X AC;	2 X P; 2 X S; 2 X D; 2 X A; 1 X B	2 X AA; 2 X ABD; 1 X ACA	0
2	4 X WT (STR); 2 X AC; 2 X CA; 2 X AG	2 X P; 5 X S; 2 X D; 2 X A; 2 X B	1 X AA; 2 X ABD; 1 X ACA; 2 X AA+CA	0	3 X WT (STR); 2 X AG	2 X P; 2 X S; 2 X D; 1 X A; 1 X B	1 X AA; 2 X ABD; 1 X ACA	0
3	2 X WT (STR/PO); 2 X PPC; 1 X CA; 1 X AG	1 X P; 3 X S; 1 X D; 2 X A; 2 X B	2 X ABD; 1 X ACA; 1 X AA+CA	2	2 X WT (STR/PO); 1 X PPC	1 X P; 3 X S; 1 X D; 2 X A; 1 X B	2 X ABD; 1 X ACA; 2 X AA+CA	2
4	2 X WT (PO)	1 X P; 3 X S; 1 X B	1 X AA; 1 X ABD; 1 X ACA; 1 X AA+CA	0	2 X WT (PO)	1 X P; 3 X S; 1 X B	1 X AA; 1 X ABD; 1 X ACA; 1 X AA+CA	0

X – sessions; WT – weight training; AC – aerobic circuit; CA – continuous aerobic training; AG - Agility; PPC – power physical circuit; P – pass; S - service; A - attack; B - block; D - defense; AA - amount of attack; ABD – amount of block/defense; ACA – Amount of counter-attack; AA+CA – amount of attack + counter-attack ; .HYP – hypertrophy; STR – strength; PO – power.

Table 2. Variables related to the training loads measured in different Groups throughout the 4 microcycles and 2 training periods. Data are means (±SD).

Microcycles	Groups	TWTL (AU)	Monotony (AU)	Strain(AU)
1	NT	2870 (807)	1.52 (.53)	4630 (2239)
	IT	4427 (409) **	1.93 (.09)	8543 (604) **
2	NT	2113 (545) ##	1.23 (.18)	2647 (933)
	IT	4138 (664) *	1.75 (.22)	7282 (1778) **
3	NT	1641 (323) #	1.08 (.10)	1790 (436) #
	IT	2319 (489) #†	1.28 (.17)	3019 (896) #†
4	NT	1435 (232) #	2.75 (.69) #†‡	4033 (1283) ‡
	IT	1764 (257) #†	3.15 (.82) #†‡	5648 (2065) #‡
Periods	**Groups**	**TWTL (AU)**	**Monotony (AU)**	**Strain (AU)**
1st Period	NT	4423 (954)	1.52 (.34)	6846 (2212)
	IT	7635 (787) **	2.50 (.14) *	19006 (1697) **
2nd Period	NT	3638 (570)	1.34 (.15)	4911 (1137)
	IT	5013 (827) §**	1.49 (.15) §	7485 (1623) §*

NT – Group with normal training load; IT - Group with intensified training load; TWTL – Total weekly training load. Significantly different for the NT Group (* p <0.05;** p < 0.01); Significantly different to microcycle 1 (# p < 0.01); significantly different for microcycle 2 (†p < 0.01); significantly different to microcycle 3(‡ p < 0.01p < 0.05); Significantly different to the 1st period (§ p < 0.01).

sport and 4 to specific recovery in sport. The sum of the stress and recovery scales was calculated, as well as the difference between them.

Total Quality Recovery Scale (TQR): To evaluate the athletes state of recovery, the TQR scale (Kentta and Hassmen, 1998), from 6 to 20 was used, presented to the athletes before the daily training session using the question: "What *is your condition now?*". The athletes had been familiarized with the instrument for 5 months prior to the beginning of the study. The pre-recovery was considered as the perception of the recovery state at the beginning of the training microcycle and the post-recovery, as the one measured at the end of each microcycle.

Creatine kinase (CK): Blood sampling was performed by a qualified and experienced professional, respecting the Brazilian biosecurity principles. One hour after their last meal, the athletes remained sitting for 30 minutes. Blood sampling was carried out in a room near the training facilities, with the athletes remaining sitting. Approximately 5 ml of blood was collected from one of the veins of the antecubital fossa of the right arm and stored in a tube (Becton, Dickinson Vacutainer®, EUA) with separating gel. The samples were stored in a thermal compartment with ice and taken to a laboratory for clinical analysis. On arrival at the laboratory, the samples were centrifuged for 15 minutes at 3500 rpm, during which the CK was analyzed immediately through the UV kinetic method by means of the CK concentration in the serum, using the automatic analyzer BS 400 (bioclin®, Brazil).

Statistical analysis

The internal consistency of the RESTQ-Sport scales was investigated by means of Cronbach's Alpha. Values equal to or higher than 0.70 were regarded as acceptable reliability. To test the difference between the descriptive variables of different groups the independent samples t-test was performed. To test the difference between the variables related to the training load, CMJ, RESTQ-Sport, TQR and CK, between the different groups and the moments analyzed, a two way repeated measures analysis of variance (ANOVA) was performed followed by Turkey's post-hoc. The assumptions of normality were evaluated using the Shapiro-Wilk test. If not parametric, logarithmic transformation of data was used (natural logarithm). All data were analyzed using the *Statistica* software (v.8.0, StatSoft®, Tulsa, Ok), considering a probability of a type I error (α) of 0.05. The data are presented as mean (± standard deviation).

Results

Despite the difference in the average age and body mass of the groups ($p < 0.05$), the average height and fat percentage were similar ($p > 0.05$). There was no difference in performance in the CMJ, CK, and RESTQ-Sport between the groups at baseline.

The variables related to training load are described in Table 2. In the NT group, TWTL was higher in microcycle 1 compared to the other microcycles ($p = 0.03$, $p < 0.01$ and $p < 0.01$, respectively). In the IT group, TWTL was higher in the first 2 microcycles compared to the last 2 ($p < 0.01$). In the first 2 microcycles, the TWTLs were higher in the IT group compared to the NT group ($p < 0.01$), but were not different between the groups in the last 2 microcycles. The monotony of training performed in microcycle 4 was higher than the monotony in all the other microcycles, both in the IT and NT groups. The NT group had higher training strain in microcycles 1 and 4 compared to microcycle 3 ($p < 0.01$ and $p = 0.04$). In the IT group, the strain was greater in the first 2 microcycles compared to microcycle 3 ($p < 0.01$), while microcycle 4 elicited a lower strain than microcycle 1 ($p < 0.01$) and a higher strain than microcycle 3 ($p < 0.01$). The IT group also presented higher strain in microcycles 1 and 2 compared with the NT group ($p < 0.01$).

In the NT group, the TWTLs in the two periods were not different ($p = 0.14$). In the IT group, the FP elicited higher TWTL than the SP ($p < 0.01$). The IT group performed greater TWTL in the 2 periods when compared with the NT group ($p < 0.01$). The IT group had higher monotony than the NT group in the FP, as well as higher monotony in the FP when compared to the SP (p <

Table 3. Creatine Kinase and countermovement vertical jump behavior between the different groups and training periods.

Variables	Groups	Baseline	Post 1st period	Post 2nd period
Creatine kinase (U/L)	NT	158.14 (56.12)	288.71 (105.05	331.33 (125.94)
	IT	185.50 (80.06)	585.87 (273.11) *#	293.13 (190.46) #
Countermovement Vertical Jump (cm)	NT	51.76 (6.61)	51.63 (5.26)	52.71 (5.51)
	IT	48.83 (3.86)	49.04 (4.98)	50.78 (3.90)

Significantly different to the NT Group (* $p < 0.05$); Significantly different to the previous measurement (# $p < 0.01$).

0.01). In the NT group, the training strain was not different between the 2 periods analyzed ($p < 0.01$). In the IT group, this variable was greater in the FP when compared to the SP ($p < 0.01$). The IT group reported greater strain than the NT group in both periods.

Performance in the CMJ did not change along the different moments and this variable was not different between the groups ($p = 0.90$) (Table 3).

The internal consistency of the RESTQ-Sport scales presented reliability scores above 0.70 across the three moments in which the questionnaire was applied, except for: the Conflicts/Pressure scales at all three moments; the Lack of Energy at baseline and post FP; Success at baseline and Injuries at post SP. In the comparisons made between the scales of the RESTQ-Sport (Table 4), the IT group reported a higher value in the Fatigue scale post FP when compared to the baseline and the moment post SP, as well as a higher value in the Injuries scale compared to the baseline. After the FP, the IT group rated a higher value in the Physical Complaints scale and a lower value in the Physical Recovery scale compared to the NT group.

In the NT group, the state of recovery of the athletes evaluated using the TQR scale was not different along the different moments analyzed. In the IT group, this variable was reduced at the end of microcycle 2 when compared to the pre-recovery of microcycles 1, 3 and 4 ($p < 0.05$), and lower when compared to the post-recovery of microcycle 3 ($p < 0.05$). This variable was lower at the end of microcycle 2 in the IT group when compared to the NT group ($p < 0.01$) (Table 5).

Table 5. Recovery state behavior between the different groups and training microcycles.

Microcycles	Recovery	NT Group	IT Group
1	Pre	**17.0 (1.2)**	**15.4 (2.1) ****
	Post	**14.0 (1.3)**	**12.5 (2.5)**
2	Pre	**16.5 (2.1)**	**14.3 (2.0)**
	Post	**16.0 (2.3)**	**11.5 (2.6) #**
3	Pre	**16.3 (1.8)**	**16.3 (1.5) †***
	Post	**17.3 (1.7)**	**14.8 (1.4) ****
4	Pre	**16.9 (1.2)**	**15.5 (2.4) ***
	Post	**16.4 (1.8)**	**14.8 (1.6)**

Significantly different to the post-recovery in microcycle 1 († $p < 0.01$); Significantly different to the post-recovery in microcycle 2 (*$p<0.01$; ** $p < 0.05$); Significantly different to the NT Group (# $p < 0.01$).

In the NT group, the CK did not change between the different moments analyzed. In the IT group, the CK was higher after the FP when compared to the baseline and after SP ($p < 0.01$). The IT group had a higher CK post FP when compared with the NT group ($p < 0.05$) (Table 3).

Table 4. Responses to the RESTQ-Sport scales between the different groups and periods analyzed (continues).

RESTQ Scales	Group	Baseline	Post 1st period	Post 2nd period
General Stress	NT	.94 (.86)	1.03 (.85)	.87 (.74)
	IT	2.25 (1.27)	1.41 (1.08)	1.59 (1.09)
Emotional Stress	NT	1.75 (1.04)	1.56 (.75)	1.43 (1.11)
	IT	2.44 (1.00)	1.69 (.90)	1.91 (.91)
Social Stress	NT	1.03 (.98)	1.25 (.94)	1.20 (1.02)
	IT	1.47 (1.04)	1.59 (1.13)	1.53 (1.10)
Conflicts/Pressure	NT	2.59 (1.03)	2.56 (1.03)	2.40 (.55)
	IT	2.91 (.94)	2.81 (.80)	3.00 (1.18)
Fatigue	NT	1.25 (.82)	2.72 (1.06)	1.89 (.77)
	IT	2.22 (1.06)	3.81 (.94) #	2.38 (1.27) †
Lack of Energy	NT	1.47 (.60)	1.72 (.84)	1.12 (.69)
	IT	2.13 (.98)	1.59 (.61)	1.81 (.97)
Physical Complaints	NT	1.59 (1.41)	1.34 (.64)	1.34 (.77)
	IT	2.53 (1.30)	3.03 (.88) *	2.56 (.75)
Success	NT	3.38 (1.04)	4.06 (.86)	4.34 (.81)
	IT	2.91 (.69)	3.09 (1.08)	3.16 (.88)
Social Recovery	NT	4.28 (1.37)	3.84 (1.01)	3.87 (.96)
	IT	3.50 (1.54)	3.13 (1.04)	3.03 (1.10)
Physical Recovery	NT	4.06 (1.22)	4.22 (.75)	4.25 (.73)
	IT	3.06 (.95)	2.50 (.83) *	3.25 (.79)
General Well-Being	NT	4.25 (1.27)	4.19 (1.11)	4.34 (1.08)
	IT	3.69 (1.47)	3.91 (.88)	4.06 (1.08)
Sleep Quality	NT	3.94 (1.21)	4.00 (1.36)	3.94 (1.02)
	IT	2.94 (1.05)	3.06 (1.40)	3.06 (.86)

Significantly different for the NT group (* $p < 0.05$). Significantly different to the baseline (# $p < 0.05$). Significantly different to the post 1st period († $p < 0.05$).

Discussion

The main findings of this study were that in the group submitted to deliberate intensification of training load, the RESTQ-Sport scales comprising Fatigue, Injuries, Physical Complaints and Physical Recovery, the TQR and the CK were altered after the intensified period and returned to baseline levels after reduction of the load. These variables did not change in the group that remained training with normal loads. On the other hand, the performance in the CMJ did not change in either of the two groups. Thus, performance in the CMJ was not a sensitive variable to the fatigue occasioned by the intensification of training loads during a pre-competitive period in volleyball, unlike the other variables which were sensitive, thereby partially confirming the hypothesis of the study.

The results of the internal training load, quantified by the session-RPE method, show that the additional external training load (Table 1) had repercussions in the IT group, especially in the first period of the mesocycle. This load was higher in the IT group than in the NT group. The scarcity of studies which quantify the intensification of the training load in volleyball using the session-RPE method as in this study limits the comparison of the reported values. However, magnitudes of training loads have been determined in other sports, showing a similarity with the values observed in this study. In studies with triathletes, the loads presented when the training was intensified were ~4500 AU (Coutts et al., 2007d), ~5000 AU (Coutts et al., 2007c), and ~3100 AU in studies with rugby athletes (Coutts et al., 2007a; 2007b). In the present study, the corresponding load was ~4200 AU. Also in studies with triathletes, when the training loads were reduced, the magnitudes were ~2000 AU (Coutts et al., 2007c; 2007d) and ~1500 AU in studies with rugby athletes (Coutts et al., 2007a; 2007b). In the present study, the volleyball players accumulated ~1500 AU. Lastly, the values of training load presented by the group of triathletes that remained training with normal training loads were ~1500 AU (Coutts et al., 2007c; 2007d), and ~2000 AU in rugby athletes (Coutts et al., 2007b), values that approximate the average of volleyball players in this study.

Performance in the CMJ did not change over the 25 days of training in either of the 2 groups analyzed in this study. A decline in performance was expected due to the high number of eccentric actions and contractions involved in the stretch-shortening cycle accomplished through several jumps and other skills executed during the volleyball training, mainly in periods of intensification. Such actions are expected to cause decline in muscle function in the days following the exercise, with a decrease in muscle power as a consequence of the damage and muscle inflammatory processes taking place after the eccentrically-biased exercise (Chen and Hsieh, 2001; Horita et al., 1999; Johnston et al., 2013; Skurvydas et al., 2011). However, the performance results of this study do not corroborate with those of other studies (Coutts et al., 2007a; Delextrat et al., 2012; Johnston et al., 2013; McLellan et al., 2011), even with the possible muscle damage, as suggested by the increased blood levels of CK. Delextrat et al. (2012) reported a decrease in the CMJ in the third day of a habitual training week in basketball players. McLellan et al. (2011) also suggested a decrease in the performance in CMJ up to 24 hours after a rugby match. Finally, Jonhston et al. (2012) identified an impaired muscular function in CMJ, with special reference to the peak power of the jump in response to an intensified period of rugby fixtures. A reduction in CMJ performance has also been shown after a pre-competitive period with intense training in rugby athletes (Coutts et al., 2007a).

A plausible explanation for the lack of CMJ performance sensitivity to the fatigue occasioned by the intensification of training load in this study is a possible resistance to muscle damage effects induced by volleyball training (Chen et al., 2012; Skurvydas et al., 2011). As shown in tables 1 and 2, the intensification of load in the first period of training in the IT group was induced by larger training volume, but without altering the intensity of training drills performed by the athletes. Accordingly, even with the increased blood levels of CK, the change in the neuromuscular system responsible for CMJ, resulting from the thousands of jumps carried out during the season, may not have been large enough to lead to loss of muscular function. Coutts et al. (2007b) also did not find any change in vertical jump performance after a period of training load intensification in rugby athletes, even with increased CK levels. Thus, our results discourage the use of CMJ to evaluate the temporary negative effects (fatigue and/or damage) caused by the intensification of training load in volleyball, a fact which has not been demonstrated in prior studies.

The psychometric tools, RESTQ-Sport and TQR, which are considered valid simple and practical strategies for monitoring the effects of training loads (Coutts and Reaburn, 2008; Kentta and Hassmen, 1998), were also sensitive to identifying changes in stress and recovery after the intensification of load in this study. The same sensitivity for monitoring the effect of intensification of loads in this study presented by the Fatigue, Injuries, Physical Complaints and Physical Recovery scales has been demonstrated in other studies on other sports (Coutts and Reaburn, 2008; Coutts et al., 2007d; Gonzalez-Boto et al., 2008). After a period of training with an intensified load, rugby athletes presented a decrease in the Physical Recovery scale and an increase in the Fatigue scale (Coutts and Reaburn, 2008), but no change in the Physical Complaints or Injuries scales. In addition, the triathletes who were similarly submitted to overloading showed changes in the Injuries, Physical Recovery and Physical Complaints scales (Coutts et al., 2007d). In swimmers, the Physical Recovery scale decreased and the Injuries scale increased after a period of increased training volume (Gonzalez-Boto et al., 2008). The result found in these studies (Coutts and Reaburn, 2008; Coutts et al., 2007d; Gonzalez-Boto et al., 2008), besides reinforcing the results found in this study, with volleyball athletes, may suggest a higher sensitivity of these scales to monitoring the effects of increased training load. This inference is consistent as we anecdotally believe that symptoms of fatigue, worsened physical recovery, as well as a higher incidence of injuries and physical complaints, are related to excessive training loads. On the other hand, the sum of the stress scales, recovery scales and the difference between the sum of the scales of stress and recovery, which have been effective for monitoring the stress, recovery and stress balance and recovery after intensified training load in other studies (Gonzalez-Boto et al., 2008; Coutts et al., 2007d), were not sensitive in our sample. This may be explained by the small number of scales that significantly changed during the training in this study, along with their respective magnitude of changes, which in other studies (Gonzalez-Boto et al., 2008; Coutts et al., 2007d) were more pronounced.

The worsening state of recovery of the athletes submitted to the intensification of training load is evidenced in the results found in the TQR scale. Besides a worsened state of recovery presented by the IT group after the intensification of training load, it is important to note that the average values found in the TQR scale were under 13 (reasonable recovery) at the end of the 2 microcycles with intensified load; this value is considered the minimum desirable level of recovery by the athletes (Kentta and Hassmen, 1998). Furthermore, in microcycles where the training loads were reduced, the values found in the scale returned to baseline levels and did not differ to those of the NT group. There are few studies that have used the TQR for monitoring a period of intensification of training load, making it difficult to compare the results of this study. However, we can verify that the moment of lowest recovery presented by the IT group is related to the period of higher levels of CK and lower values in the RESTQ-Sport Physical Recovery scale.

Higher blood levels of CK were noted after the period in which the training load was intensified in the IT group, demonstrating greater muscle damage (Brink et al., 2010; Hartmann and Mester, 2000; Johnston et al., 2013) and/or increased membrane permeability (Goodman et al., 1997). This result may be a consequence of the high number of jumps and other skills performed during this period of training, which involved many eccentric actions and contractions with the stretch-shortening cycle. High levels of CK are noted after exercises with eccentric contractions (Skurvydas et al., 2011; Snieckus et al., 2012), after an intense period of volleyball competitions (Cordova et al., 2004) as well as after a period of intense training (Coutts et al., 2007a; 2007b). The levels of CK presented in this study, however, were fair, below the ~1350U/L observed after a period of intense training in rugby athletes that presented an accumulated weekly load of ~ 3200 AU. However, we must highlight the nature of rugby as a contact sport predisposing the athletes of this modality to more severe muscle damage than in volleyball. However, the CK levels presented after a period of intense volleyball competitions (Cordova et al., 2004), ~560U/L, are consistent with the values reported in this study. Again, we should be alert to the possibility of resistance to muscle injury induced by the exercise (Chen et al., 2012; Skurvydas et al., 2011), presented by the athletes of this study, that may have dampened the increase in CK blood levels. The group that trained with normal training loads did not present changes in blood CK levels. In fact, the blood levels for this variable after the period of intense training load increased and this increase may be associated with the cumulative nature presented by CK when there are consecutive days of training with high loads (Totsuka et al., 2002). Thus, this variable reflected the muscular stress caused by the intensification of training load.

Monitoring the effect of training loads using subjective methods has some limitations, mainly because it requires honest responses and a thorough understanding of the instrument by the athletes. However, the reliability presented by the RESTQ-Sport scales in this study qualifies it as a reliable questionnaire. Furthermore, prior studies have qualified these tools as reliable and practical for such monitoring (Coutts and Reaburn, 2008; di Fronso et al., 2013; Foster, 1998; Suzuki et al., 2006).

Conclusion

In conclusion, the RESTQ-Sport scales of Fatigue, Injuries, Physical Complaints and Physical Recovery, the TQR scale and the CK were sensitive to deliberate intensification of training loads during the pre-competitive period in volleyball athletes, a fact which was not demonstrated by CMJ performance. Volleyball coaches and physical trainers can use the RESTQ-Sport and TQR to monitor and control stress and recovery of athletes submitted to a period of intensification of training load in this sport as simple and easily applied strategies. The evaluation of CK complements this monitoring by generating information on muscle damage and loss of this marker in the plasma. However, the results of this study show that CMJ performance should not be used to evaluate the negative adaptations to training in this sport, necessitating investigations on the use of other tests for this evaluation. Thus, the sensitivity demonstrated by the aforementioned markers to the fatigue caused by the intensification of training load may assist coaches in the control of training load, enabling them not merely to be intuitive but quantitative.

References

Bara Filho, M.G., Andrade, F.C.D., Nogueira, R.A. and Nakamura, F. Y. (2013) Comparison of different methods of internal load control in volleyball players. *Brazilian Journal of Sports Medicine* **19,** 143-146.

Borresen, J. and Lambert, M.I. (2009) The quantification of training load, the training response and the effect on performance. *Sports Medicine* **39,** 779-795.

Bosco, C. (1994) *Strength Assessment with the Bosco's Test.* Barcelona, Paidotribo.

Brancaccio, P., Lippi, G. and Maffulli, N. (2010) Biochemical markers of muscular damage. *Clinical Chemistry Laboratory Medicine* **48,** 757-767.

Brink, M.S., Nederhof, E., Visscher, C., Schmikli, S.L. and Lemmink, K.A. (2010) Monitoring load, recovery, and performance in young elite soccer players. *Journal of Strength and Conditioning Research* **24,** 597-603.

Chen, H.L., Nosaka, K. and Chen, T.C. (2012) Muscle damage protection by low-intensity eccentric contractions remains for 2 weeks but not 3 weeks. *European Journal of Applied Physiology* **112,** 555-565.

Chen, T.C. and Hsieh, S.S. (2001) Effects of a 7-day eccentric training period on muscle damage and inflammation. *Medicine & Science in Sports & Exercise* **33,** 1732-1738.

Cordova, A., Martin, J.F., Reyes, E. and Alvarez-Mon, M. (2004) Protection against muscle damage in competitive sports players: the effect of the immunomodulator AM3. *Journal of Sports Sciences* **22,** 827-833.

Costa, L.O.P. and Samulski, D.M. (2005) Validation Process of The Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) in Portuguese. *Brazilian Journal of Science and Movement* **13,** 79-86.

Coutts, A., Reaburn, P., Piva, T.J. and Murphy, A. (2007a) Changes in selected biochemical, muscular strength, power, and endurance measures during deliberate overreaching and tapering in rugby league players. *International Journal of Sports Medicine* **28,** 116-124.

Coutts, A.J. and Reaburn, P. (2008) Monitoring changes in rugby league players' perceived stress and recovery during intensified training. *Perceptual & Motor Skills* **106,** 904-916.

Coutts, A.J., Reaburn, P., Piva, T.J. and Rowsell, G.J. (2007b) Monitoring for overreaching in rugby league players. *European Journal of Applied Physiology* **99,** 313-324.

Coutts, A.J., Slattery, K.M. and Wallace, L.K. (2007c) Practical tests for monitoring performance, fatigue and recovery in triathletes. *Journal of Science and Medicine in Sport* **10,** 372-381.

Coutts, A.J., Wallace, L.K. and Slattery, K.M. (2007d) Monitoring changes in performance, physiology, biochemistry, and psychology during overreaching and recovery in triathletes. *International Journal of Sports Medicine* **28,** 125-134.

Delextrat, A., Trochym, E. and Calleja-Gonzalez, J. (2012) Effect of a typical in-season week on strength jump and sprint performances in national-level female basketball players. *The Journal of Sports Medicine and Physical Fitness* **52,** 128-136.

di Fronso S., Nakamura F.Y., Bortoli L., Robazza C. and Bertollo M. (2013) Stress and recovery balance in amateur basketball players: differences by gender and preparation phase. *International Journal of Sports Physiology and Performance* **8,** 618-622.

Foster, C. (1998) Monitoring training in athletes with reference to overtraining syndrome. *Medicine & Science in Sports & Exercise* **30,** 1164-1168.

Foster, C., Florhaug, J.A., Franklin, J., Gottschall, L., Hrovatin, L.A., Parker, S., Doleshal, P. and Dodge, C. (2001) A new approach to monitoring exercise training. *Journal of Strength and Conditioning Research* **15,** 109-115.

Gonzalez-Boto, R., Salguero, A., Tuero, C., Gonzalez-Gallego, J. and Marquez, S. (2008) Monitoring the effects of training load changes on stress and recovery in swimmers. *Journal of Physiology and Biochemistry* **64,** 19-26.

Goodman, C., Henry, G., Dawson, B., Gillam, I., Beilby, J., Ching, S., Fabian, V., Dasig, D., Kakulas, B. and Morling, P. (1997) Biochemical and ultrastructural indices of muscle damage after a twenty-one kilometre run. *Australian Journal of Science and Medicine in Sport* **29,** 95-98.

Hakkinen, K. (1993) Changes in physical fitness profile in female volleyball players during the competitive season. *The Journal of Sports Medicine and Physical Fitness* **33,** 223-232.

Hartmann, U. and Mester, J. (2000) Training and overtraining markers in selected sport events. *Medicine & Science in Sports & Exercise* **32,** 209-15.

Horita, T., Komi, P.V., Nicol, C. and Kyrolainen, H. (1999) Effect of exhausting stretch-shortening cycle exercise on the time course of mechanical behaviour in the drop jump: possible role of muscle damage. *European Journal of Applied Physiology and Occupational Physiology* **79,** 160-167.

Impellizzeri, F.M., Rampinini, E., Coutts, A. J., Sassi, A. and Marcora, S.M. (2004) Use of RPE-based training load in soccer. *Medicine & Science in Sports & Exercise* **36,** 1042-1047.

Johnston, R.D., Gibson, N.V., Twist, C., Gabbett, T.J., Macnay, S.A. and Macfarlane, N.G. (2013) Physiological responses to an intensified period of rugby league competition. *Journal of Strength and Conditioning Research* **27(3),** 643-654.

Kellmann, M. and Kallus, K.W. (2001) *Recovery Stress Questionnaire for Athletes; User manual,* Champaingn, Human Kinetics.

Kentta, G. and Hassmen, P. (1998) Overtraining and recovery. A conceptual model. *Sports Medicine* **26,** 1-16.

Komi, P. V. (2000) Stretch-shortening cycle: a powerful model to study normal and fatigued muscle. *Journal of Biomechanics,* 33**,** 1197-206.

Lazarim, F.L., Antunes-Neto, J.M., Da Silva, F.O., Nunes, L.A., Bassini-Cameron, A., Cameron, L.C., Alves, A.A., Brenzikofer, R. and De Macedo, D.V. (2009) The upper values of plasma creatine kinase of professional soccer players during the Brazilian National Championship. *Journal of Science and Medicine in Sport* **12,** 85-90.

Mclellan, C.P., Lovell, D.I. and Gass, G.C. (2011) Markers of postmatch fatigue in professional Rugby League players. *Journal of Strength and Conditioning Research* **25,** 1030-1039.

Milanez, V.F., Pedro, R.E., Moreira, A., Bonfim, M.R., Salle Neto, F. and Nakamura, F.Y. (2011) The role of aerobic fitness on session-rating of perceived exertion in futsal players. *International Journal of Sports Physiology and Performance* **6,** 358-366.

Nederhof, E., Zwerver, J., Brink, M., Meeusen, R. and Lemmink, K. (2008) Different diagnostic tools in nonfunctional overreaching. *International Journal of Sports Medicine* **29,** 590-597.

Noce, F., Costa, V.T., Simim, M.A.M., Castro, H.O., Samulski, D.M. and Mello, M.T. (2011) Analysis of Overtraining Symptoms during Training and Rehabilitation Periods: A Case Study of Women's Volleyball Super League Team 2003/2004. *Brazilian Journal of Sports Medicine* **17,** 397-400.

Sheppard, J.M., Cronin, J.B., Gabbett, T.J., Mcguigan, M.R., Etxebarria, N. and Newton, R.U. (2008) Relative importance of strength, power, and anthropometric measures to jump performance of elite volleyball players. *Journal of Strength and Conditioning Research* **22,** 758-65.

Sheppard, J. M., Gabbett, T., Taylor, K.L., Dorman, J., Lebedew, A.J. and Borgeaud, R. (2007) Development of a repeated-effort test for elite men's volleyball. *International Journal of Sports Physiology and Performance* **2,** 292-304.

Sheppard, J.M., Gabbett, T.J. and Stanganelli, L.C. (2009) An analysis of playing positions in elite men's volleyball: considerations for competition demands and physiologic characteristics. *Journal of Strength and Conditioning Research* **23,** 1858-1866.

Sheppard, J.M., Nolan, E. and Newton, R.U. (2012) Changes in strength and power qualities over two years in volleyball players transitioning from junior to senior national team. *Journal of Strength and Conditioning Research* **26,** 152-157.

Skurvydas, A., Brazaitis, M., Venckunas, T., Kamandulis, S., Stanislovaitis, A. and Zuoza, A. (2011) The effect of sports specialization on musculus quadriceps function after exercise-induced muscle damage. *Applied Physiology Nutrition and Metabolism* **36,** 873-880.

Snieckus, A., Kamandulis, S., Venckunas, T., Brazaitis, M., Volungevicius, G. and Skurvydas, A. (2012) Concentrically trained cyclists are not more susceptible to eccentric exercise-induced muscle damage than are stretch-shortening exercise-trained runners. *European Journal of Applied Physiology* **113(3),** 621-628.

Suzuki, S., Sato, T., Maeda, A. and Takahashi, Y. (2006) Program design based on a mathematical model using rating of perceived exertion for an elite Japanese sprinter: a case study. *Journal of Strength and Conditioning Research* **20,** 36-42.

Totsuka, M., Nakaji, S., Suzuki, K., Sugawara, K. and Sato, K. (2002) Break point of serum creatine kinase release after endurance exercise. *Journal of Applied Physiology* **93,** 1280-1286.

Waskiewicz, Z., Klapcinska, B., Sadowska-Krepa, E., Czuba, M., Kempa, K., Kimsa, E. and Gerasimuk, D. (2012) Acute metabolic responses to a 24-h ultra-marathon race in male amateur runners. *European Journal of Applied Physiology* **112,** 1679-1688.

Key points

- The RESTQ-Sport and the TQR scales were sensitive to deliberate intensification of training loads during the pre-competitive period in volleyball athletes;
- The CK can be used to complement this monitoring;
- The CMJ performance was not sensitive to deliberate intensification of training loads in volleyball athletes.

AUTHORS BIOGRAPHY

Victor Hugo de FREITAS
Employment
Associate Post-Graduate Program in Physical Education UEM/UEL, State University of Londrina, Brazil.
Degree
PhD student
Research interest
Physiological adaptations to training
E-mail: Victorfre@ig.com.br

Fabio Yuzo NAKAMURA
Employment
Associate Post-Graduate Program in Physical Education UEM/UEL, State University of Londrina, Brazil.
Degree
PhD
Research interest
Physiological adaptations to training
E-mail:
fabioy_nakamura@yahoo.com.br

Bernardo MILOSKI
Employment
Post-Graduate Program in Physical Education USP, State University of São Paulo, Brazil.
Degree
PhD student
Research interest
Sport Science, Exercise physiology
E-mail: bernardomiloski@yahoo.com.br

Maurício Gattás BARA-FILHO
Employment
Physical Education Faculty (Post-Graduate Program) UFJF, Federal University of Juiz de Fora, Brazil.
Degree
PhD
Research interest
Sport Science, Training load control, Volleyball
E-mail: Mgbara@terra.com.br

✉ **Victor H. Freitas**
Rua Ibitiguaia 690, Santa Luzia, CEP 36031-000, Juiz de Fora–MG, Brazil