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Do differences between the training load perceived by elite beach volleyball players and that planned by coaches affect neuromuscular function?

¿Las diferencias entre la carga de entrenamiento percibida por los jugadores de voleibol de playa de élite y la planificada por los entrenadores afectan la función neuromuscular?

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Summary. This study aimed to verify the differences between the training load planned by coaches and that perceived by Beach Volleyball (BV) players and observe the effects on athletes' neuromuscular function. Three female BV players and well-known coaches participated in the research and were accompanied for three training
weeks in the preseason phase. Rating of perceived exertion (RPE) was collected through the 0-10 scale during a previous training session. Strength, physical fitness and tactical-technical training have been assessed with coaches and athletes' responses 30 minutes after the end of the session. RPE Session was calculated by the product between the training duration in minutes and RPE, to estimate Internal Training Load (ITL). Neuromuscular function was assessed through Countermovement Jump (CMJ). To verify differences between coaches and athletes' responses and vertical jump performance were used either the magnitude of differences and clinical inference. Athletes experienced lower RPE and ITL as planned by coaches in the first week of training. CMJ increased substantially from the first to the third week (with likely differences (93/03/04), standardized difference = 1.60 and 90% confidence intervals = 0.00; 3.21). We suggest that training load planned by coaches similar to that perceived by athletes have a concomitant improvement with neuromuscular performance.
Keywords: Internal Load, Sports Science, Performance, Perceived effort, Trainer.

Resumen. Este estudio tuvo como objetivo verificar las diferencias entre la carga de entrenamiento planificada por los entrenadores y la percibida por los jugadores de voleibol de playa (VP) y observar los efectos sobre la función neuromuscular de los atletas. Tres jugadoras de VP y entrenadores conocidos participaron en la investigación y fueron acompañadas durante tres semanas de entrenamiento en la fase de pretemporada. El valor nominal del esfuerzo percibido (NEP) se recolectó a través de la escala 0-10 durante una sesión de entrenamiento anterior. La fuerza, la forma física y el entrenamiento táctico-técnico se evaluaron con las respuestas de los entrenadores y atletas 30 minutos después del final de la sesión. El producto calculó la sesión de NEP entre la duración del entrenamiento en minutos y el NEP, para estimar la carga interna de entrenamiento (CIE). La función neuromuscular se evaluó mediante salto contramovimiento (SCM). Para verificar las diferencias entre los entrenadores y las respuestas de los atletas y el rendimiento del salto vertical, se utilizó la magnitud de las diferencias y la inferencia clínica. Los atletas experimentaron menos NEP e CIE que fueron planificados por los entrenadores en la primera semana de entrenamiento. SCM aumentó sustancialmente de la primera a la tercera semana (con diferencias probables (93/03/04), diferencia estandarizada = 1.60 e intervalos de confianza del 90% = 0.00; 3.21). Sugerimos que la carga de entrenamiento planificada por entrenadores similar a la percibida por los atletas tenga una mejora concomitante con el rendimiento neuromuscular.
Palabras clave: Carga interna, Ciencias del deporte, Rendimiento, Esfuerzo percibido, Entrenador.

Introduction

The improvement and maintenance of fitness is important to prepare athletes for the demands of competition (Franco Lima, Palao, Castro, & Clemente, 2019; McLaren et al., 2018a). In BV, athletes experience high efforts and short recovery periods during the match (Medeiros, Marcelino, Mesquita, & Palao, 2014). Further, the game comprises a lot of jumps (i.e. serve, block, attack), sprints with change of direction and digs (Natali, Ferioli, A, & Bonato, 2017). Hence, coaches need to plan training sessions and think about game demands (Doeven, Brink, Frencken, & Lemmink, 2017). Coaches must manage the variables of volume and intensity during all season to improve performance (Campbell, Bove, Ward, Vargas, & Dolan, 2017) and to adequate recovery, monitoring athlete's dose-response to training (Lima, Silva, Afonso, Castro, & Clemente, 2020).

A recent study has evidenced the importance of monitoring training load in various modalities (McLaren et al., 2018b). Training load can be described as external and/or internal, depending on whether we are referring to outcomes that occur internally or externally to the athlete (Bourdon et al., 2017). To measure external load we used duration session, accelerometer, GPS, jumps and several variables. Variables such as heart hate, blood lactate and RPE were used to quantify internal load (Cardinale & Varley, 2017). Due to cost-effectiveness, non-invasive measure and practicability, RPE and session RPE (sRPE - duration of session x RPE) is utilized in various modalities (Haddad, Stylianides, Djaoui, Dellal, & Chamari, 2017). In a recent study, sRPE was sensible to identify modulations in load during different mesocycles in BV athletes (Kassiano et al., 2018). Furthermore, sRPE and RPE can bring information about the relationship between training load, fitness and well-being, besides enabling the analysis of derived variables, such as monotony and strain, which contribute to maladaptive responses to training (Foster, Rodriguez-Marroyo, & Koning, 2017). The quantification and monitoring of training load is thus an important aspect of athlete management and has the potential to provide coaches with decisions for an objective structure based on evidence (McLaren, Smith, Spears, & Weston, 2017).

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However, despite the benefits in using these tools in monitoring load, some authors have reported an incompatibility between the training load planned by coaches and that perceived by athletes (Foster et al., 2001). Previous studies have found a mismatch between training loads planned by coaches and those perceived by athletes (Andrade Nogueira et al., 2015; Brink, Frencken, Jordet, & Lemmink, 2014; Redkva, Gregorio da Silva, Paes, & Dos-Santos, 2016). In fact, these findings indicate that training sessions planned by the coaches as easy are perceived as hard by the athletes; or, sessions designed to be hard are perceived as easy or moderate (Brink & Frencken, 2018). Investigations performed in individual sports, as tennis (Murphy, Duffield, Kellett, & Reid, 2014), athletics (Cruz et al., 2017), cross-country (Barnes, 2017) have also showed a mismatch in RPE planned by coaches and perceived by athletes, despite the greater ease of individual monitoring of athletes when compared to collective modalities.

Information is scarce on factors that explain the mismatch between intended and perceived exertion and how it affects athletes' neuromuscular function (Brink & Frencken, 2018). Since disagreements are associated with performance worsening (Foster et al., 2001), establish a level of agreement between coaches' RPE , i.e. planned training and athletes' RPE, i.e. training response may favor the increase of fitness and minimize deleterious conditions (Campbell et al., 2017; Kellmann et al., 2018; Murphy et al., 2014). Finally, to the best of our knowledge, this is the first article to either 1) investigate the mismatch in planned RPE and that perceived by BV athletes; and 2) verify the influence of these disagreements on neuromuscular performance. Therefore, the aim of the study is to verify if there are differences between intended and perceived load in BV and observe if they affect athletes' neuromuscular function.

Material and Method

Subjects

Three elite female BV players (age: 23.2 ± 2.2 years; body mass: 79.0 ± 6.0 kg; height: 1.8 ± 0.1 m; body fat: 16.5 ± 1.6 %) participated in the study. All athletes participated in the Brazilian Beach Volleyball Open Circuit and World Championships 2017/2018. In addition, athletes were in the top ten of the National ranking (2019/2020) and two of these athletes will participate in the Olympic Games 2021. Coaches of tactical-technical and physical fitness had more than 15 years of professional coaching experience and 150 titles in their careers in the Brazilian Beach Volleyball Open Circuit and World Championships. Athletes and coaches worked together for 5.0 ± 2.0 years.

Athletes trained two or three days a week with one or two daily sessions. When performing two daily sessions, both were separated by 4,9 ± 0,4 hours. One coach was responsible to plan strength and physical training and these sessions were conducted in the morning with both coaches always present. The other coach was responsible by the tactical-technical training that was performed in the afternoon (Table 1). All sessions started with a specific 15 min warm-up and after the training. Strength training consisted of full - body exercises to develop strength, power, muscle strengthening, and exercises were interspersed with one- or two-min recovery. Physical training comprised repeated sprint and plyometric exercises with two to five min interval. Players performed specific exercises in blocks during the tactical-technical sessions, with intervals between two or five min.

This is an initial study and data were collected for three weeks in the pre-season of the Brazilian Beach Volleyball Open Circuit 2018. Athletes and coaches signed a consent form after being informed of the possible risks and benefits of the study. All procedures were previously approved by the Ethics Committee of the Federal University of Ceará/ PROPESQ (n° 2.435.889) and were conducted meeting the international norms for human experiments (Declaration of Helsinki, 1975).

Table 1.
Description of the different training sessions.

Physical training	Tactical-technical training	Strength training
~15' warm up	~15' warm up	~15' warm up
30' – 70' specific work	40' – 120' specific work	30' – 90' specific work
Content:		
Sprint training and plyometric	-Exercises with ball (serve, reception, set, attack, block and defense) and agility; - Specific work to develop game strategies, tactical systems and collective.	Strength and resistance training session; and/or aerobic training.

Procedures

Researchers followed all training, physical, tactical-technical aspects and strength for three weeks in the pre-season. Prior to each training session the tactical-technical or strength and conditioning coach rated RPE in accordance with the objective of the session and it was registered by researchers, using the 0-10 Borg scale (Foster et al., 2001). Researchers did not interfere in all training plan. Coaches and athletes familiarized themselves with the Borg scale to understand RPE use and CMJ assessment for two weeks before starting the study. Before starting the training session, athletes performed a specific 15-min warm-up and then started six CMJ attempts to assess neuromuscular function. After these evaluations, athletes started the specific training. Athletes answered verbally the question «How was your training?» about their perception of effort with the RPE scale, 30 min after the end of the session.

Countermovement jump test

All jump performance was performed on Mondays, in the morning, before physical fitness and strength training. To assess neuromuscular function, we utilized countermovement jump (CMJ) test and adopted a six jump average, with 60 s rest between each repetition (Claudino et al., 2017). Participants were instructed to start the jump in the standing position and perform the jump in full extension of the knee and hip and freely determine the amplitude of the countermovement to avoid changes in jumping coordination (Nakamura et al., 2016). Athletes utilized arm swing to execute all jumps, to approximate the execution to the movement performed in the modality. The CMJ was evaluated on a contact platform (Chronojump, Barcelona, Spain).

RPE and internal load

Coaches reported the intended RPE before starting the training with the Borg scale (Foster et al., 2001). Athletes were asked the RPE and it has been obtained with the same scale 30 min after the final of the session. Data was collected

individually by given verbal description to avoid interference from coach and other athletes. Internal load was quantified through the session-RPE (Foster et al., 2017). Method of the session-RPE was calculated, multiplying the duration of training session (in minutes) by the intensity value indicated by coach and athlete's RPE. This method has also been adopted due to its easy external application and association between training load and performance (Foster et al., 2017).

Statistical analyses

Data was reported as mean, standard deviation and percent delta. Comparisons between coach and athlete's RPE and ITL and CMJ of weeks were performed through standardized mean differences (SMD) and their respective confidence intervals (CI). The quantitative possibility of practical effect of finding differences between coach and athlete's RPE and ITL and CMJ of weeks was evaluated qualitatively as: <1%, it almost certainly is not; 1-5%, very unlikely; 5-25%, improbable; 25-75%, possible; 75-95%, likely; 95-99%, most likely; > 99%, almost certainly. If the best and the smallest results were> 5%, one possibility of a difference was classified as unclear (Hopkins, Marshall, Batterham, & Hanin, 2009). In addition, the effect size of the differences was used according to the scale: 0-0.2 (trivial),> 0.2 (small),> 0.6 (moderate),> 1.2 (large),> 2, 0 (very large).

Results

Table 2 presents coach and athlete's RPE results, ITL and CMJ for 3 weeks. Coach and athlete's RPE differences decreased during the weeks of training («% Coach x Athlete: first week = 6%; second week = 4% and third week = 2%). CMJ has had a 7% («%) increase in height in the first and third weeks.

Table 2
Descriptive values of coach and athlete's RPE, ITL and CMJ.

Variables	1st week	2nd week	3rd week
RPE coaches (AU)	6.7 ± 1.0	5.0 ± 0.8	5.3 ± 1.1
RPE athletes (AU)	5.6 ± 1.2	5.1 ± 1.4	5.2 ± 1.6
Physical fitness (min)	64.0 ± 4.2	56.5 ± 3.8	55.8 ± 12.4
Strength (min)	63.6 ± 5.0	70.2 ± 16.6	73.5 ± 7.4
Tactical-technical (min)	108.7 ± 19.5	94.1 ± 20.3	98.4 ± 26.5
ITL coaches (AU)	564.4 ± 202.9	363.8 ± 85.6	411.9 ± 97.0
ITL athletes (AU)	485.1 ± 210.3	381.6 ± 113.6	416.7 ± 186.5
CMJ (cm)	40.1 ± 1.2	40.6 ± 3.6	43.1 ± 2.4

RPE = rating perceived exertion, AU = arbitrary units, ITL = internal training load, CMJ = countermovement jump.

Figure 1 presents comparisons between coach and athlete's RPE in tactical-technical training, strength and physical fitness. Strength and physical fitness training showed likely differences between coach and athlete's RPE [Strength: SMD = 0.43 (-0.04; 0.90); 80/19/02; Physical fitness: SMD = 0.40 (-0.04; 0.84); 78/21/01] during the training weeks.

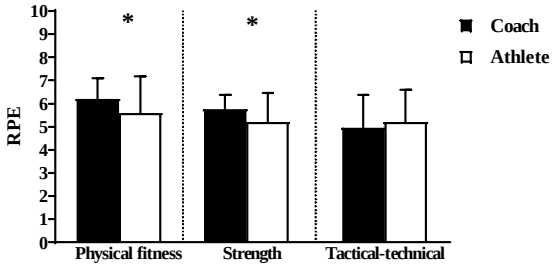

Figure 1. Comparisons between coach and athlete's RPE in physical, strength and tactical-technical training. *Likely differences in strength training (80/19/02) and physical fitness (78/21/01).

Figure 2 shows the internal load in the types of training planned by coaches and perceived by athletes. Strength and conditioning coach prescribed a greater internal load compared with that perceived by athletes [SMD = 0.33 (-0.20; 0.85); 66/29/05]. On the other hand, in the physical fitness training athletes perceived more internal load than that intended by the coach [SMD = 0.34 (-0.10; 0.77); 70/28/02].

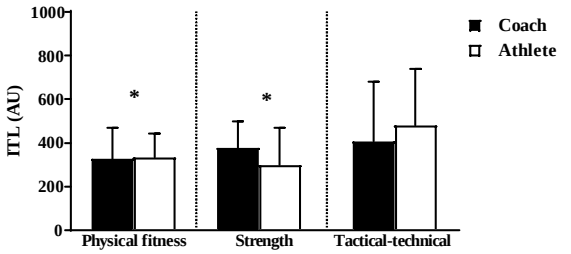

Figure 2. Comparisons between internal load in physical, strength and tactical-technical training, applied by coach and perceived by athletes. *Probable differences in strength training (66/29/05) and physical fitness (70/28/02).

Figure 3 illustrates the substantial weekly differences of coach and athlete's CMJ and RPE. CMJ demonstrated a substantial increase in the third week [SMD = 1.60 (0.00; 3.21); 93/03/04]. Substantial differences between coach and athlete's RPE were observed in the first week [SMD = -1.29 (-1.99; -0.58); 00/01/99].

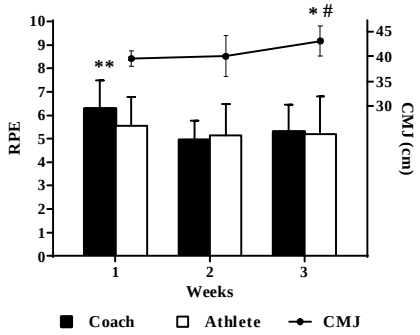

Figure 3. Comparisons between coaches and athletes' weekly RPE average and athletes' CMJ during training weeks. * Likely differences between CMJ of the first and third weeks (93/03/04). # CMJ likely differences between second and third weeks (84/12/04). ** Likely differences between PSE-coach and PSE-athlete in the first week (99/01/00).

Discussion

The objectives of the present investigation were :1) to test whether there were differences in the training load planned by the coaches vs that perceived by elite VB athletes; and 2) verify whether such differences have affected neuromuscular performance. To our knowledge, this is the first study whose aim was to verify the relationship between RPE of coach and athlete in BV. Furthermore, it has observed the differences in the agreement of the RPE and neuromuscular performance during pre-season. Its main finding is the improvement in the CMJ performance jointly with the greater similarity in the RPE reported in the second and third weeks of training.

During strength and physical fitness training, athletes tend to underestimate sessions recommended by coaches, due to training sessions in the preseason that aimed to develop fitness and obtain skills required by the competition

(Aoki et al., 2017). This occurs commonly in the training sessions classified as hard (Andrade Nogueira et al., 2015; Foster et al., 2001; Viveiros, Costa, Moreira, Nakamura, & Aoki, 2011), as in agreement with the results of the present study (Strength = 5.6 ± 1.1; Physical fitness = 5.6 ± 1.2). This is important due to the mismatch between what was recommended and perceived and that demonstrates the possibility of an insufficient training, i.e. undertraining, or suppression of adaptations (Redkva et al., 2016). Furthermore, the recommendation of lower training load may cause increased risk injury and sustain a subsequent injury in athletes. This might occur due to the inadequate workloads in the training sessions (Gabbett, 2016). Moreover, that may interfere with athlete's performance, mainly in BV, which requires the athlete to adapt to unpredictability and climate changes during the training or game (Kassiano et al., 2018).

Athletes presented no substantial differences in the tactical-technical training, between the perceived load compared to that planned by the coach and the other types of training. This result is in disagreement with the studies that monitored the tactical-technical training (Magalhaes, Inacio, Oliveira, Ribeiro, & Ascensao, 2011; Rodríguez-Marroyo, Medina, García-López, García-Tormo, & Foster, 2014; Vaquera et al., 2018). This type of training can be improved by psychological and physiological demands (Vaquera et al., 2018) and thus result in increments in RPE responses. Besides, in BV, players have a greater demand in decision making imposed by the tactical-technical actions and physical demands (Magalhaes et al., 2011). In spite of the demand imposed by the environment and training, the duration of the tactical-technical session also influences the increasing of training load, due to coach's intervention and a larger number of breaks (Rodríguez-Marroyo et al., 2014). An answer to this result is the experience of athletes to tactical-technical training and coach. Therefore, experienced athletes can respond more precisely to perceived exertion (Foster et al., 2001; Viveiros et al., 2011).

The intensity planned by the coach and that perceived by the athletes mismatched just in the first week, but during the second and third weeks it presented a greater similarity between the RPE. Likewise, the performance in CMJ increased over the weeks. These findings can be partly explained by the fact that the athletes are in pre-season. In theory, in this stage, athletes present an impoverished physical condition when compared to the subsequent stages, where they are already adapted to the stimuli (i.e., training and competitions) and present substantial improvements in the different physiological systems. In the present study coaches may have overestimated their athletes' condition, e.g., by prescribing training sessions that are considered easy and that are perceived as moderate/hard due to athletes' training status. Thus, as athletes started to improve and return to their optimal physical condition, the stimuli planned as easy started to be perceived as easy

Increasingly, coaches use monitoring training to assess the responses of athlete's performance from what was planned (Gabbett et al., 2017). The importance of careful periodization is already known and makes all the difference in the different periods of the competitive calendar (Haddad et al., 2017). Among the forms of monitoring demands of training and competition, RPE and CMJ have gained prominence in the literature (Claudino et al., 2017; Cruz et al., 2018; McLaren et al., 2017; Nakamura et al., 2016; Thorpe et al., 2017). The subjective perception in training can demonstrate magnitude of the load imposed in the planned sessions (Haddad et al., 2017). In addition, improvements in performance in the neuromuscular system due to training loads are monitored to verify the effectiveness of training and fitness-fatigue status (Claudino et al., 2017).

Notwithstanding the importance of the present study for the literature, we have limitations and suggestions for further investigations. In the present study, we analyzed 3 training weeks in pre-season. Athletes in this initial period were exposed to high training loads and the mismatch between what is planned and what is perceived can induce either injuries and overtraining incidence (Barroso, Cardoso, do Carmo, & Tricoli, 2014; Foster et al., 2001). Despite the increase in neuromuscular performance, it would be important to monitor these athletes in the long term. In BV, the players have different characteristics and game demands, e.g., the blocker executes a higher number of jumps and the defender may contact more during the games (Medeiros, Marcelino, Mesquita, & Palao, 2014). In fact, players may have different perceptions during training sessions. Therefore, it is necessary to consider the player's role during the training sessions and if it is consistent with what has been planned. Future studies could investigate the congruence between coaches and players' effort perception in the competition context. Furthermore, coaches overestimate either athletes' match exertion and their degree of recovery (Doeven et al., 2017). This information can influence recovery strategies of consecutive matches in Beach Volleyball competitions.

Conclusion

Coaches overestimated sessions of physical and strength training, in the early training sessions in the preseason period. Tactical-technical training presented no differences in comparison to what was planned and perceived by athletes. Over weeks, two and three of training sessions presented a similarity between the RPE planned and perceived, with an athletes' improvement in neuromuscular performance. These results revealed what is expected during the pre-season adaptation, the practical application for coaches due to the importance of verifying and monitoring the magnitude of the load imposed in training sessions, as athletes' perception can be not the same. Therefore, coaches should carefully assess responses of training load to improve adaptations and avoid maladaptation.

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