

Effect of different training strategies with the use of weight vests on the internal load in volleyball athletes

Efeito de diferentes estratégias de treinamento com o uso de coletes de peso sobre a carga interna em atletas de voleibol

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Abstract – The aim of this study was to compare the internal load coming from different training strategies in volleyball athletes and that planned by the coach. Seventeen male athletes (22.8 ± 2.9 years of age), national university level, participated in a training period and were randomized into three groups: Plyometric training with weight vests (PVG), technical-tactical training with weight vests (TVG) and control group (CG). Vests were equal to 7.5% body mass (BM) and all groups participated in the same training routines. Six training weeks were monitored from the method of ratings of perceived exertion (Session-RPE). Prior to sessions, the coach ranked Session-RPE estimation based on the previously prepared planning and after sessions, the Session-RPE of each athlete was recorded to analyze the cumulative total weekly training load (Cumulative-TWTL). One-way ANOVA was used to compare Cumulative-TWTL among groups and to compare the Session-RPE of groups in each session with that predicted by the coach. No difference in Cumulative-TWTL among groups was observed ($p < 0.05$) and only in session 21, the Session-RPE of CG was higher than that predicted by the coach ($p < 0.05$). It was concluded that the use of weight vests (7.5% BM) did not alter the training responses in the study athletes, with Session-RPE being in line with the load planned by the coach.

Key words: Hypergravity; Muscle strength; Physical fitness.

Resumo – O objetivo deste estudo foi comparar a carga interna advinda de diferentes estratégias de treinamento em atletas de voleibol e destas com a planejada pelo treinador. Dezesete atletas masculinos (22,8±2,9 idade), nível universitário nacional, participaram de um período de treinamento, sendo randomizados em três grupos: Treinamento pliométrico com coletes de peso (GCP), treinamento técnico-tático com coletes de peso (GCT) e grupo controle (GC). Os coletes equivaleram à 7,5% da massa corporal (MC) e todos os grupos participaram das mesmas rotinas de treinamento. Foram monitoradas seis semanas de treinamento a partir do método da percepção subjetiva ao esforço da sessão (PSE-sessão). Antes das sessões, o treinador classificou sua estimativa da PSE-sessão com base no planejamento previamente elaborado e após as sessões foi registrada a PSE-sessão de cada atleta para analisar a carga de treinamento semanal total acumulada (CTST-acumulada). A ANOVA “one way” foi utilizado para comparar CTST-acumulada entre os grupos e para comparar a PSE-sessão dos grupos, em cada sessão, com a predita pelo treinador. Não houve diferença na CTST-acumulada entre os grupos ($p < 0,05$) e apenas na sessão 21 a PSE-sessão do GC foi maior que a predita pelo treinador ($p < 0,05$). Conclui-se que o uso de coletes de peso (7,5% da MC) não alterou as respostas ao treinamento nos atletas analisados, estando a PSE-sessão em consonância com a carga planejada pelo treinador.

Palavras-chave: Aptidão física; Força muscular; Hipergravidade.

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Received: May 24, 2018

Accepted: February 04, 2019

How to cite this article

Freitas-Junior CG, Fortes LS, Santos TM, Batista GR, Paes PP. Effect of different training strategies with the use of weight vests on the internal load in volleyball athletes. Rev Bras Cineantropom Desempenho Hum 2019, 21:e57233. DOI: <http://dx.doi.org/10.5007/1980-0037.2019v21e57233>.

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INTRODUCTION

The physical training planning of volleyball athletes aims to optimize the performance of physical abilities demanded by the modality, aiming at achieving and maintaining performance at high levels for prolonged periods of time during the season^{1,2}. However, physical training may generate different adaptive responses and inadequate control of training loads may leave athletes' performance below or above expected for a certain period of sports programming³.

Adaptations to training programs result from the level of stress imposed on the organism, a situation described as internal training load (ITL)⁴, depending on the quality and quantity of training performed, in addition to the genetic potential and previous motor experiences of each athlete^{5,6}. In this sense, Foster et al.⁵ proposed a method for monitoring ITL through the ratings of perceived exertion of the session (Session-RPE), being an effective and user-friendly tool^{7,8}. The Session-RPE method can be used to verify the agreement between the load planned by the technical committee and the load experienced by the athlete, aiding in the adjustments of the training program⁶. Specifically in volleyball, Nogueira et al.⁹ observed that athletes tend to overestimate intensities proposed by the coach in activities planned to be mild and to underestimate heavy activities. Rodriguez-Marroyo et al.¹⁰ verified that coaches underestimate the load perceived by athletes during physical training, a situation that does not occur in games and technical-tactical training.

In volleyball, vertical jump directly influences decisive actions such as the attack¹¹, causing technical committees to develop training programs that develop this action¹², among them training with the use of weight vests^{13,14}. However, this strategy imposes greater eccentric load on the lower limbs¹⁵ and as the amount of vertical jumps performed in training can influence ITL perceived by athletes⁸, the monitoring of adaptive responses becomes important³.

Observing the ITL behavior of athletes during weight vest training may provide subsidies for the development of individualized training programs without jeopardizing collective goals. Therefore, the aims of this study were: a. to compare ITL perceived during participation in different training strategies with the use of weight vests in volleyball athletes; and b. to compare the Session-RPE of athletes, according to the training strategy used in each training session, with the load proposed by the coach. Considering that the extra weight imposed by the use of the weight vests could cause greater stress to the muscle structures of the lower limbs¹⁵, the following hypothesis was formulated: athletes who used weight vest would present higher ITL values perceived during the training sessions.

METHOD

Subjects

Initially, eighteen male volleyball athletes (22.8 ± 2.9 years of age, $84.4 \pm$

10.4 kg, 187.2 ± 6.3 cm) of a Brazilian university team, special division, participated in the study. Athletes could not present muscular injuries or any condition that could impair them from carrying out activities at the maximum of their performances. Athlete who missed more than 20% of sessions or was injured during the training period would be excluded from the survey.

Athletes were randomly distributed into three groups (<http://www.randomizer.org>) in a counterbalanced way. Groups were: plyometric training with weight vests (PVG), technical-tactical training with weight vests (TVG) and control group (CG). An athlete was disengaged from the team and excluded from the study during intervention. Thus, 17 athletes completed the study (Table 1). Before the beginning of the training protocol, athletes were informed of the research conditions, which was approved by the Ethics Research Committee of the Federal University of Pernambuco (protocol No. 1.575.390 / 2016) and requested to sign the Informed Consent Form.

Table 1. Physical characteristics of participants

Group	N	Age (years)	Height (cm)	Mass (kg)
PVG	5	21.4 ± 2.6	186.8 ± 5.1	81.9 ± 11.2
TVG	6	24.8 ± 2.5	186.8 ± 2.4	89.4 ± 10.6
CG	6	22.3 ± 2.9	186.8 ± 5.8	89.5 ± 10.5

Note. PVG = Plyometric training group with weight vests, TVG = technical-tactical training group with weight vests, CG = control group.

Procedures

The experiment was conducted during six weeks of training at the beginning of the season. Previously, athletes participated in a two-week micro-cycle with approximately 8 and 7 hours of training, respectively, and there were no activities within 48 hours prior to the beginning of the experiment. Athletes participated in all training sessions and weight vests were equivalent to 7.5% body mass (BM) of each athlete. Before the training protocol was applied, the body mass and height of athletes were measured. After sessions, the ITL of athletes was evaluated by the Session-RPE method and subsequently quantified. Before each session, the team coach predicted the Session-RPE that would possibly be perceived by athletes, according to the previously prepared planning. In this way, it was possible to compare the load predicted by the coach with the load perceived by athletes. Athletes became familiar with the Session-RPE method in the pre-season. The Session-RPE of activities carried out in the gymnasium was collected, that is, from technical-tactical, plyometric training and games.

Training program

The program had technical-tactical, plyometric and resisted training sessions distributed in seven weekly sessions (Table 2). All training sessions were prescribed by the team's technical committee. Technical-tactical training was composed of exercises aimed at improving the technical gestures

required by the modality and improving defensive and offensive systems. Plyometric training had the objective of improving vertical jump, being composed by exercises shown in Table 3. The recovery time between jumps was of 10 seconds and between series was of 1.5 to 2 minutes. According to the technical committee, plyometric training was adapted from the study by Miller et al.¹⁶, with similar exercises. There was a gradual reduction in the number of jumps in the last two weeks, 210 and 200 respectively (Table 3), in order to promote satisfactory results soon after intervention, since the team would have games in the following weeks considered by the coach of higher requirements.

All athletes participated of plyometric exercises and technical-tactical training routines in an equalized form. Weight vests (model Proaction G236, São Paulo-SP, Brazil) were used by PVG and TVG in two weekly training sessions. TVG used weight vests on Tuesdays and Fridays. Exposure to the use of weight vests in both situations lasted ~ 45 minutes and the technical-tactical training sessions in which TVG used the vests were composed of simulated games.

The weight of vests was defined based on the study of Janssen et al.¹⁷ and the self-report of four athletes who participated in a pilot study three weeks before the beginning of the experiment. In the pilot study, athletes participated in four technical-tactical training sessions, held on alternate days. On the first and third days, athletes performed actions with the weight vest equivalent to 7.5% their body masses and in the second and fourth days 10% their body masses. After the four sessions, they reported that the technical gestures performed during training were better performed when the extra weight was equivalent to 7.5% their body masses. Athletes participating in the pilot study also participated in the research.

Table 2. Weekly training program

Shift	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Morning	Res		Res		Res	Rec	Rec
Afternoon	Plyo Tec-Tat	Tec-Tat	Game*	Plyo Tec-Tat	Tec-Tat	Game**	

Note. Res = resistance training, Plyo = plyometric training, Tec-Tet = Technical-tactical training, Rec = recovery day. *Game played in week 2, ** games played in weeks 4 and 6.

Before each training session, athletes underwent a 15-minute warm-up session consisting of a submaximal run of 05 minutes, coordinating and stretching exercises and ten submaximal jumps. During this period, athletes participated in three games and were instructed to routinely maintain their sleep hours and feeding routine.

Quantification of the internal training load (ITL)

The Session-RPE method was used to analyze ITL perceived by athletes. The procedure consisted in making the following question: “how was your training session?”, which was answered according to the CR10 scale proposed by Borg¹⁸ and modified by Foster et al.⁵. The question was asked

Table 3. Plyometric training program

Jump exercises per session	Weeks					
	1	2	3	4	5	6
Unilateral for the box (30cm)	2x10		2x10			
Side with counter movement	3x10					
Frontal over barrier (10cm)	3x10					
With counter movement		2x10				
Side over barrier (10cm)		2x10				2x8
Sequential with knee elevation		3x10	3x10			
Frontal over barrier (30cm)		2x15				
Frontal over barrier (40cm)			3x10			
Side on barrier (30cm)			3x10			
Front unilateral in sequence				2x6/7		
Front in sequence over barrier (40cm / 1 m between barriers)				3x6	3x5	
Lateral in sequence over barrier (10cm)				2x10		
For the box after step (50cm)				2x10		4x5
Squat for the box (50cm)					2x10	
In depth (40cm) with jump					4x5	4x5
Frontal in sequence over 3 barriers (40cm / 1 m between barriers)						2x4
Total jumps	160	200	220	240	210	200

30 minutes after the end of the training session so that mild or intense activities performed at the end of the session did not influence the assessment⁵. The coach was asked to answer the question 10 minutes before the beginning of the training session.

From the athletes' responses, ITL was determined, which was established through the product of session duration (in minutes) by the Session-RPE score (CR-10). From the sum of daily ITL, the total weekly training load (TWTL) was obtained.

Statistical analysis

The Shapiro-Wilk test was used to verify data normality. To compare the accumulated TWTL of the whole period (cumulative-TWTL) among groups, "one way" ANOVA was used. The same test was conducted to verify differences between Session-RPE of groups with that predicted by the coach in each training session, using the Bonferroni test when necessary. Data were analyzed using the GRAPH PAD Prisma software. The significance level was 5%.

RESULTS

The mean TWTL of the period perceived by athletes was 1400.82 ± 73.40 AU. No significant difference in the cumulative-TWTL among groups ($F_{(3,14)} = 1.55$, $p = 0.25$) was observed, presenting the following results: 8291.20 ± 1737.14 AU, $9340.50 \pm 1768, 37$ AU and 7464.17 ± 1247.71 AU for PVG, TVG and CG, respectively (Figure 1). Of the 24 training sessions developed in the gymnasium, difference between Session-RPE

perceived by the CG and that predicted by the coach was observed only in session 21 ($F_{(4,14)} = 3.77, p = 0.04$) (Figure 2).

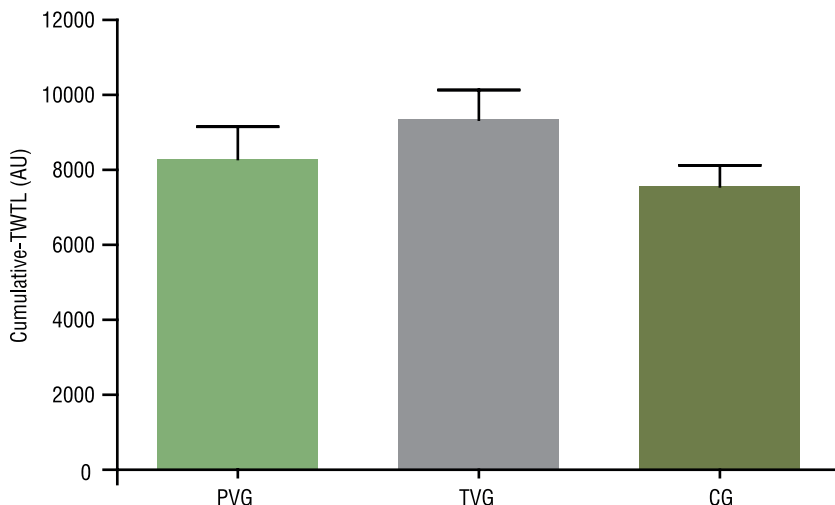


Figure 1. Comparison of cumulative-TWTL at six weeks for all three groups. Cumulative-TWTL = total weekly training load accumulated in the period; PVG = plyometric training with weight vests; TVG = technical-tactical training with weight vests; CG = control group.

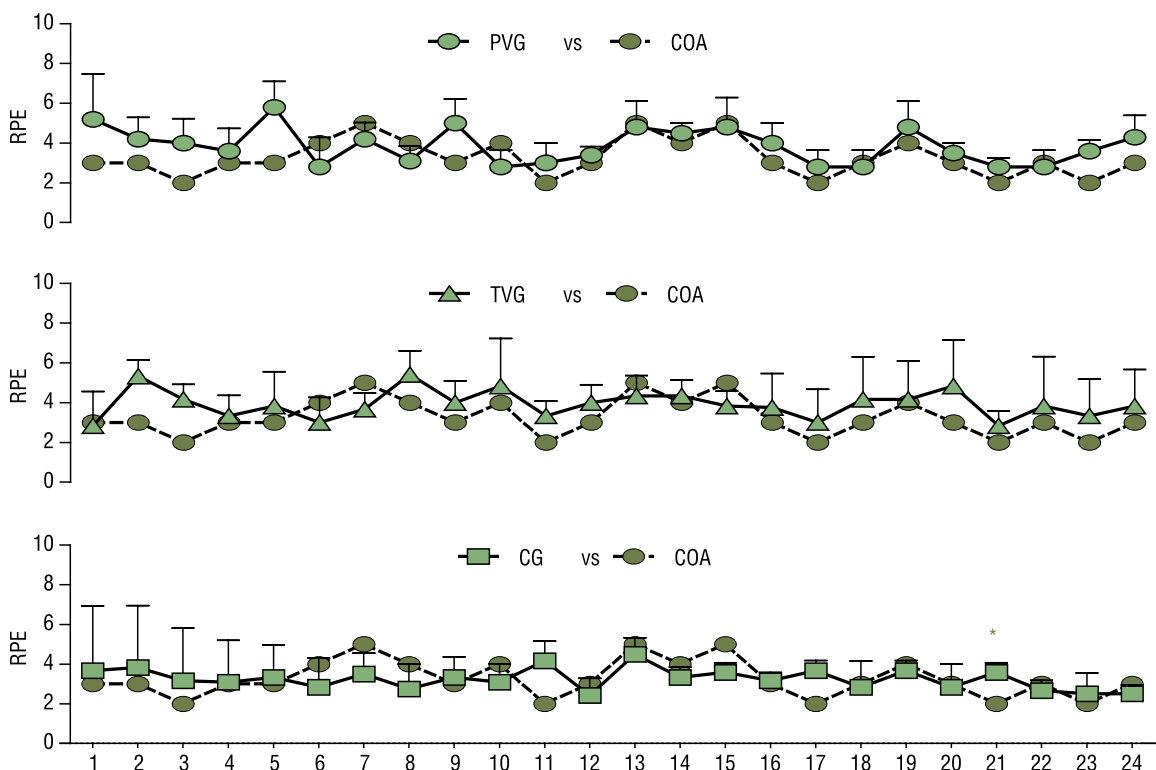


Figure 2. Session-RPE predicted by coach and reported by athletes. RPE = rating of perceived exertion; COA = coach; PVG = plyometric training with weight vests; TVG = technical-tactical training with weight vests; CG = control group. * Significant difference between CG and COA ($p < 0.05$).

DISCUSSION

The aims of this study were to compare ITL perceived by athletes during participation in different training strategies with the use of weight vests

and to compare the Session-RPE of groups with the load predicted by the coach. The findings of this research showed that during the analyzed period, athletes had the same ITL perception, regardless of strategy used and that the three groups perceived the training load of the session similarity to that predicted by the coach.

The mean ITL of athletes for the analyzed period was 1400.82 ± 73.40 AU, a value close to those found in literature for volleyball athletes both during the preseason^{7,19,20}, and during the preseason and season¹⁰. Freitas et al.¹⁹ analyzed the effect of a four-week physical training program on strength and explosive power of the lower limbs of young athletes and found average ITL of ~ 1720 AU. Freitas et al.⁷ tested the sensitivity of vertical jump and recovery capacity after a deliberate training intensification over a period of 25 days, with average ITL of ~ 1500 AU. In another study, average ITL of 1790.9 AU was observed after follow-up of 22 weeks of training²⁰. Rodriguez-Marroyo et al.¹⁰, reported values of 1716.2 AU after a period of 15 weeks, being 7 in the preseason and 8 in the season.

It was observed that the mean ITL of the present study was below the average ITL of studies above. The tendency of coaches to plan training with lower loads during the season in order to maximize gains achieved during the preseason in physical performances^{10,21} may justify the results found. However, the new fact of the present study was the follow-up of ITL from different training strategies. It is common for coaches to seek to individualize training depending on the needs of each athlete, such as the use of weight vests^{13,14}.

Klhifa et al.¹³ associated improvements found in the vertical jump with the possible increase of phosphagen reserves and the ability to reuse the elastic energy that is produced during the eccentric phase of the movement, providing greater motor power in the concentric phase of the movement. However, this strategy imposes greater eccentric load on the lower limbs¹⁵, which in turn may reflect on the ITL perceived by athletes.

The results of the present study showed that the groups did not present differences when compared to the cumulative-TWTL of the six weeks of training (Figure 1), contrary to the hypothesis formulated. Rey et al.¹⁴ in a six-week study observed that soccer athletes who used weight vests (18.9% body mass) during twice-weekly sprint training reported the same Session-RPE as athletes who did not use weight vests, indicating that the cumulative ITL was similar. In the aforementioned study, improvements were found in the sprint but not in the vertical jump with countermovement¹⁴.

The training specificity is a factor that may have influenced the results obtained in the present study with regard to cumulative-TWTL, since the number of jumps performed by volleyball athletes during training can offer greater resistance against muscle injuries, causing a protective effect for functions of the neuromuscular system^{8,22}. In this way, even though jumping exercises over barriers and in depth have not been individualized, the ITL perceived by athletes was similar. For Khodaei et al.²³, these exercises are considered of medium intensities, i.e., the mechanisms responsible

for fatigue during plyometric training, plasma creatinine depletion, pH decrease, blood lactate increase or carbohydrate depletion are moderately stimulated²⁴. This situation is corroborated by results found by Asadi²⁴, who verified that in depth jump exercises with heights between 35 and 60 cm impose similar ITL perceptions.

The aerobic fitness level may also have influenced the results found, since athletes with higher levels of this ability have lower ITL perception^{25,26}. Thus, it is possible to believe that athletes had similar aerobic capacity conditions.

In some technical-tactical training sessions, coaches perform constant stops for technical and tactical corrections of athletes and intervals between vertical jumps of approximately 14 to 17 seconds are enough to delay the onset of neuromuscular fatigue, keeping the performances of technical actions in good conditions²⁷. This characteristic may justify the fact that the TVG does not present difference in cumulative-TWTL in comparison with CG, even performing vertical jumps during the technical-tactical training session with the use of weight vest. Another possibility is the fact that training vertical jumps with counter movements performed with the use of vests weighing up to 10% body mass does not change the kinematic and kinetic patterns¹⁷. In this way, the possible manifestation of fatigue in knee extensors due to the repetition of vertical jumps, inducing athletes to adopt new motor coordination strategies in order to maintain performances in maximum conditions²⁸, would be one of the factors that could have influenced the ITL perception by some athletes. In this sense, manipulation of the interval time between jumps performed, as previously reported, would be determinant to delay the onset of fatigue in the extensors of the lower limbs²⁶, contributing to a similarity of ITL perceived among groups.

According to literature, studies have shown that ITL perceived by volleyball athletes is in disagreement with the load planned by the technical committee^{9,10}. However, the Session-RPE of groups analyzed in the present study presented similarity to that predicted by the coach. This situation is due to the fact that athletes tend to perceive ITL in agreement with that proposed by the coach during moderate activities, unlike activities planned to be mild or more intense^{9,29}. Figure 2 shows that the coach planned activities with predominantly moderate intensities and since training during the season is aimed at maintaining performances acquired in the preseason^{3,21}, it is possible that the coach has had this concern.

This situation should be carefully considered, since the low variation in the distribution of loads, especially between light and heavy loads, is associated with negative adaptations to training, such as decreased performance of athletes and increased incidence of infectious diseases, as well as injuries²⁹. Nevertheless, the similarity of the Session-RPE of groups analyzed and that predicted by the coach should be seen as a positive aspect. This factor may prevent the development of the overtraining syndrome, a common situation when there are discrepant differences between prescription and athletes' perception⁵. Overtraining is usually due to the

poor distribution of training loads, especially when recovery periods are insufficiently distributed³⁰.

Another factor that contributed to the similarity of ITL perceived by athletes and predicted by the coach is the fact that four weekly sessions were composed of technical-tactical training (Table 2). According to Rodríguez-Marroyo et al.¹⁰, athletes tend to perceive ITL in disagreement with the coach during physical training sessions and not in technical-tactical training and games. The motivation that athletes have to perform this type of training can influence the perceived ITL, favoring the concordance scenario found in this study¹⁰.

The limiting factors of this study are: the fact that the Session-RPE method is subjective may limit the scope of this investigation, the lack of follow-up of athletes' physical performance, and the fact that the authors did not participate in the training program planning.

CONCLUSION

The results found reinforce the importance of monitoring ITL in athletes and that the Session-RPE method is effective in this sense, offering subsidies to coaches to properly distribute training loads.

The use of weight vests with 7.5% body mass was not sufficient to cause differences in perceived ITL among groups, indicating that the use of weight vests may be prescribed to meet individual needs, in line with collective objectives. This situation was reinforced by the fact that the groups analyzed presented Session-RPE in line with that prescribed by the coach, which is favorable for the improvement of the sports performance.

COMPLIANCE WITH ETHICAL STANDARDS

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-profit sectors. This study was funded by the authors.

Ethical approval

Ethical approval was obtained from the local Human Research Ethics Committee – Federal University of Pernambuco and the protocol (1.575.390/2016) was written in accordance with standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conceived and designed the experiments: CGF; LSF; TMS; PPP. Performed the experiments: CGF; PPP. Analyzed data: CGF; LSF; GRB.

Contributed with reagents/materials/analysis tools: CGF; LSF. Wrote the paper: CGF; LSF; TMS; GRB; PPP.

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