COMPARISON OF DIFFERENT METHODS OF INTERNAL LOAD CONTROL IN VOLLEYBALL PLAYERS

Maurício Gattás Bara Filho[1]
Francine Caetano de Andrade[1]
Ruan Alves Nogueira[1]
Fábio Yuzo Nakamura[2]

1. Federal University of Juiz de Fora, Physical Education and Sports College, Juiz de Fora, MG, Brazil.
2. State University of Londrina, Physical Education and Sports Center, Londrina, MG, Brazil.

Mailing address:
E-mail: mgbara@terra.com.br

ABSTRACT

Introduction: The ability to accurately monitor training loads is an important aspect of athletic effectiveness and prevention of negative effects, such as performance loss. Objectives: The purpose of this study was to compare and correlate different methods for internal training load control for volleyball players. Methods: Fifteen male volleyball athletes between 18 and 30 years old who compete at state and national levels, participated in this study. Training load for each session was calculated using three different methods: RPE/Foster, HR zones (TRIMP) Edwards and Stagno. Results: It was observed that there are positive and significant correlations between the method proposed by Foster and Edwards and Stagno. However, the values of individual correlations RPE x Edwards (0.451 to 0.670), in general, were higher than RPE x Stagno (0.206 to 0.597). Conclusion: It can be concluded that the method proposed by Edwards, as well as the Foster's method, better reflect the training loads in volleyball, making it more reliable to control them than the method proposed by Stagno.

Keywords: heart rate, athletic performance, exercise, RPE.

INTRODUCTION

Improvement in sports performance directly depends on the suitable distribution of the training loads and recovery provided to the athletes. The ability to accurately monitor the training load is an important aspect for the effectiveness of the periodization as well as prevention of negative effects, such as performance decrease[1-7].

Some methods have been used for internal training loads control, such as the Session Rate of Perceived Exertion (Session RPE) and the calculation of the training impulse (TRIMP) through the heart rate zones during training sessions[1-4,7-12].

The Session Rate of Perceived Exertion (Session RPE) was proposed by Foster[13] and Foster et al.[9,10], using a scale adapted from the one originally proposed by Borg[14], and is based on the idea that the physiological responses derived from physical stress are followed by proportional perception responses[5]. The RPE value obtained after the training session is multiplied by its total duration, integrating intensity and volume.

The TRIMP method, based on the heart rate measurement, was proposed by Banister[16] and later adapted by Edwards[17] and Stagno et al.[11]. All of them adopt a progressive weight factor for each HR zone. These methods have been used in studies which monitor the training loads in team sports[1,11,18] and were adopted as reference for the Session Rate of Perceived Exertion (Session RPE) validation.

Volleyball is a sports modality of intermittent characteristic which requires that the athletes perform efforts of short duration and high intensity, intervaled by periods of low intensity, especially for being a game with relatively long pauses after each point. The exertion necessary to play volleyball demands mainly neuromuscular fitness, since it presents short dislocations and fast and very fast jumps[19,20]. Such aspect contrasts with other team sports with demand equally important on the cardiovascular system[21].

The training of team sports involves different elements as technical and tactic aspects which are collectively performed, making it difficult to control individual training load, which can lead the athletes to train below or above the intensity planned by the external load[22]. Many studies have been carried out with this purpose to validate methods of internal load, such as the Session Rate of Perceived Exertion (Session RPE), in different modalities[1,2,7,15,18,23]. However, as far as we know, there are no studies which have compared objective and subjective methods in volleyball, verifying which method would be more faithful for the training and games load control in volleyball. Thus, the present study has the aim to compare and correlate different methods of internal training load in volleyball players. Due to the sport's exertion and pause characteristics, our hypothesis is that the high correlations found between Session Rate of Perceived Exertion (Session RPE) and TRIMP in sports like soccer[1,7] and basketball[8] would not be equally high in volleyball.

METHODOLOGY

Experimental protocol

The training load for each session was calculated using three different methods:

- Session Rate of Perceived Exertion (Session RPE) using the method proposed by Foster et al.[9];
- Sum of the points of heart rate zones (TRIMP) according to Edwards[17];
- Sum of the points of heart rate zones (TRIMP) according to Stagno et al.[11].

SAMPLE

Fifteen male professional volleyball athletes, aged between 18 and 30 years (weight: 84.6 ± 11.14 kg; height: 189.3 ± 9.7 cm; % fat: 8.8 ± 3.04), who competed at state and national levels, participated in this study.

The study's procedures respected the international guidelines of medical research involving human subjects, according to the Declaration of Helsinki (1975), having been approved by the Ethical Committee with Research in Human Subjects of the Federal University of Juiz de Fora (133/2008). The athletes signed a consent form authorizing data collection and release.

Procedures

The training load for each session was calculated using three different methods, being one of them based on the percentage response and two of them based on the heart rate.

The Session Rate of Perceived Exertion (Session RPE) method was measured for each athlete during the period of the study. The calculation consists in the multiplication of the training session duration in minutes by the training intensity, indicated by the RPE through the scale adapted by Foster et al.[9,10]. The scale's use requires some Anchorage procedures. The athletes were told to choose a describer and a number from 0 to 10. The maximum value (10) corresponds to the highest physical exertion experienced by the individual and the minimum value is the rest condition (0).

In order to guarantee that the RPE mean data obtained refers to the total training, the athlete was asked to answer this question: "How was your training today?", answered from 20 to 30 minutes after the end of the session. The RPE value, with precision of 0.5, was multiplied by the training session duration.

The heart rate (HR) zones calculation used the monitored maximum HR of the training. In all cases, it was within the values (±10 bpm) expected for the athletes' age (220 – age). The HR data were recorded at every five seconds by the Polar RS800 cardio frequency meter and transferred after the training to a computer through interface with infrared device and filtered (moderate power filter) by the Software Polar Precision Performance.

The load was quantified through the HR from the TRIMP method, which evaluates the session volume and intensity through specific scores in each training zone. The time in which the athlete remained in each zone during each session is multiplied by factors as proposed by Stagno et al.[11] (Zone1 – 65 to 71% HRmax, factor 1.23/; Zone 2 – 72 to 78% HRmax, factor 1.71/; Zone 3 – 79 to 85% HRmax, factor 2.54/; Zone 4 – 86 to 92% HRmax, factor 3.61/; Zone 5 – 93 to 100% HRmax, factor 5.16).

Other factors proposed by Edwards[17] (Zone 1 – 50 to 60% HRmax, factor 1/; Zone 2 – 60 to 70% HRmax, factor 2/; Zone 3 – 70 to 80% HRmax, factor 3/; Zone 4 – 80 to 90% HRmax, factor 4/; Zone 5 – 90 to 100% HRmax, factor 5) were used in this study.

The data were collected during 37 weeks of training. Every day two to three athletes were randomly chosen to go through the monitoring of the heart rate intensity, in a total of 266 individual training sessions during the season. The RPE was obtained from the same athletes.

The athletes' training occurred five to six times a week during the period of the study and the monitored sessions consisted of technical-tactical elements collectively performed. The basic training session consisted of three parts included in the total duration of the session:

- Warm-up, divided in general and specific (mean time of 20 minutes);
- Technical part, which consisted in the training of volleyball fun-

damental rules: serve, reception, defense, block and attack (mean time between 30 and 40 minutes) and;
- Tactical part, which consisted in training of the offensive and defensive systems (mean time between 40 and 60 minutes).

Statistical analysis

Descriptive analysis (mean, standard deviation) of the training loads and the Pearson correlation index to relate the training load control varaibles (heart rate and Subjective Perceived Exertion) were used. The data were analyzed using the SPSS statistical package, version 13.0 for Windows, with significance level adopted of $p < 0.05$ in all cases.

RESULTS

When the training load was calculated using the method proposed by Edwards[17], the percentage of the time spent in the volleyball technical and tactical training in each zone was of: 25.6% in zone 1; 35.8% in zone 2; 26.8% in zone 3; 10.8% in zone 4 and 1% in zone 5, while in the method proposed by Stagno et al.[11], the percentage of the time spent in each zone was: 41.8% in zone 1; 31.9% in zone 2; 18.7% in zone 3; 6.8% in zone 4 and 0.8% in zone 5. The correlation between these methods was of 0.95.

The Session Rate of Perceived Exertion (Session RPE) data correlation with the values of the HR zones of each methods obtained r = 0.301 values ($p < 0.001$) between TRIMP Stagno and RPE (figure 1) and r = 0.409 ($p < 0.001$) between TRIMP Edwards and RPE (figure 2).

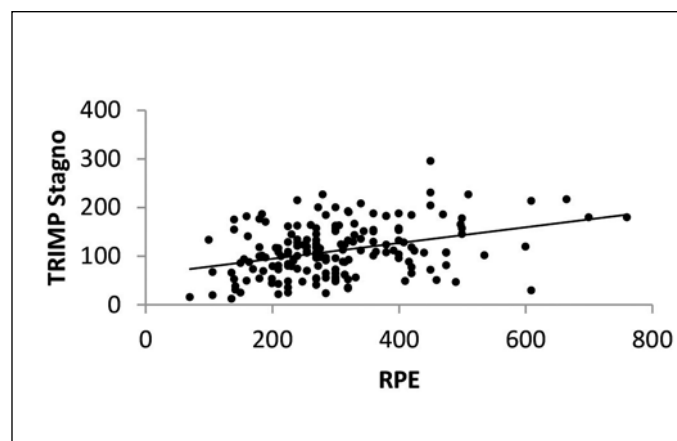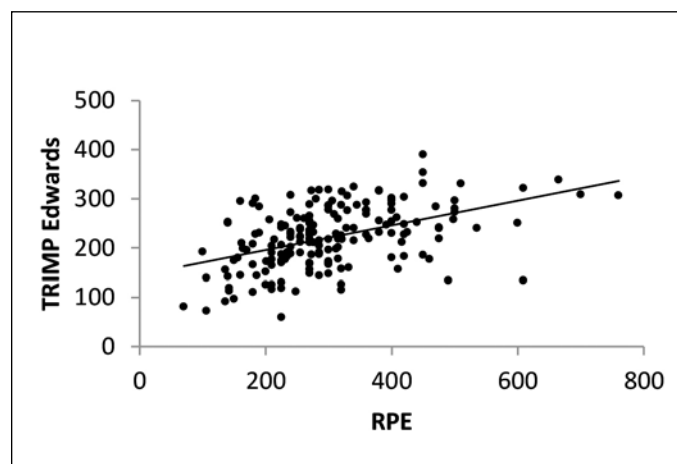**Figure 1.** Relation between the individual RPE and TRIMP Stagno values (n = 178; r = 0.301).

Figure 2. Relation between the RPE individual and TRIMP Edwards values (n = 178; r = 0.409).

Table 1 presents individual correlations of athletes who performed minimum of 15 monitored sessions. It is observed that there is positive and significant correlation between the method proposed by Foster et al.[9] and the TRIMP methods proposed by Edwards[17] and Stagno et al.[11] in some individuals, but not in all of them. However, the values of the RPE x Edwards correlation, are usually higher than the ones in the RPE x Stagno.

Table 1. Individual correlations between the different quantification methods of training load.

Athlete	RPE x Edwards	RPE x Stagno
A (19)	0.647*	0.516*
B (21)	0.470*	0.210
C (23)	0.494*	0.517*
D (23)	0.451	0.274
E (15)	0.506	0.535*
F (17)	0.670*	0.597*
G (20)	0.576*	0.546*
H (16)	0.560*	0.461
I (14)	0.465	0.206
J (15)	0.453	0.251
Mean	0.529	0.411
SD	0.080	0.156
Minimum	0.453	0.251
Maximum	0.67	0.597

*Statistically significant values (p < 0.05).

DISCUSSION

The present study had the aim to compare the training load control in volleyball from different methods (Session Rate of Perceived Exertion (Session RPE) and TRIMP). When the control methods are analyzed from the heart rate zones, higher concentration of exertion in volleyball is observed in the exertion intensity zones between 50 and 80% of Maximum Heart Rate, information that would indicate low and medium intensity exertion in an analysis from the intensity zones calculated from the maximal HR percentage. The outcomes of the present study corroborate the findings by Gabbett[19], Lidor and Ziv[20] and Sheppard et al.[24].

This first analysis suggests that, although volleyball involves short duration and high intensity efforts[20], heart rate is relatively low compared with other team sports. In volleyball, a significant amount of the exertion is performed with short duration and high intensity, using the alactic system as predominant in the modality, contrary to soccer, basketball and swimming, which also use other energy sources, especially aerobic ones[1,2,18]. Thus, high-intensity and short-duration exertion may not directly correspond to the increase of the heart rate, minimizing the calculation of the internal training load.

From the correlations established between the RPE method of the session and the ones related with the heart rate Zones, higher values are observed between RPE x Edwards[17] (r = 0.529/ interval 0.453-0.67) when compared with RPE x Stagno et al.[11] (r = 0.411/ interval 0.251-0.597). Other studies compared objective and subjective methods to training load control. Impellizzeri et al.[7] studied the correlation among three methods during training and competition in soccer. According to their results, the individual correlation between the RPE method and the one by Edwards[17] ranged between 0.54 and 0.78. Alexiou and Coutts[1] also evaluated these individual correlations in female soccer players and found values between 0.50 and 0.96. Wallace et al.[2] studied the correlation between the method proposed by Edwards and the RPE in swimming athletes with individual correlations ranging from 0.56 to 0.91. Similar data were presented by Manzi et al.[18] in basketball athletes.

The outcomes of the individual correlations found in the present study were lower than the ones found in the referred studies, a fat which may be explained by the difference between the exertion performed in volleyball when compared with the modalities studied in the remaining investigations (soccer, swimming and basketball), in which the exertion/transition between heart rate zones ratio seems to be stronger. Comparing the two objective methods evaluated in volleyball, the HR zones proposed by Edwards[17] presented higher correlations than the ones proposed by Stagno et al.[11] which underestimated real exertion performed by the athletes. An important piece of information to be highlighted is the fact this method disconsiders the exertion percentages between 50 and 64% of HRmax, which in the present study represents a mean of 37 minutes, which did not count for the calculation of the training impulse.

These confirmations indicate that the Session Rate of Perceived Exertion (Session RPE)[9,10] seems to be an interesting possibility to control the internal training load in volleyball. High-intensity and short-duration exertion as performed in volleyball seems to be better reflected through the Session Rate of Perceived Exertion (Session RPE) than the HR methods. Robson-Ansley et al.[25] found out that the TRIMP method fails in reflecting the demands of intermittent sports, the same way the mean of the heart rate in these exercises of prolonged nature is impracticable and may not provide significant data, reinforcing the importance to use another method to training load control for these sports, such as the Session Rate of Perceived Exertion (Session RPE). However, future studies should use other references for measurement of internal load to validate the Session Rate of Perceived Exertion (Session RPE) in volleyball. Many studies mention this method as an important instrument for training load control and periodization in different sports[1-4,7,12,18].

The present study presents some limitations, as the fact the heart rate data collection has been performed only with two to three athletes per training session. Moreover, the data were not collected during competitions. Collection during the official matches could aid the technical staff to adequate individual recovery after the matches from the load measured through HR and RPE.

CONCLUSION

The methods for training load control from the exertion intensity zones[11,17] present important limitations when used in volleyball. Therefore, the Session Rate of Perceived Exertion (Session RPE) is as important alternative method so that this monitoring is performed in a more reliable and trustful manner for control and periodization of the training loads in volleyball.

REFERENCES

1. Alexiou H, Coutts AJ. A comparison of methods used for quantifying internal training load in women soccer players. Int J Sports Physiol Perform 2008;3:320-30.

2. Wallace LK, Slattery KM, Coutts AJ. The ecological validity and application of the session-RPE method for quantifying training loads in swimming. J Strength Cond Res 2009;23:33-8.

3. Borresen J, Lambert MI. Quantifying training load: A comparison of subjective and objective methods. Int J Sports Physiol Perform 2008;3:16-30.

4. Borresen J, Lambert MI. The quantification of training load, the training response and the effect on performance. Sports Med 2009;39:779-5.

5. Kellman M. Preventing overtraining in athletes in high-intensity sports and stress/recovery monitoring. Scand J Med Sci Sports 2010;20 Suppl 2:95-102.

6. Roose J, De Vries WR, Schmikli SL, Backx FJG, Van Doornen LJP. Evaluation and opportunities in overtraining approaches. Res Q Exerc Sport 2009;80:756-64.

7. Impellizzeri FM, Rampinini E, Coutts AJ, Sassi A, Marcora SM. Use of RPE-based training load in soccer. Med Sci Sports Exerc 2004;36:1042-7.

8. Sweet TW, Foster C, McGuigan MR, Brice G. Quantitation of resistance training using the session rating of perceived exertion method. J Strength Cond Res 2004;18:796-802.

9. Foster C, Florhaug JA, Franklin, J, Gottschall L, Hrovatin LA, Parker S, et al. A new approach to monitoring exercise training. J Strength Cond Res 2001;15:109-11.

10. Foster C, Hoyos J, Earnest C, Lucia A. Regulation of energy expenditure during prolonged athletic competition. Med Sci Sports Exerc 2005;37:670-5.

11. Stagno KM, Thatcher R, Someren KAV. A modified TRIMP to quantify the in-season training load of team sports players. J Sports Sci 2007;25:629-34.

12. Nakamura FY, Moreira A, Aoki, MS. Monitoramento da carga de treinamento: a percepção subjetiva do esforço da sessão é um método confiável? (Training load monitoring: Is the rate of perceived exertion a reliable method?) R da Educação Física/UEM (Impresso) 2010;21:1-11.

13. Foster C. Monitoring training in athletes with reference to overtraining syndrome. Med Sci Sports Exerc 1998;30:1164-8.

14. Borg G. Psychophysical bases of perceived exertion (Las bases psicofísicas del esfuerzo percibido). J Med Sci Sports Exerc 1982;14:377-81.

15. Coutts AJ, Duffield R. Validity and reliability of GPS devices for measuring movement demands of team sports. J Sci Med Sports 2010;13:133-5.

16. Banister EW. Modeling elite athletic performance. In: Physiological Testing of the High-Performance Athlete. Champaign, Illinois: Human Kinetics, 1991.

17. Edwards S. High performance training and racing. In The Heart Rate Monitor Book, 8th ed. Sacramento, CA: Feet Fleet Press, 1993.

18. Manzi V, D'Ottavio S, Impellizzeri FM, Chaouachi A, Chamari K, Castagna C. Profile of weekly training load in elite male professional basketball players. J Strength Cond Res 2010;24:1399-406.

19. Gabbett T. Do skill-based conditioning games offer a specific training stimulus for junior elite volleyball players? J Strength Cond Res 2008;2:509-17.

20. Lidor R, Ziv G. Physical and physiological attributes of female volleyball players: A review. J Strength Cond Res 2010;24:1963-73.

21. Strøyer J, Hansen L, Klausen K. Physiological profile and activity pattern of young soccer players during match play. Med Sci Sports Exerc 2004;36:168-74.

22. Milanez VF, Lima MCS, Gobatto CA, Perandini LA, Nakamura FY, Ribeiro LFP. Correlates of session-rate of perceived exertion (RPE) in a karate training session. Sci Sports 2011;26:38-43.

23. Coutts A, Gomes RV, Viveiros L, Aoki MS. Monitoring training loads in elite tennis. Rev Bras Cineantropom Desempenho Hum 2010;12:217-20.

24. Sheppard JM, Gabbett T, Taylor KL, Dorma J, Lebedew AJ, Borgeaud R. Development of a repeated-effort test for elite men's volleyball. Int J Sports Physiol Perform 2007;2:292-304.

25. Robson-Ansley PJ, Gleeson M, Ansley L. Fatigue management in the preparation of Olympic athletes. J Sports Sci 2009;27:1409-20.