
PHYSICAL DEMANDS AND PSYCHOPHYSIOLOGICAL STRESS IN YOUNG ATHLETES TEAM SPORTS**EXIGÊNCIAS FÍSICAS E ESTRESSE PSICOFISIOLÓGICO EM JOVENS ATLETAS DE ESPORTES COLETIVOS****Fernanda Martins Brandão¹, Thiago Seixas Duarte¹, Vinícius Figueroa da Cunha¹, Francisco Zacaron Werneck², and Maurício Gattás Bara Filho¹**¹Federal University of Juiz de Fora, Juiz de Fora, MG, Brazil.²Federal University of Ouro Preto, Ouro Preto, MG, Brazil

RESUMO

O monitoramento do treinamento é importante no processo de desenvolvimento dos atletas. O objetivo do estudo foi comparar as respostas psicofisiológicas e as demandas físicas de jovens atletas de futebol, basquete, handebol e voleibol. A amostra foi constituída por 61 indivíduos de ambos os gêneros que foram acompanhados ao longo de 10 sessões de treino de cada modalidade em questão. As respostas psicofisiológicas foram monitoradas através da percepção subjetiva de esforço da sessão (PSE da sessão) e o impulso de treinamento (TRIMP). As demandas físicas analisadas foram a distância total percorrida (DP), DP por zona de velocidade (DP_Z1, DP_Z2, DP_Z3, DP_Z4, DP_Z5), número de *sprints* e a duração das sessões. Além disso, o estado de recuperação (TQR) também foi analisado. Foram observadas diferenças significativas entre a duração das sessões ($p < 0,001$), DP_Z1 ($p < 0,017$), DP_Z2 ($p < 0,05$), DP_Z3 ($p < 0,05$), DP_Z4 ($p < 0,003$), DP_Z5 ($p < 0,05$), número de *sprints* ($p < 0,001$), TRIMP ($p < 0,02$), PSE da sessão ($p < 0,05$) e TQR ($p < 0,007$). Nas respostas psicofisiológicas, o handebol apresentou mais tempo nas zonas 4 e 5 em comparação demais modalidades. Nas demandas físicas, o basquete e o handebol apresentaram maior número de *sprints* e também maiores valores na DP_Z5. Dessa forma, o monitoramento em conjunto das demandas físicas e respostas psicofisiológicas fornecem informações complementares no monitoramento de jovens atletas.

Palavras-chave: Esportes juvenis. Esportes de equipe. Educação física e treinamento.

ABSTRACT

Training monitoring is important in the development process of the athlete. The objective of the study was to characterize the psychophysiological response and physical demands of soccer, basketball, handball, and volleyball with young athletes. The sample consisted of 61 young athletes of both genders and members of team sports, 10 training sessions for each modality were monitored. The psychophysiological responses were monitored by the session rating perception of exertion (Session RPE) and training impulse (TRIMP). The physical demands were, distance covered (DC), DC by speed zone (DC_Z1, DC_Z2, DC_Z3, DC_Z4, DC_Z5), number of sprints, and duration of the session. In addition, the recovery status (TQR) was also collected. Differences were noted between duration ($p < 0.001$), DC_Z1 ($p < 0.017$), DC_Z2 ($p < 0.05$), DC_Z3 ($p < 0.05$), DC_Z4 ($p < 0.003$), DC_Z5 ($p < 0.05$), sprints ($p < 0.001$), TRIMP ($p < 0.02$), Session RPE ($p < 0.05$) and TQR ($p < 0.007$). In psychophysiological responses, handball showed more time in zones 4 and 5 than other modalities. According to physical demands, basketball, and handball had a higher number of sprints and also higher values in DP_Z5. Therefore, the simultaneous monitoring of physical demands and psychophysiological responses provides supplementary information in monitoring young athletes.

Keywords: Youth sports. Team sports. Physical education and training

Introduction

Sports training aims to generate adaptations that lead to improved or sustained performance, through the development of physical, technical, tactical, and psychological skills¹. Thus, for this to happen, it is necessary to systematically monitor the psychophysiological responses and the physical demands^{2,3}. Similar to the adult category, tracking these responses among young athletes is also important. Previous studies have

suggested that the relationship between high volumes of training and injuries can lead to early retirement, abandonment of the sport, or even abandonment of physical activities^{4,5}.

In this context, some methods to control the psychophysiological responses are widely used. Among the subjective methods it's important to highlight the session of Rating Perception of Exertion (Session RPE)⁶ and as an objective method, the training impulse (TRIMP) calculated through the intensity zones of the heart rate (HR)⁷. From this, combine methods that integrate both physical demands and psychophysiological measures, such as the use of microsensors⁸. There is a greater potential for improvement the prescribing, periodicity, and management of athlete training through detailed evaluation of training effectiveness⁹.

Then, the characterization of the demands and responses in team sports can allow a better understanding of the training with young athletes. Also, make sure that athletes train at an appropriate intensity so that their physical and technical abilities improve considerably³ and identify young athletes who are at risk of injury⁴. In addition, it contributes to the definition of risk thresholds for young athletes, so that an approach to long-term athletic development is emphasized as maladaptations are avoided. Thus, the objective of the study was to compare the physical demands and the psychophysiological stress induced by specific training sessions in young athletes' team sports, in addition to correlating the monitoring methods.

Methods

Sample

The sample includes 61 young athletes, from both genders, members of soccer, basketball, volleyball, and handball team that compete at state and national levels, with the following characteristics: age = 15.5 ± 1.1 years, body mass = 67.8 ± 6.2 kg, high = 1.73 ± 0.06 .m and 3.4 ± 1.8 years of sport experience. This includes 13 male basketball athletes, 17 male soccer athletes, 14 female handball athletes, and 17 male volleyball athletes. The eligibility criteria were that the young athlete should have been training with the team in the last 6 months.

The study was approved by the Institutional Local Ethical Committee of the Federal University of Juiz de Fora-MG, Brazil protocol number, 74111517.8.0000.5147. The athletes were invited to participate in the study and informed about the procedures that would be adopted during the research. After accepting the invitation, all athletes and their guardians signed the Agreement Term and the Informed Consent Term, respectively, consenting to participate voluntarily.

Procedures

The variables were obtained from 380 individual training sessions (Soccer-100 sessions; Basketball-97 sessions; Handball-94 sessions; Volleyball-89 sessions) referring to 10 training sessions for each modality, with 7 to 10 athletes being monitored in each session. The average duration of sessions was 83.2 ± 12.98 minutes, and the sessions were focused on technical/tactical activities, situational methods, and small side games were used for technical and tactical development.

Athletes were familiarized with the instruments and procedures three weeks prior to the start of the investigation period. Then, ten training sessions for the teams were monitored, without any influence on the planning and execution of the training. The physical demands were collected through the variables: distance covered (DC), distance covered by speed zone (DC_Z), number of sprints, and duration. The psychophysiological response was collected at each training session using the session of Rating Perception of Exertion (Session

RPE)⁶ and training impulse (TRIMP)⁷. Before each training session, the athletes responded scale of the Total Quality of Recovery (TQR)¹⁰.

During the training sessions, the athletes used a Polar Team Pro System equipment microsensor (Polar Team Pro System, Polar Electro Oy, Kempele, Finland), attached to an elastic strap attached to the chest. The microsensor consists of a GPS, a triaxial accelerometer, and a HR monitor. It was therefore used both to measure physical demand data through GPS or accelerometer and psychophysiological response data by the objective method, based on heart rate (HR). In addition to the objective method, based on HR, the subjective method was also used, the Session RPE, recorded at the end of all training sessions, being obtained from the same athletes who underwent monitoring with Polar Team Pro System microsensors. Before the training sessions, the athletes answered to TQR.

Physical Demand

The physical demand variables collected through the GPS were, DC, and DC_Z defined by five-speed zones: DC_Z1 = 0 to 2 m/s, DC_Z2 = 2.02 to 3.97 m/s, DC_Z3 = 4 to 5.97 m/s, DC_Z4 = 6 to 7 m/s and DC_Z5 \geq 7.02 m/s^{11,12} and number of sprints.

Psychophysiological responses

TRIMP

The TRIMP method, proposed by Edwards⁷ uses HR responses by maximum HR percentages. Thus, HR was recorded using a short-range telemetry HR transmitter belt at intervals of 1 s, in which data recording took place from the moment the athletes put on the microsensors (Polar Team Pro System, Polar Electro Oy, Kempele, Finland).

The HR zones were determined through the maximum HR expected for young athletes¹³. However, if a higher value of maximum HR value was recorded throughout the training sessions, it would serve as a reference and replace the estimated value by the formula. In this sense, TRIMP was calculated based on the time spent in each HR zone and multiplied by a zone-specific weighting factor as proposed by Edwards⁷: zone 1 (50 -59% of maximum HR), factor 1; zone 2 (60-69% maximum HR), factor 2; zone 3 (70-79% HR maximum), factor 3; zone 4 (80-89% HR maximum), factor 4; and zone 5 (90-100% HR maximum), factor 5, and these scores are then added together.

Session RPE

The subjective method was the Session RPE, proposed by Foster et al.⁶ Approximately 30 minutes after the end of each session and without any contact with each other, the athletes answered the question “How was your workout?”, pointing to the CR-10 RPE scale, a value from 0 (“rest”) to 10 (“maximum”) referring to the descriptor that represents the global intensity of the training session. All of the young athletes assessed indicated a number on the scale that represented an entire training session. The Session RPE was obtained from the product of the duration of the training session, in minutes, from the value of the training intensity (represented by the score indicated on the scale), resulting in a value in arbitrary units (AU).

Recovery Status

To monitor the state of recovery, before each training session, the athletes responded to the TQR scale, proposed by Kenttä and Hassmén¹⁰. They answered the question “How do you feel about your recovery?”, pointing out a scale value ranging from 6 (“not at all recovered”) to 20 (“completely well recovered”), and its corresponding description.

Statistical analysis

Descriptive data analysis, the Kolmogorov-Smirnov test, and the Levene test were performed to assess the normality and homogeneity of the data. The repeated measures ANOVA with Bonferroni post-hoc was used to identify differences in the analyzed variables between the modalities. The Pearson correlation test was used to test the existence of a correlation between the variables Session RPE and TRIMP. Correlation magnitudes were evaluated according to established criteria: trivial (0 - 0.10), small (0.11 - 0.30), moderate (0.31 - 0.50), large (0.51 - 0.70), very large (0.71 - 0.90) and almost perfect (0.91 - 1.00)¹⁴. All analyses were performed using SPSS statistical software version 22.0 (IBM Corp., Armonk, NY), adopting a significance level of 5% ($p \leq 0.05$).

Results

The mean behavior of the physical demand variables, taking into account the 10 training sessions for each modality is described in Table 1. Table 2 shows the mean behavior of the psychophysiological response.

Table 1. Physical demands over the 10 training sessions monitored

	Soccer	Basketball	Handball	Volleyball
Duration (min)	69.42±15.45*#	76.98±11.62*	86.93±12.27	97.61±12.53
DC (m)	3819 ± 1067	3376 ± 647	4102 ± 1296	3176 ± 789
DC_Z1 (m)	2301 ± 537	1811 ± 345*	2161 ± 545	2434 ± 468
DC_Z2 (m)	1118 ± 453*	1066 ± 266*	1156 ± 458*	547 ± 234
DC_Z3 (m)	359 ± 184*	419 ± 198*	601 ± 421*	87.07 ± 94.47
DC_Z4 (m)	33 ± 40#	53.69 ± 43	103.59 ± 136.44*	5.89 ± 15.3
DC_Z5 (m)	6.21 ± 13#	25.53 ± 29.63	78.78 ± 166.84*	2.03 ± 6.61
Sprints (n)	0.81 ± 1.66#†	17.41 ± 9.48*	24.14 ± 22.18*	0.29 ± 0.85

Note:DC = total distance covered; DC_Z1 = distance covered at speed 0-2m/s; DC_Z2 = distance covered at speed 2.02-3.97 m/s; DC_Z3 = distance covered at speed 4-5.97 m/s; DC_Z4 = distance covered at speed 6-7 m/s; DC_Z5 = distance covered at speed above 7.02 m/s. *Significant difference to volleyball; #Significant difference to handball; †Significant difference to basketball. Data presented as mean ± SD.

Source: author

Table 2. Mean and standard deviation of psychophysiological responses and recovery state

	Soccer	Basketball	Handball	Volleyball
TRIMP	186.5 ± 67.93#*	211.27 ± 47.07*	258.03 ± 70.53	266.19 ± 74.72
Session RPE	274 ± 127†	443.06 ± 126.05*	380.22 ± 162.5	331.62 ± 109.45
TQR	16 ± 1.5	17.05 ± 2.1#	15.26 ± 3.15	15.88 ± 2.01

Note:*Significant difference to volleyball; #Significant difference to handball; †Significant difference to basketball. Data presented as mean ± SD

Source: author

Figure 1 shows the composition of the modalities through the HRmax zones of TRIMP, handball presented the highest percentage of time in zone 4 (26%) and 5 (12%) among the evaluated modalities. In soccer, the highest percentages were found in zone 2 (26%) and 3 (24%), as well as in basketball (zone 2 - 28% and zone 28%) and volleyball (zone 2 - 30% and zone 3 - 30 %).

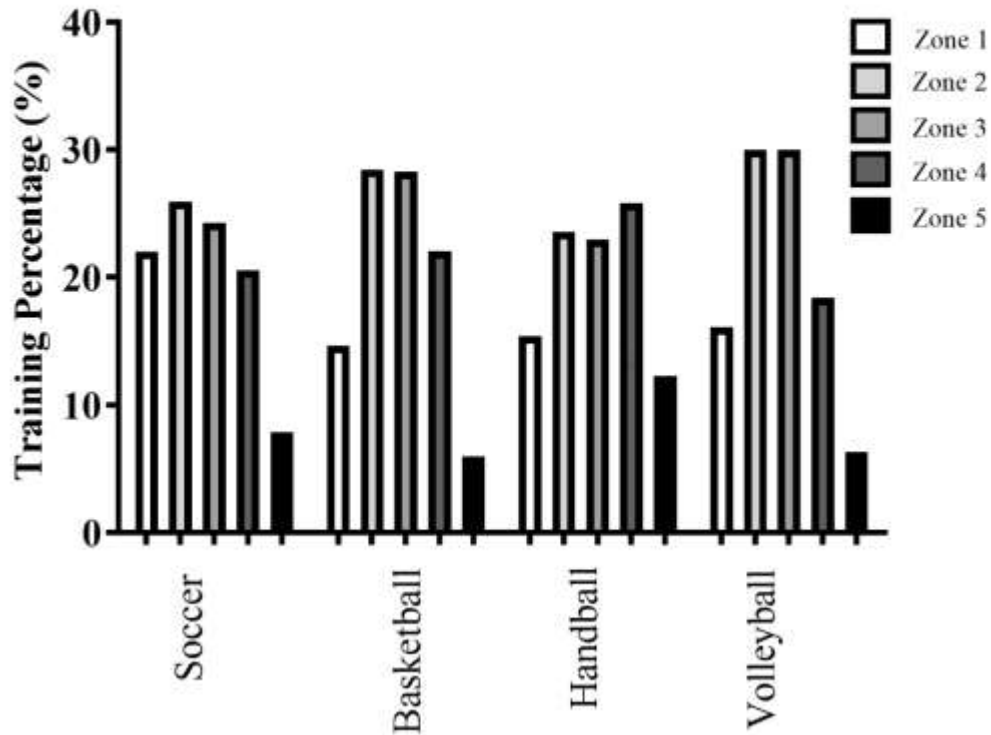


Figure 1- Percentage by TRIMP zones in different modalities
Source: author

Significant correlations of moderate and positive magnitude were found between session RPE and TRIMP in soccer ($r = 0.47$; $p < 0.05$), basketball ($r = 0.40$; $p < 0.05$), handball ($r = 0.32$; $p < 0.05$) and volleyball ($r = 0.36$; $p < 0.05$). The psychophysiological response monitored in each session by the TRIMP and session RPE methods of the sessions in the different modalities are presented in Figure 2.

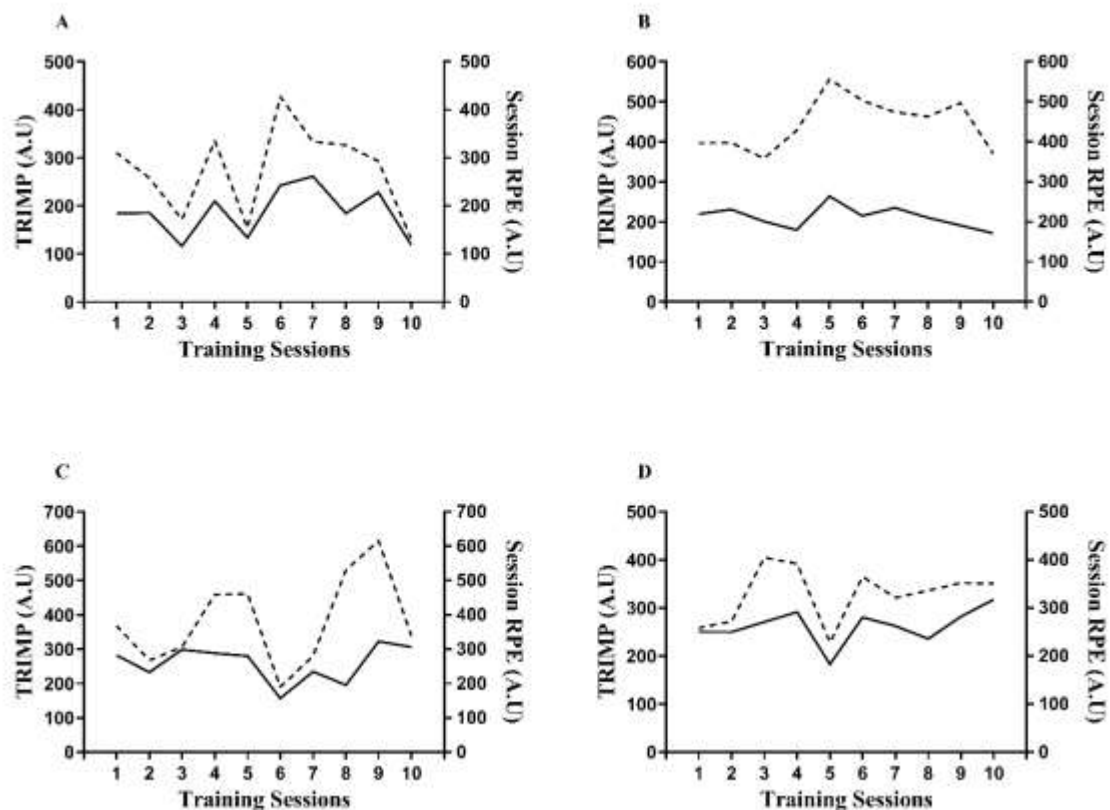


Figure 2- Mean TRIMP and Session RPE during the 10 training sessions in soccer (A), basketball (B), handball (C), and volleyball (D). - - - Session RPE TRIMP

Source: author

Discussion

The objectives of this study were to compare the physical demands and the psychophysiological stress induced by specific training sessions in young athletes' team sports and to correlate the methods of monitoring the psychophysiological responses, TRIMP, and Session RPE.

Regarding the variables of physical demands used in our study, the values obtained for distance covered (DC) were lower compared to the study in soccer with young athletes¹⁵ and during matches in professional basketball athletes¹⁶. In handball, the values were similar to those of young athletes¹⁷ and in volleyball, DC was higher than professional athletes in matches of 3 and 4 sets¹⁸. The other markers such as DC_Z and several sprints presented different values when compared to other studies in the evaluated modalities^{15,19,20} these differences may be explained by the different definitions used for the speed and sprint zones in our and other studies. The differences found in the physical demands variables in our study are due to the characteristics of the sports assessed as well as the organization of the training in each modality.

For the monitoring of psychophysiological response, the TRIMP and Session RPE were used, the values found in soccer and volleyball were similar to those of studies with professional and university athletes, both in TRIMP^{21,22} as in the Session RPE^{21,22}. In basketball, the observed TRIMP values were higher than in other studies^{23,24} and the Session RPE values were lower or similar compared to other studies^{23,24}. In handball, the Session

RPE had lower values than the male elite team²⁵, however, no studies were found that used TRIMP as a method of monitoring the psychophysiological response.

When evaluating the time in the HR zones divided by TRIMP, it was observed that in soccer there was a higher prevalence in Zone 2 and Zone 3 during training, in line with previous studies²⁶, but in comparison to studies that evaluated matches for a higher prevalence of Zone 4 and Zone 5^{26,27}. Zone 2 and 3 predominated in basketball, corroborating the findings of Lupo et al.²³ with under-17 basketball athletes. About handball, was the sport among the evaluated ones that had the longest time in Zone 4 and Zone 5, and in professional athletes, it is the highest concentration of effort during different game situations²⁸, the highest number of sprints recorded is a possible explanation for a longer time in Zone 4 and Zone 5 in our study. In volleyball there was a prevalence of Zone 2 and Zone 3, similar results were observed among college athletes in technical-tactical training²¹ as well as professional athletes²⁹.

The correlations between the TRIMP and Session RPE methods of the session, for the evaluated modalities, were significant and of moderate magnitude. In soccer, Impellizzeri et al.³⁰ found a correlation between the methods in young soccer athletes ($r = 0.54 - 0.78$; $p < 0.01$), while Rodríguez-Marroyo et al.²¹ found no correlation between these methods ($r = 0.17$; $p = 0.335$) in young soccer athletes, but the average age of the athletes was 11.4 ± 0.5 years. In basketball, Lupo et al.²³ observed a significant correlation when investigating young basketball players ($r = 0.85$; $p < 0.01$).

Maciel et al.¹⁷ reported a moderate correlation ($r = 0.40$; $p < 0.001$) in youth women handball players. In volleyball, Duarte et al.²⁹ demonstrated a significant correlation between the methods in tactical training and also in technical training in general with professional athletes. However, no studies were found in young volleyball athletes to establish a correlation between these monitoring methods.

Conclusion

The tools used for monitoring psychophysiological response (session RPE and TRIMP) and physical demands (GPS) and also the recovery state (TQR) are useful to be used with young athletes in modalities evaluated. These modalities showed similar behavior regarding time in the heart rate zones, with the exception of handball, with a longer time in zones 4 and 5 compared to the others. In the monitoring of the physical demands, the basketball and handball modalities showed a higher number of sprints and also greater distances in the speed zone 5, justifying higher RPE values for the session in these modalities. That is, the information complements each other. In this way, monitoring psychophysiological response and physical demands together generates important information for coaches and physical trainers.

However, the study presents some limitations, the use of young athletes of different genders and the sports evaluated are characterized by different movements. Future studies should assess different ages by categories of these sports and also monitor the characteristics of the environment in which training takes place, such as temperature and humidity. Monitor possible HR responses to training due to their impact on training.

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