ANALYSIS AND COMPARISON OF TRAINING LOAD BETWEEN TWO GROUPS OF WOMEN'S ARTISTIC GYMNASTS RELATED TO THE PERCEPTION OF EFFORT AND THE RATING OF THE PERCEIVED EFFORT SESSION

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Original article

Abstract

The aim of this study was to assess the internal training load in female artistic gymnastics through subjective perception of effort (PSE) by calculating the sRPE variable and different associated variables. Ten gymnasts participated (age: 14.4 ± 2.9 years; height: 1.5 ± 0.1 m; mass: 43.3 ± 12.2 kg) and were divided into two groups according to their competitive level and weekly training volume: High Level Gymnasts (HLG) and Medium Level Gymnasts (MLG). The PSE of each gymnast was recorded daily for four weeks after the end of each training block. The HLG group recorded a significantly higher RPE and sRPE value in the specific physical preparation (SST) and in the parallel technical training (UB) contents ($p < 0.05$) compared to MLG. Statistically significant differences were also obtained from the registered mean values of RPE and sRPE when comparing training content. Furthermore, a direct relationship between volume and workload was observed. Finally, the variables associated with injury risk control provided relevant information to determine that the HLG group had a higher risk of injury than the MLG group. Therefore, the sRPE has been a useful tool to assess the internal training load in women's artistic gymnastics. Such information may help quantify the load in this sport in the future.

Keywords: *training load, internal load, gymnastic.*

INTRODUCTION

Training load is defined as the set of stimuli that cause certain effects on the organism (Mujika, 2013; Navarro, 1999; Zintl, 1991). In order to identify the effects of training on athletes, observe whether specific adaptations are achieved, understand individual responses to training, and evaluate fatigue and the need for associated recovery processes, it is necessary to quantify and monitor the training load of athletes (Bourdon, et al., 2017; Mujika, 2013).

Training load measurements can be classified as internal and external. Internal load can be defined as biological stimuli (physiological and psychological) applied to the athlete during training or competition (Bourdon et al., 2017); while the external load is an objective measurement, exercised by the athlete regardless of the internal characteristics, and usually measured through the power output, speed, acceleration, analysis of movement as a function of time, measurements through GPS systems or parameters derived from measurements with accelerometers (Bourdon et al., 2017).

Internal load is mainly measured by four internal variables: heart rate (HR), maximum oxygen consumption (VO2 max), blood lactate concentration (BLC) and subjective perception of effort (SPE), (Bourdon et al., 2017; Mujika, 2006). In general, if the effort is controlled with several of these variables simultaneously, we have a valuable and useful tool available to control and plan training (Achten & Jeukendrup, 2003; Hopkins, 1991; Viru &Viru, 2000).

More and more studies are paying attention to the sensations that athletes experience during training (Foster, 1998; Gabbett, 2016; Gabbett, 2020; Hulin & Gabbett, 2019; Malone, Hughes, Doran, Collins, & Gabbett, 2019). Cognitive awareness of these sensations considers a form of feedback in which central, peripheral, and metabolic changes that occurred during exercise are integrated (Pfeiffer, Pivarnik, Womoc, Reeves, & Malina, 2002). The most widely used indices controlled in the athlete's perception to observe and control these psychological variables include: the profile of mood states (POMS) and its derivatives (McNair, Loor & Droppleman, 1971), the RPE (Rating of Perceived Effort) or Borg scale (Heath, 1998), the session-RPE (sRPE) (Foster et al., 1996) and the Recovery Stress Questionnaire for athletes (Bourdon et al., 2017).

Currently, the RPE scale is frequently used during physical exercise, and the subject is instructed to verbally express a numerical value for their RPE with the help of text descriptors on the scale (Pereira, Souza, Reichert, & Smirmaul, 2014). Foster et al., (1996), in an attempt to simplify the quantification of training load, introduced the term "Session-RPE" (sRPE). The session load is calculated by multiplying the session RPE by the exercise session duration (in minutes), (Borresen & Lambert, 2009; Foster et al., 2001). One of the main benefits of this index is that it caters for the different modalities that a training has, in addition to the fact that it is favorably related to the objective and to other tools for quantifying internal load (Williams et al., 2017). It is also an economical and very practical tool.

The variables that can be calculated from the sRPE measurement are: weekly load accumulation (weekly sum of daily load values) (Colby, Dawson, Heasman, Rogalski, & Gabbett, 2014; Gabbett et al., 2017; Rogalski, Dawson, Heasman, & Gabbett, 2013), changes between training weeks (absolute difference between training load totals for the current and previous week) (Cross, Williams, Trewartha, Kemp, & Stokes, 2016; Rogalski et al., 2013), monotony of workouts (average weekly load x standard deviation between the daily values of week load) (Foster, 1998), training stress (weekly training load × training monotony) (Foster et al., 2001) and chronic acute workload, which is calculated by expressing player's acute workload as a percentage of their chronic workload (Hulin et al., 2014) and the exponentially weighted moving average (Holt, 2004; Keskin, Kıraç, Kara, & Akarun, 2013).

The purpose of measuring monotony, load and stress is to increase the quality of work and reduce injuries. Training monotony is a metric that assesses load fluctuations at the repetition site of the exercise (Comyns & Flanagan, 2013). Stress refers to how hard someone is working based on the backlog of work done over time, usually per week (Comyns & Flanagan, 2013). Many sports scientists are currently investigating how the daily load, the periodic monotony and the stress that results from the relationship of the two services effect (Comyns & Flanagan, 2013; Colby, Rogalski, Dawson, Heasman, & Gabbett, 2013; Dawson, Heasman, Rogalski, & Gabbett, 2014; Gabbett et al., 2017). Studies have shown that gymnastics is a very complex sport due to high demand for technical perfection (Cavallerio, Wadey, & Wagstaff, 2016). Hence, obtaining indices that control the risk of injury can be of great help to improve gymnasts' performance.

There are several studies that provide reliable data on how to consider the subjective perception of effort, a useful method to quantify the training load in women's artistic gymnastics (WAG), (Minganti, Capranica, Meeusen, Amici, & Piacentini, 2010; Sartor, Vailati, Valsecchi, Vailati, & De La Torre, 2013).

The objectives of this study were: (1) to assess the internal training load in WAG using the sRPE and different associated variables (accumulation of weekly load, accumulation of load of a training cycle (4 weeks), monotony of workouts, training tension and chronic acute workload); (2) to compare the differences in the variables analysed between two groups of gymnasts (High Level Gymnasts (HLG) vs Medium Level Gymnasts (MLG)) of different age, level of competition and volume of training, and (3) to compare the existence of differences in the perception of effort and training load between different contents of training in women's artistic gymnastics (WAG).

The analysis was performed using data from the sessions and differentiates the training content in order to analyse whether there are differences between the training load of the physical preparation contents used in sessions, and the technical contents in the four-competition apparatus (vault, uneven bars, balance beam and floor exercise). In this way we are able to assess whether the effort perceived by gymnasts in the diverse work contents is different. In addition, we can observe the evolution of the effort perceived during the four weeks of training and obtain certain indexes that help control the risk of injury.

METHODS

Ten gymnasts at the national competitive level (age: 14.4 ± 2.9 years; height: 1.5 ± 0.1 m; mass: 43.3 ± 12.2 kg) participated in the study. According to their competitive level and weekly training volume they were divided into two groups, into high level gymnasts (HLG) (n = 5) (Age: 17.25 ± 0.95 years; Level 7-8; 20 h / week) and medium level gymnasts (MLG) (n = 5) (Age: 13.25 ± 0.98 years; Level 4-6; 17 h / week). The HLG training week consisted of 4 sessions of 3 hours (Monday, Tuesday and Wednesday) and 2 sessions of 4 hours (Friday and Saturday) (Rest day: Sunday). The MLG training week consisted of 3 sessions of 3 hours (Monday, Tuesday and Wednesday) and 2 sessions of 4 hours (Friday and Saturdays) (Rest days: Thursday and Sunday). Training sessions were divided into 30-minute blocks with different training content. As there are transition times between each block, the start and end time of each block was recorded in a spreadsheet to have a more precise reference of the duration of each. The subjective perception of effort (RPE) for each gymnast was recorded daily for four weeks after completing each training block and just after the transition time and the start of the next block. The gymnasts became familiar with the use of this instrument for three days in the week prior to the start of data collection. Gymnasts recorded RPE values on a computer located in the training room with the adapted Borg scale of values right in front of them (Heath, 1998). This ten-item scale ranges from 1 (rested; effortless) to 10 (maximum effort). The RPE data was used to calculate the variable "session-RPE" (sRPE), which was calculated by multiplying each gymnast's CR-10 RPE score by the duration of each block (Foster, 2001). With the control of time and the RPE value for each content, the specific value of sRPE was calculated as the sum of 6 or 8 training blocks comprising the total load of the session. The training contents that were differentiated were: General Strength Preparation (GST), Specific Strength Preparation (SST), Vault Technique (VA), Uneven Bars Technique (UB), Balance Beam Technique (BB), Floor Technique (FX), Preparation Physical Resistance (END), Physical Preparation Flexibility (FLEX) and Trampoline (TRP). The contents of warm-up and return to calm were not analysed.

The variables used in the study were: total load (4-weeks) (sRPE); total load per content (4-weeks) (sRPEGST, sRPESST,…); relative load of cycle per content (% sRPEGST,% sRPESST ,. .); training monotony (Tm) (Foster, 1998); training strain (Ts) (Foster, 1998), and acute: chronic workload (ACW) (Hulin, Gabbett, Blanch, Chapman, Bailey & Orchard, 2014).

The variable Tm was noted by Foster (1998) as a training variability index that can be defined as the daily mean / standard deviation calculated over a period of time. Ts is defined by this same author as the product of training load and training monotony (Foster, 1998). Both variables give information about negative adaptations to training. Table 1 shows schematically the calculations of variables Tm and Ts.

The variable Acute: chronic workload (ACW) was defined by Hutlin et al. (2012) as a parameter that would help quantifying the risk of injury to the athlete. It is calculated by exposing the acute training load (accumulation of load in one week) in relation to the chronic training load (average of the load registered during the last 4 weeks of training (Table 1). The risk of injury is very low (ACW <0.49), low (0.50 <ACW <0.99), moderate (1.00 <ACW <1.49), high (1.50 <ACW <1.99) or very high (ACW> 2.00) (Hutlin et al., 2014).

Table 1
Schematic evaluation of the Training monotony (Tm) and Training strain (Ts) variables from the sRPE values of the high-level gymnasts (HLG) at week 1 of registration.

WEEK 1 (HLG)			
Day	Duration (min)	RPE	Load
Monday	110	4.6	504.2
Tuesday	117	3.8	443.6
Wednesday	108	6.7	720.0
Thursday	109	5.7	617.7
Friday	165	5.2	849.8
Saturday	174	5.0	870.0
Daily Mean Load			667.5
Daily standard deviation of load			176.8
Monotony (Daily mean/standard deviation)			3.8
Weekly load (daily mean load x 6)			4005.2
Strain (Weekly load x Monotony)			1060.7

The data analysis was performed with version 25.0 of IBM SPSS for Windows (IBM Corporation, Armonk, NY, USA). Descriptive statistics mean and standard deviation of all data sets were calculated. To check the normality and homogeneity of the variables used for the comparison between the two groups of gymnasts (HLG vs. MLG), the Kolmogorov-Smirnov (K-S) test and the Levene test (homogeneous variances) were applied respectively. However, considering the size of the sample, it was decided to apply non-parametric statistics. To identify the existence of differences between the two groups of gymnasts, the nonparametric Mann-Whitney U test was calculated. To observe the differences between the perceptions of each content and determine how different content is perceived compared to the others, as well as to observe if there are contents that imply a greater load, the Kruskal Wallis test was carried out. η^2 was used as the effect size index (Morse, 1999). The Mann-Whitney U post-hoc test was applied in pairs to compare data between the two groups. The interpretation for η^2 was categorized as small for effect sizes 0.01 - 0.06, medium for 0.06 - 0.14, and large for $\geq$ 0.14 (Cohen, 1988). The significance level for all procedures was established at 0.05.

All gymnasts voluntarily participated in the study, and were informed about its design, implications, and characteristics. After receiving detailed information, they signed an informed consent. Ethical standards for human study were met as recommended by the Declaration of Helsinki, and the study was conducted in accordance with international ethical guidelines for research in the sciences of physical activity and sport (Harriss, Macsween, & Atkinson , 2020).

RESULTS

Table 2 represents the descriptive statistics of RPE and sRPE for each content of the two groups of gymnasts analysed. The HLG group registered a significantly higher RPE value in the SST content (Z=3.03; p=0.002) and in the uneven bars technical training (UB) (Z=3.05; p=0.002), compared to MLG (Figure 1). No significant differences were observed in other analysed training contents.

The SST contents (Z=2.03; p=0.04) and the UB training (Z=3.17; p=0.001) also show a statistically significant difference in the quantification of the training load using the sRPE (Figure 1).

Statistically significant differences were obtained from the recorded mean RPE values in the comparison by training content. The results of the Kruskal-Wallis test calculated with the RPE results of the HLG group ($x^2(5)$=69.63; $p < 0.001$; η^2=0.458), and MLG group ($x^2(5)$=46.26; $p < 0.001$; η^2=0.458), show differences between analysed contents.

In the HLG group, the contents of GST (5.2 ± 1.0) and FLEX (1.8 ± 0.6) showed RPE values significantly ($p < 0.05$) lower than the rest of the training contents (Figure 2). However, there were no significant differences regarding the RPE of the HLG group among the technical contents for different apparatus ($p > 0.05$) (Figure 2).

Regarding the MLG group, the FLEX content (2.2 ± 0.9) continued to show a significantly lower value ($p <0.05$) than the rest of the training content. As also happened with the HLG group, the MLG group did not show significant differences among the technical contents carried out on different apparatus (Figure 2). The GST content showed a significant difference ($p < 0.05$) in comparison to the technical work on balance beam (BB). In addition, the SST content showed significant differences ($p < 0.05$) between the balance beam (BB) and ground (FX) contents. No significant differences were found among the contents of technical training on different apparatus.

Comparisons in the case of the sRPE variable were made by calculating the relative value in relation to each training content block. The training time of the HLG group was greater than that of the MLG, therefore, the absolute values of sRPE were superior with a higher training volume.

Table 2
Results (MD ± SD) of rating of perceived exertion (RPE) and session-RPE (sRPE) by training content in the groups of high-level gymnasts (HLG) (n = 5) and medium-level gymnasts (MLG) (n = 5).

	HLG (n=5)		MLG (n=5)	
	RPE	sRPE	RPE	sRPE
GST	5.17±0.96	97.90±15.63	5.37±0.94	103.64±18.07
SST	6.57±0.79 ***	125.04±27.14 **	5.57±1.30 ***	103.95±35.08 **
VA	5.71±0.68	118.38±22.28	5.68±0.28	112.74±11.14
UB	6.56±1.13 ***	134.23±24.12 *	5.82±0.91 ***	117.91±20.45 *
BB	6.16±0.82	123.09±18.50	6.13±0.34	128.78±14.04
FX	6.85±1.50	135.33±29.22	6.49±0.89	130.39±19.61
END	8.70±0.36	123.23±12.67	8.93±0.45	133.42±19.86
FLEX	1.83±0.64	36.66±14.78	2.17±0.91	44.99±20.11
TRP	3.34±1.92	67.43±41.17	3.81±0.72	80.31±10.22

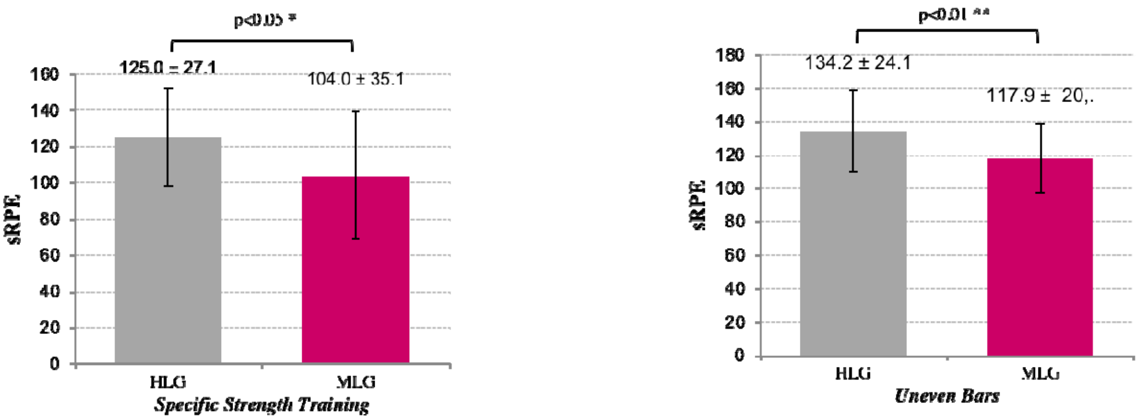

Figure 1. Statistically significant differences in the mean session-RPE (sRPE) value found between high-level gymnasts (HLG) and medium-level gymnasts (MLG) in the contents of Specific Physical Preparation (SST) training and technical training in uneven bars (UB) .

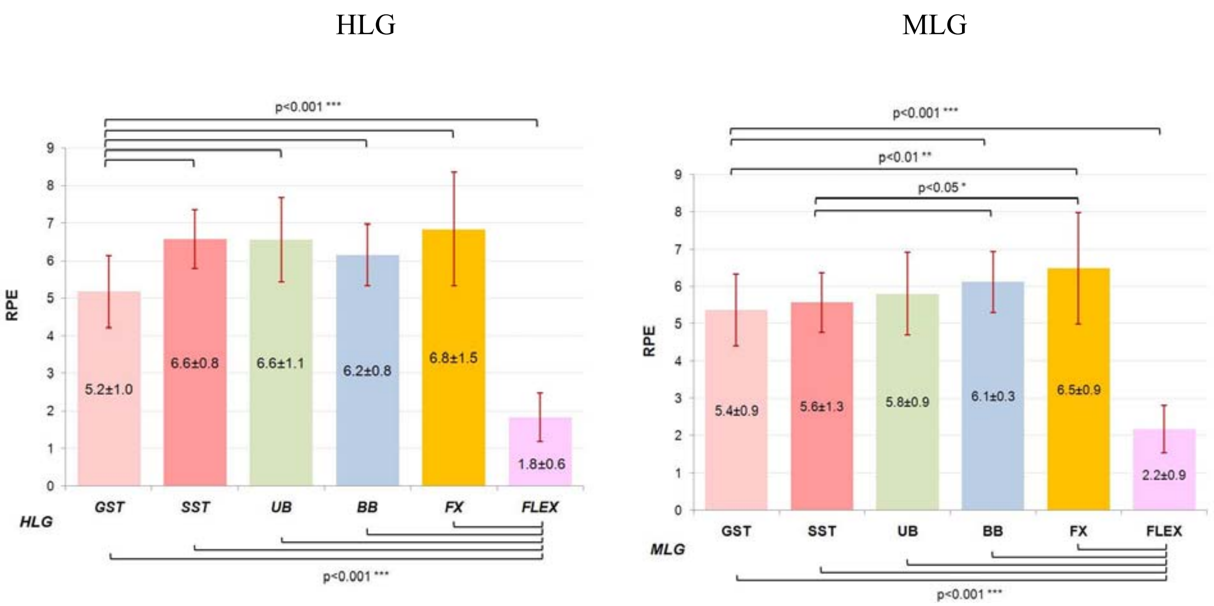

Figure 2. Statistically significant differences in the mean rating of perceived exertion (RPE) value found between the contents (HLG = high level gymnasts; MLG = medium level gymnasts). Statistically significant differences at 0.05 level.

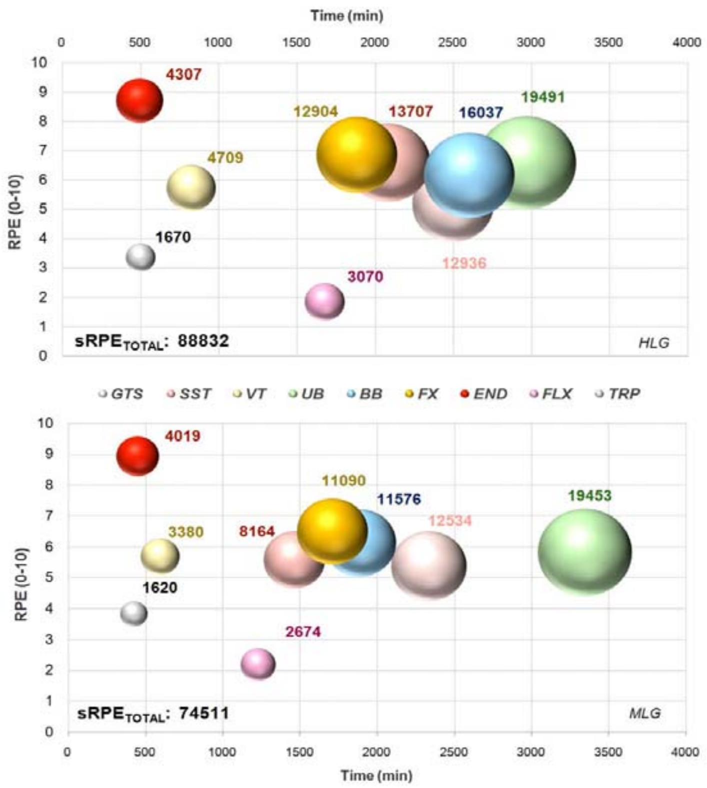

Figure 3. Results of the amount of training load (sRPE) by training content in the HLG and MLG groups as a function of the volume (Time) and Intensity (RPE) of the load (sRPE = session rating of perceived exertion; RPE = rating of perceived exertion; HLG = High Level Gymnasts; MLG = Medium Level Gymnasts; GST = General Strength Training; SST = Specific Strength Training; VT = Vault; UB = Uneven Bars, BB = Balance Beam; FX = Floor; FLEX = Flexibility; TRP = Trampoline).

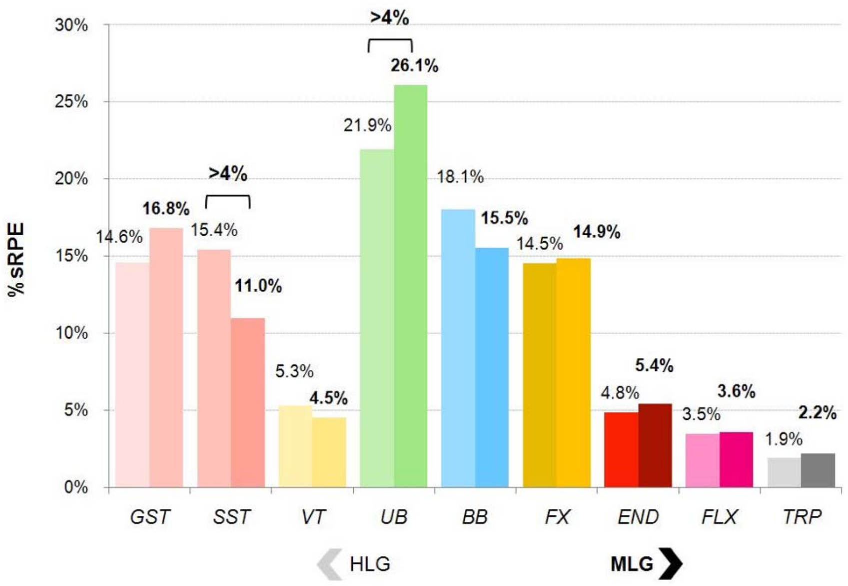

Figure 4. %SRPE values per content (HLG = High Level Gymnasts; MLG = Medium Level Gymnasts; GST = General Strength Training; SST = Specific Strength Training; VT = Vault; UB = Uneven Bars, BB = Balance Beam; FX = Floor; FLEX = Flexibility; TRP = Trampoline).

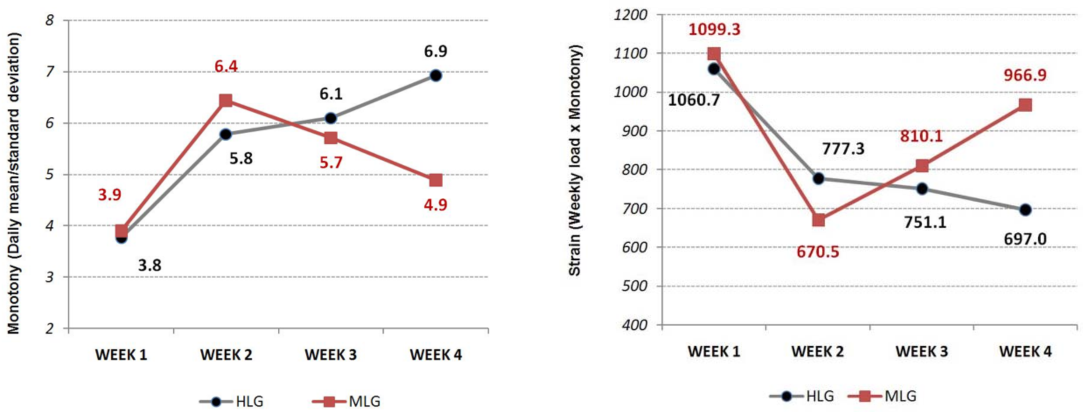

Figure 5. Comparison of the monotony and tension curves of the gymnasts during the four weeks of training (HLG = High Level Gymnasts; MLG = Medium Level Gymnasts).

Table 3
Results of the variable Acute: chronic workload (ACW) of all the gymnasts analyzed.

Week Total Load sRPE (Acute load)						
HLG	Week 1	Week 2	Week 3	Week 4	*CW*	*ACW*
Gymnast 1	4674	5075	5061	5299	5027.3	*1.05*
Gymnast 2	4024	3406	3544	4487	3865.3	*1.16*
Gymnast 3	3204	4993	3472	5442	4277.8	*1.27*
Gymnast 4	4139	4591	4565	4611	4476.5	*1.03*
Gymnast 5	4160	4666	4309	5110	4561.2	*1.12*
MLG	Week 1	Week 2	Week 3	Week 4	*CW*	*ACW*
Gymnast 1	3438	3642	3789	3534	3600.8	*0.98*
Gymnast 2	3458	3871	3736	4258	3830.8	*1.11*
Gymnast 3	3583	3830	3727	3630	3692.5	*0.98*
Gymnast 4	3738	3742	2678	4357	3628.8	*1.20*
Gymnast 5	3684	3771	3887	4158	3875.1	*1.07*

**CW: chronic workload; ACW: acute chronic workload*

The mean load volume (sRPE) per content block also showed statistically significant differences in the Kruskal-Wallis test results when comparing different working contents, both in the HLG group ($X^2(5)$ = 73.90; p < 0.001; η^2= 0,458) as in that of MLG ($X^2(5)$ = 51.60; p < 0.001; η^2= 0,458).

The differences between the training contents in terms of sRPE per block presented the same differences in the HLG group as those shown in the case of RPE, except for the significant difference between the content on uneven bars (UB) and balance beam (BB), being significantly higher on the uneven bars apparatus (UB) (p < 0.005). In the HLG group, the contents of SST (97.9 ± 15.6) and especially the FLEX (36.7 ± 14.8) revealed a load volume per block significantly lower (p < 0.05) than the rest of the contents. No statistically significant differences were found among the rest of the training contents under comparison.

The same trend was observed in the MLG group with respect to the contents, i.e., the lowest volume of load per block presented significantly (p < 0.05) with the rest of the contents (GST: 103.6 ± 18.1; FLEX: 45.0 ± 20.1). In this case, it is observed that the technical contents in BB (128.8 ± 14.0) and FX (130.4 ± 19.6) show a significant difference (p <0.05) due to their load value of training higher than GST (103.6 ± 18.1) and SST (104.0 ± 35.1). In addition, there is another significant difference between the content on uneven bars (UB) (mean / ds) and balance beam (BB) (mean / ds).

In a single graph, Figure 4 presents the results of load volume (Time (min): horizontal axis X), intensity of load (RPE: vertical axis Y) and amount of training load (sRPE: volume of sphere) of the two groups of gymnasts.

It points out out that the technical content of UB is the one with the highest total training volume (HLG: 2970 min; MLG: 3345 min) and relative training volume (HLG: 21.9%; MLG: 26.1%); whereas the two groups of trampoline gymnasts (TRP) recorded lower total training volume (HLG: 1670 min; MLG: 1620 min) and relative training volume (HLG: 1.9%; MLG: 2.2%).

Regarding the perceived intensity of each training content (RPE), the END obtained in both groups the highest values (RPE_{HLG}= 8.70±0.36; RPE_{MLG}= 8.93±0.45). The content in which the gymnasts showed a lower intensity value was FLEX (RPE_{HLG}=1.83±0.64; RPE_{MLG}= 2.17±0.91), (Figure 3).

In both groups, it was agreed that the UB technical training content registered the highest training load (sRPE) ($sRPE_{HLG}$= 19491; $sRPE_{MLG}$= 19453) and that the lowest training load was found in trampoline ($sRPE_{HLG}$= 1670; $sRPE_{MLG}$= 1620), (Figure 3).

The total sRPE was higher for the HLG group ($sRPE_{HLG}$= 88832; $sRPE_{MLG}$= 74511). For a more reliable comparison, the relative value (%) of sRPE by content is also taken into account, with UB training being the content with the highest % sRPE ($\%sRPE_{HLG}$ = 21.9%; $\%sRPE_{MLG}$ = 26.1%) (Figure 4).

Figure 5 shows the results of monotony (Tm) and tension (Ts) calculated from the training load recorded by gymnasts from their weekly sRPE values. The HLG group showed a constant increase during the 4 weeks of training of the value of Tm, registering the maximum peak in the fourth week (Tm_{HLG} = 6.9). The MLG group obtained their maximum peak in the second week of training (Tm_{MLG} = 6.4), decreasing the value in the third and fourth week. For both groups, the lowest Tm result was obtained in the first week (Tm_{HLG}= 3.8; Tm_{MLG}= 3.9).

The evolution of Ts was different; the maximum values were obtained for both groups in the first week (Ts_{HLG}= 1060.7; Ts_{HLG}= 1099.3). The HLG group experienced a decrease in Ts during the following weeks of training, obtaining the minimum value in the fourth week (Ts_{HLG}= 697.0). The MLG group obtained the minimum tension result in the second week (Ts_{MLG}= 670.5), subsequently registering an increase during the third and fourth week.

Finally, the ratio between chronic and acute workload (ACW) was calculated (Hulin et al., 2014). Every high-level gymnast was observed to have a moderate risk of injury (ACW> 1.0) and only two medium-level gymnasts had low risk of injury (ACW <1.0) results (Table 3).

DISCUSSION

The main objective of this study was to assess the internal training load in WAG, based on the RPE record, by calculating the sRPE variable and applying different variables associated with measuring training load, in order to assess the risk of injury for gymnasts.

The RPE values of the different training contents showed statistically significant differences between both analyzed groups (HLG vs. MLG). The HLG group expressed a higher RPE in 5 of the 9 training contents evaluated. The difference between the RPE of the SST contents (Z=3.03; p=0.002) and the UB (Z=3.05; p=0.002) was higher and statistically significant in the HLG group. No other differences were found between the two analysed groups regarding their RPE of the training contents.

To a certain degree these results coincide with the study by Burt, Naughton, Higham, & Landeo (2010), in which they affirm the perceptions that training load is greater for gymnasts at a higher level of competition. In our case, a higher evaluation of the RPE was observed for the HLG group. This aspect is evident in the four-competition apparatus. This difference may be due to the difficulty of the technical elements worked on, which can directly influence the assessment of intensity in the technical work blocks. In the future, it would be interesting to analyse the possible relationship between the technical difficulty of the trained elements (A, B, C, D, etc.) and the associated RPE recorded. Determining a greater perception of effort depending on the difficulty of the elements carried out could be very useful when designing the training loads involved in technical work on the different apparatus.

It should be noted that the SPE scores for the technical work contents on the different apparatus were found in the range of 5.7 to 6.8, a range of values that are considered on the RPE scale as moderate perceived efforts. The study by Sartor et al. (2013) demonstrates that obtaining moderate results in relation to the perceived effort could be due to the fact that gymnasts were asked to rate the RPE during the entire training session, as well as after effective work on each apparatus. In the present study, the intention was to solve the first problem raised by Sartor et al. (2013), i.e., to record the RPE after each training block. Despite recording after each content-specific training period, assessment of the technical work on apparatus continued to be considered as a moderate perceived effort. An attempt was made to get as close as possible to the effective work on each apparatus by noting the specific start and end of each block; this aspect is closer to the calculation of the sRPE but is not a reflection of the actual work done by the gymnast on the apparatus due to the intermittent nature of gymnast's performance on the training apparatus.

Another aspect to analyse is the relationship exposed by Burt et al. (2010) between the gymnasts´ perception of effort and working time. The contents with the highest volume of work had higher perceptions (Burt et al., 2010). This direct relationship between volume and workload is also observed in the present study (Figure 4), the UB content being the one with the highest volume and training load, both in the HLG and MLG group; whereas the TRP content was the one with the lowest volume and training load in both groups.

It should be noted that the content considered to be the most intense was END, characterized by interval aerobic work with hardly any recovery time. On the other hand, the content considered to be less intense was the FLEX content, work in static and with hardly any fatigue production.

The amount of training load (sRPE) showed differences quite similar to those reported in the case of RPE. A higher total training load was observed in the HLG group ($sRPE_{HLG}$ = 88832) versus the MLG group ($sRPE_{HLG}$ = 88832). This difference was influenced both by the longer training time of the HLG gymnasts (T_{HLG} = 15545 min; T_{MLG} = 13445 min) and by the greater average perception of effort in this group (RPE_{HLG} = 5.7±2.0; RPE_{MLG} = 5.5±1.8).

In both cases the highest volume load was recorded on uneven bars (UB: $sRPE_{HLG}$ = 19491; $sRPE_{HLG}$ = 19453). In this case, such a high load value is directly related to the content with the highest load volume (UB: T_{HLG} = 2970 min; T_{HLG} = 3345 min) since, as we have previously indicated, it is not the apparatus that registers the higher values of RPE.

The most notable differences between the amount of load (sRPE) by content were found in the GST and FLEX contents, which showed statistically significant differences ($p < 0.05$) in comparison to other contents, both in the HLG group and in the MLG group.

Regarding the validity of this method to quantify the load in gymnasts, the study by Minganti et.al (2010) stands out. This analysis set out to relate methods of quantifying the internal load of a team of gymnasts from the record of RPE and HR. Positive evidence was found regarding the relationship between the two methods, and they observed that the higher HR values, reflecting a higher intensity of training, generated perceptions of more intense effort. The validation of the sRPE method as a way to quantify the training load in gymnasts is established as a future objective.

Finally, the variables Tm, Ts, ACW, helped to quantify and identify the risk of injury in gymnasts. Foster (1998) showed that workload, monotony of training, and stress during training are involved in 84% of athletes' injuries. In artistic gymnastics the percentage of injuries is high and is proportional to the gymnast's level (Meeusen & Borms, 1992); in the present investigation, a possible relationship between the risk of injury and the gymnast's level is intuited, since the HLG scored higher on the Tm, Ts and ACW variables than the MLG. All gymnasts in the HLG group showed an ACW value in the range of moderate risk consideration (1.00-1.49) while in the MLG group two of them showed values below 1.00, which defines a low risk injury. These variables (Tm and ACW) directly help to establish an injury risk quantification that can be very useful in artistic gymnastics.

Considering all these aspects that are the object of this analysis, we can conclude that the results found show us the possibilities if training load and other associated variables are controlled by registering gymnasts' perceptions during training. The RPE is an inexpensive, easy to administer method, and provides a unique value for interpreting training loads. This non-invasive measurement approach is particularly valuable for gymnasts, in addition to other internal load quantification instruments, such as FC, VO2max and CLS, which will all provide a more extensive and reliable information on the specific effort exerted and will assess and guide a training session according to the results obtained. In addition, limited scientific knowledge regarding the quantification of the load in artistic gymnastics reinforces the fact that it is a subject in which interesting possibilities for the future can be provided.

However, this study encountered certain limitations, such as the impossibility of having a larger sample size. Furthermore, it would be desirable to extend the duration of data collection and obtain data from a full training mesocycle.

CONCLUSION

As a general conclusion of the study, it can be observed that the sRPE has proved a useful tool to evaluate the internal training load in WAG. More studies should be carried out to confirm and properly guide the use of these variables, as they can be a very practical means that can be used on many levels of artistic gymnastics training.

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Article received: 10.6.2020
Article accepted: 2.9.2020