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EFFECT OF STRENGTH TRAINING ON PSYCHOPHYSIOLOGICAL ASPECTS IN PARALYMPIC POWERLIFTING ATHLETES: A PILOT STUDY

original paper
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ABSTRACT
Purpose. The study aim was to evaluate the maximum dynamic strength (MDS), mood levels, stress, and recovery during strength training in Paralympic powerlifting (PP).
Methods. The study involved 7 male PP athletes (41.0 ± 10.1 years; 84.7 ± 21.1 kg). MDS (one-repetition maximum [1RM] with bench press), stress/recovery (RESTQ-Sport), mood status (BRUMS), and resting heart rate (oximeter) were determined before and after a PP training mesocycle (4 weeks). The bench press training was performed with 5 sets of 5 repetitions (5 × 5) with 80–85% of 1RM in the 1st week, 5 × 3 with 85–90% of 1RM in the 2nd week, 5 × 1–3 with 90–95% of 1RM in the 3rd week, and 5 × 5 with 40–70% of 1RM in the 4th week.
Results. There was a significant increase in MDS ($p < 0.001$; effect size [ES]: 0.50). In the RESTQ-Sport scales, lack of energy ($p < 0.022$; ES: 1.30), success ($p < 0.035$; ES: 0.33), and sleep quality ($p < 0.007$; ES: 0.62) increased. The scales of general well-being ($p < 0.012$; ES: 2.18), interval disturbances ($p < 0.021$; ES: 3.14), personal acceptance, and self-regulation ($p < 0.006$; ES: 2.21) decreased. Regarding mood, the dimensions of tension ($p < 0.003$; ES: 1.32), depression ($p < 0.001$; ES: 5.00), anger ($p < 0.001$; ES: 4.75), fatigue ($p < 0.002$; ES: 0.72), and confusion ($p < 0.002$; ES: 2.09) increased and the vigour decreased ($p < 0.001$; ES: 0.87).
Conclusions. The internal training load can be controlled by psychophysiological indicators in PP.
Key words: Paralympic powerlifting, muscle strength, physiological stress, recovery, mood

Introduction

Paralympic powerlifting (PP) is a sport that requires muscle strength, with the only discipline being the adapted bench press, so the sport is practised by men and women with physical disabilities in the lower limbs [1]. The sport has aroused interest in a number of participants; thus, it becomes increasingly important to monitor the preparation of athletes, aiming to optimize the results in competitions [2, 3]. In this sense, to maximize performance, training in PP involves the manipulation of several biodynamic variables, such as volume, intensity, frequency, and density, among others [2, 4–6].

However, the product of this set is classified as external training load, and the organization of these variables contributes to the desired physiological adaptations, which imply an increase in sports performance in PP [7]. On the other hand, the internal training load is considered any psychophysiological response presented by the individual to a given stimulus [6, 8]. An

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increase in training loads is necessary to achieve high performance in high-performance sports. However, a balance must be sought between the stress generated by training and recovery; otherwise, many physiological and psychological functions may be affected [9].

Thus, it is necessary to monitor the external and internal training loads during the training periods in PP so that the athlete is considered as a physical and a psychological body that coexist and interact with each other [10]. For Kellmann [11], the control of training can be achieved through the association of psychological and physiological parameters and specific performance. Previous studies have suggested that the stress/recovery process and mood state, in response to the stimuli generated by training and several factors (i.e., sleep restriction or insufficient nutrient intake, among others), can be controlled through the Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) scales (monitoring of stress and recovery) and the Brunel Mood Scale (BRUMS) (monitoring of mood) in sports [8, 12].

On the other hand, studies focused on PP have addressed issues of heating, biomechanical procedures, as well as the use of supplements, or even the aetiology of injuries [3, 13–20]. However, recovery is a crucial point in sports training [21] and involves load control leading to functional adaptations, preventing and managing stress [22, 23]. In this sense, stress control in training and competition has been achieved by using self-report and questionnaires at virtually no cost to the athlete [11, 24, 25]. Thus, the relationship between stress and recovery tends to impact on performance by interfering with training [26, 27], which points to the need for individualization and load monitoring [28–30]. In addition, individual sports seem to cause more stress [31], interfering even more with recovery [32]. This, associated with high training loads, tends to increase physical and psychological stress [8]. Given the few studies related to the modality and psychosocial indicators [33], the issue implies a problem in PP.

This study therefore aimed to evaluate the maximum dynamic strength (MDS), mood levels, stress, and recovery over a period of strength training in PP athletes.

Material and methods

Sample

The sample consisted of 7 athletes, all male (age: 41.0 ± 10.1 years; body mass: 84.7 ± 21.1 kg). The initial one-repetition maximum (1RM) with the bench press adapted from 96.4 ± 20.5 kg was classified by the Brazilian Paralympic Committee. The sample was chosen for convenience and involved 6 athletes with a spinal cord injury below the 8th thoracic vertebra and 1 amputee (transtibial athlete). The participants were recommended to maintain their daily activities, to sleep and eat as usual, not to drink alcohol or caffeine within the 24 hours before the collection of psychophysiological data, and not to perform any other type of physical exercise during the study period. All subjects were informed about the possible benefits and risks of the participation in the study.

Study design

A randomized study was carried out, in which the participants were allocated in a single group and were submitted to data collection before and after a mesocycle (1 mesocycle corresponds to 4 weeks) of strength training of the modality. Figure 1 depicts the experimental design of the study.

During the collection sessions, the volunteers attended the Brazilian Paralympic Reference Centre of

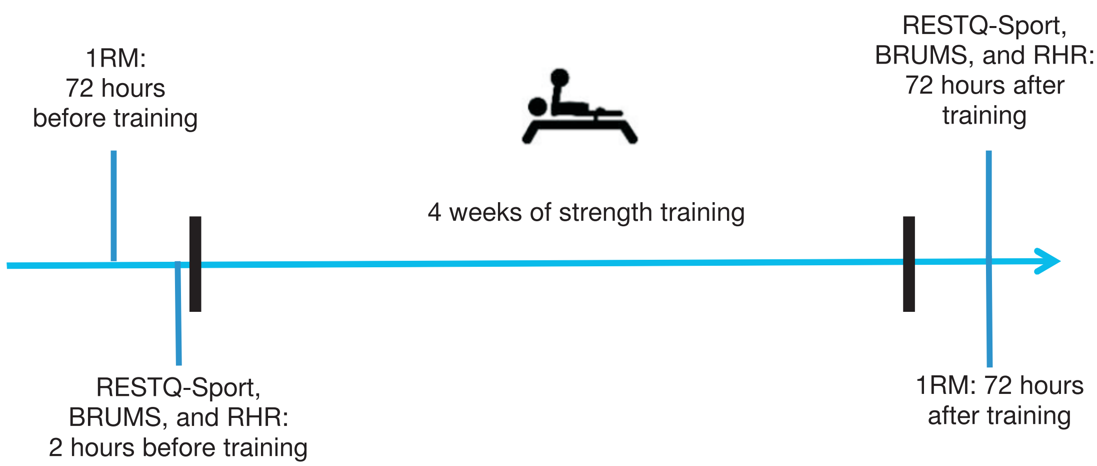

Figure 1. Experimental design

1RM – one-repetition maximum, RESTQ-Sport – Recovery-Stress Questionnaire for Athletes, BRUMS – Brunel Mood Scale, RHR – resting heart rate the Federal University of Minas Gerais in the morning. They filled in a questionnaire concerning personal data, occupation, health history, use of medication, practised sports and other physical activities. In the 1RM test, the athletes performed a warm-up of 3 exercises for the upper limbs (abduction of the shoulders with dumbbells, shoulder development on a machine, rotation of the shoulders with dumbbells), with 3 sets of 10–20 RM [34].

Then, a specific warm-up was performed with the bench press adapted with 30% of the load for 1RM. The bench press 1RM tests were conducted 72 hours before the mesocycle and 72 hours after the mesocycle. For the assessment of the psychophysiological data (stress/recovery and mood), the athletes answered the questionnaires in an isolated noise room at an ambient temperature of 25° at the same time of the day. The collections were performed 2 hours before the mesocycle and 72 hours after the mesocycle (before the 1RM test). Resting heart rate (RHR) was evaluated in the same time interval.

We highlight, in relation to the data collection period, that according to the coach of the sport, the periodization was done exactly through monthly training cycles, owing to the tight schedule of competitions. Therefore, the training period in which data collection was performed did not suffer the effect of specific moments such as the beginning of the season, pre-competitive and/or competitive period.

Instruments

The weighing of the athletes was carried out on a digital electronic scale platform (Micheletti®, São Paulo, Brazil) with an accuracy of 0.001 kg, a maximum supported capacity of 3000 kg, and a dimension of 1.50 × 1.50 m. This scales model makes it easy to weigh wheelchair users.

Maximum dynamic strength

The 1RM test was performed to determine the maximum dynamic strength; thus, each participant started the attempts with a weight that they could lift only once using the maximum effort. Weight increments were then added until the maximum load was reached. The 1RM was determined within a maximum of 6 attempts. If the subject was unable to perform a single repetition, 2.5% of the load was subtracted [35]. The participants rested for 3–5 minutes between the attempts. The test to determine MDS was conducted 72 hours before the mesocycle and 72 hours after the training mesocycle.

Strength training protocol

There was a progression in training for 3 weeks so that when the volume (the number of exercises, sets, and repetitions) decreased, the intensity (percentage of 1RM for bench press) increased. The 4^{th} week involved the taper period, interrelation of volume and intensity, and recovery [36]. The load configuration in this training included recommendations from several systems and techniques used in strength training [35, 37, 38] in an attempt to increase the maximum strength. The participants trained 3 times a week. In week 1, they performed 5 sets of 5 repetitions (5 × 5) using 80–85% of 1RM in the bench press and auxiliary exercises with 3 sets of 6 repetitions (3 × 6) with 70–90% of 1RM (bench press 45°, shoulder press, triceps pulley, biceps curl with dumbbells and pronated row). In week 2, 5 sets of 3 repetitions (5 × 3) were performed with 85–90% of 1RM in the adapted bench press and the same auxiliary exercises as in the previous week. In week 3, 5 sets of up to 3 repetitions (5 × 1–3) were performed with 90–95% of 1RM in the adapted bench press, in addition to the set of auxiliary exercises performed in weeks 1 and 2. In week 4, a 5 × 5 pattern was applied with 40–70% of 1RM, without auxiliary exercises [34, 39].

Psychosocial indicators (RESTQ-Sport and BRUMS)

To assess the athletes' state of stress and recovery in their perception, the RESTQ-Sport was applied before and after the mesocycle. The questionnaire has 19 scales, each containing 4 items distributed throughout the questionnaire. There are 7 general scales of stress (general stress, emotional stress, social stress, conflicts/pressure, fatigue, lack of energy, and somatic complaints), 5 general scales of recovery (success, social relaxation, somatic relaxation, general well-being, and sleep quality), 3 sports stress scales (interval disturbances, emotional exhaustion, and injuries), and 4 sports recovery scales (being in shape, personal acceptance, self-efficacy, and self-regulation). The questionnaire involves a Likert scale of 0–6, indicating the frequency of occurrence of the given facts, with 0 = never, 3 = half the time, and 6 = always [29, 40–42]. The mood state of the athletes was assessed by applying the BRUMS questionnaire before and after the mesocycle. The instrument contains 6 dimensions, with 4 items each; therefore, it has 24 questions in total. Of the 6 dimensions, 5 have a negative character and 1 has a positive character. The questionnaire employs a Likert-type scale of 0–4, indicating mood-related feelings, with 0 = nothing, 2 = moderately, and 4 = extremely [43, 44].

Resting heart rate

For RHR evaluation, the volunteers were asked to sit at rest and in silence, with their back against a chair (for wheelchair users, the wheelchair itself was used) and elbow at 90° of flexion for 10 minutes. RHR was measured within 10 minutes of rest with a finger pulse oximeter (Nonin Onyx 9500®, Brazil); the mean value over this time was recorded [45].

Statistical analysis

The normality of the data was verified by using the Anderson-Darling and *z*-score tests for asymmetry and kurtosis (–1.96 to 1.96). The comparisons between the moments before and after strength training were performed with Student's dependent *t*-test (parametric variables) and the Wilcoxon test (non-parametric variables). The effect size for the differences was calculated with Cohen's *d* test; the following magnitudes were considered: insignificant (≤ 0.19), small (0.20–0.49), medium (0.50–0.79), large (0.80–1.29), and very large (≥ 1.30) [46]. Correlations were established by using the Spearman test and the magnitudes adopted were those provided by Schober et al. [47]: insignificant ($r < 0.10$), weak (r: 0.10–0.39), moderate (r: 0.40–0.69), strong (r: 0.70–0.89), and very strong (r: 0.90–1.00). All analyses were performed by using the open-source R software (version 4.0.1; R Foundation for Statistical Computing®, Vienna, Austria). The value of $p < 0.05$ was considered for statistical significance.

The sampling power of post-hoc analyses was calculated with the open-source G*Power® software (version 3.0; Berlin, Germany); the configuration 'T family statistics' was considered for the difference between 2 dependent means (matched pairs) and correlations. Thus, we used the effects of Cohen's *d* and Spearman's *r* found in the results of the present study, and we considered a pattern of $\alpha = 0.05$. The sampling power was considered acceptable as > 0.70 [48].

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Federal University of Minas Gerais Ethics Committee (approval No.: 2.637.882, date of approval: May 7, 2018).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

As implied in Table 1, MDS increased significantly, and there was no statistically significant difference in RHR during the training period. The results for scales referring to lack of energy, success, and sleep quality after training increased significantly. The scores of general well-being, interval disturbances, personal acceptance, and self-regulation decreased significantly after training. For the other variables analysed, no significant differences were found in the comparisons between the moments before and after strength training.

Concerning the BRUMS scale, the total score pointed to a significant improvement, while the isolated domains of tension, fatigue, mental confusion, depression, and anger increased significantly. Besides, the vigour domain score was reduced significantly (Table 2).

Table 3 shows the correlations between MDS and RHR and the BRUMS and RESTQ-Sport indicators. Both RHR and MDS presented significant correlations with the BRUMS and RESTQ-Sport indicators.

Discussion

This study aimed to evaluate MDS, mood levels, stress, and recovery over a period of strength training in PP. The main results were: (1) The 4 weeks of strength training contributed to increasing the athletes' performance expressed through MDS. (2) There was a change in the internal training load after the increase in psychological indicators, such as lack of energy, success, and sleep quality, and reduction in the scales of general well-being, interval disturbances, personal acceptance, and self-regulation. (3) Regarding the BRUMS scale, there was an increase in the dimensions of tension, depression, anger, fatigue, and mental confusion; decreased vigour was reported. (4) RHR and MDS showed significant correlations with the BRUMS and RESTQ-Sport indicators.

It is noteworthy that MDS is defined as the force that can be applied only once on a given external resistance [35]. Therefore, the intensity in strength training is extremely important for sports such as powerlifting and PP, in which it is regularly based on the development of maximum strength as the athletes try to lift the heaviest load possible in a maximum repetition [2, 9]. In our study, the 4-week strength training contributed significantly to an increase in MDS of

Table 1. Comparisons of the scores for MDS, RESTQ-Sport domains, and RHR before and after strength training

Variables	Parametric data (mean ± *SD*)		Effect size		Sample power	*p*
	Before	After	Cohen's *d*	95% CI		
MDS (Kg)	96.4 ± 20.5	107.1 ± 22.1	0.50	0.45; 0.55	0.31	< 0.001*
Lack of energy	1.25 ± 0.24	1.64 ± 0.36	1.30	1.00; 0.32	0.91	0.02*
Success	3.39 ± 0.75	3.64 ± 0.75	0.33	0.25; 0.38	0.19	0.03*
Sleep quality	3.57 ± 0.75	3.96 ± 0.51	0.62	0.45; 0.70	0.42	0.007*
General well-being	4.25 ± 0.24	3.75 ± 0.21	2.18	2.05; 2.30	0.99	0.01*
Interval disturbances	2.46 ± 0.27	1.86 ± 0.12	3.14	2.50; 3.20	1.00	0.02*
Personal acceptance	3.93 ± 0.27	3.29 ± 0.31	2.18	1.80; 2.30	0.99	0.01*
Self-regulation	4.11 ± 0.55	3.32 ± 0.32	2.21	1.40; 2.50	0.99	0.006*
General stress	1.11 ± 0.24	1.39 ± 0.14	–1.50	–1.00; –2.00	0.96	0.06
Emotional stress	1.25 ± 0.14	1.36 ± 0.30	0.23	0.25; 0.25	0.13	0.6
Social stress	1.25 ± 0.50	1.25 ± 0.43	0.79	0.55; 0.85	0.58	1.0
Conflicts/pressure	2.61 ± 1.46	2.32 ± 0.72	0.26	0.20; 0.30	0.15	0.5
Fatigue	2.14 ± 0.82	2.25 ± 0.41	–0.17	–0.10; –0.20	0.10	0.7
Somatic complaints	1.75 ± 0.71	1.57 ± 0.31	0.35	0.20; 0.38	0.20	0.5
Social relaxation	3.54 ± 0.75	3.54 ± 0.39	0.25	0.18; 0.35	0.14	0.7
Somatic relaxation	3.14 ± 0.31	3.57 ± 0.20	–1.68	–0.50; –1.80	0.98	0.1
Emotional exhaustion	1.46 ± 0.61	1.32 ± 0.32	0.31	0.20; 0.45	0.18	0.6
Injuries	2.50 ± 0.78	2.07 ± 0.43	0.71	0.65; 0.80	0.50	0.1
Being in shape	3.54 ± 0.47	3.25 ± 0.24	0.80	0.70; 0.87	0.60	0.4
Self-efficacy	3.79 ± 0.27	3.29 ± 0.20	2.10	1.70; 2.50	0.99	0.06

	Nonparametric data							
	M	IQI	M	IQI				
RHR (bpm)	80.0	5.00	83.0	6.00	0.01	–0.11; 0.03	0.05	0.467

MDS – maximum dynamic strength, RESTQ-Sport – Recovery-Stress Questionnaire for Athletes, RHR – resting heart rate, M – median, IQI – interquartile interval
* statistically significant

Table 2. Comparisons of the BRUMS domain variables before and after strength training

Variables	Parametric data (mean ± *SD*)		Effect size		Sample power	*p*
	Before	After	Cohen's *d*	95% CI		
BRUMS	0.76 ± 0.27	1.07 ± 0.79	3.12	2.70; 3.15	1.00	0.001*
Tension	0.68 ± 0.29	1.11 ± 0.36	–1.32	–1.00; –1.35	0.92	0.003*
Fatigue	0.68 ± 0.29	0.86 ± 0.20	–0.72	–0.60; –0.78	0.51	0.002*
Mental confusion	0.32 ± 0.14	0.89 ± 0.41	–2.09	–1.75; –2.15	0.99	0.002*

	Nonparametric data							
	M	IQI	M	IQI				
Depression	0.29	0.00	0.71	0.15	–5.00	–4.37; –5.05	1.00	< 0.001*
Anger	0.00	0.00	0.64	0.40	–4.75	–4.00; –5.00	1.00	< 0.001*
Vigour	2.86	1.10	2.29	1.40	0.87	0.67; 0.91	0.70	< 0.001*

BRUMS – Brunel Mood Scale, M – median, IQI – interquartile interval
* statistically significant

Table 3. Correlation between RHR and MDS with RESTQ-Sport domains and BRUMS scale

Indicator	Effect size		Sample power	*p*
	Spearman's *r*	95% CI		
RHR × BRUMS	0.66	0.60; 0.70	0.46	0.03
RHR × general stress	0.40	0.35; 0.45	0.40	0.001
RHR × general recovery	–0.47	–0.40; –0.50	0.29	0.04
RHR × sports stress	0.14	0.07; 0.18	0.09	0.002
RHR × sports recovery	–0.12	–0.05; –0.15	0.08	0.03
MDS × BRUMS	0.54	0.52; 0.60	0.35	0.0005
MDS × general stress	0.63	0.57; 0.65	0.43	0.001
MDS × general recovery	–0.60	–0.55; –0.65	0.40	0.01
MDS × sports stress	0.68	0.62; 0.70	0.48	0.04
MDS × sports recovery	–0.10	–0.01; –0.12	0.07	0.003

RHR – resting heart rate, MDS – maximum dynamic strength, RESTQ-Sport – Recovery-Stress Questionnaire for Athletes, BRUMS – Brunel Mood Scale

the analysed subjects. According to Allegretti João et al. [49], the rapid increase in muscle strength related to the systematization of strength training can be explained by the specific neuromuscular adaptations caused by exercise-induced stress within the central nervous system, which results from an increased frequency of firing nerve impulses, as well as recruitment and synchronization of increasingly large specific motor units.

As indicated by Matos Dos Santos et al. [18], MDS is the main physical capacity in PP, and its change is related to the training method and the biomechanics of exercise execution. On the other hand, MDS has also been the target of the load-speed relationship for sports training prescription [14]. In the present study, the stress generated by the 4-week training period increased the RESTQ-Sport scores, indicating lack of energy, success, and sleep quality after the intervention. The scales of general well-being, interval disturbances, personal acceptance, and self-regulation decreased significantly. Besides, the general stress scale showed an upward trend, while the self-efficacy scale exhibited a downward trend, with a very large effect size for the last 2 scales mentioned. For Almeida Monteiro de Moraes et al. [12], the accumulation of training overload associated with energy restriction indicates deleterious changes in the balance of stress and recovery in strength sports athletes in the pre-competitive period. In this study, the evaluation was free from the competition period. However, despite the relative negative changes in the psychological indicators caused by overload, there is evidence that the use of progressive overload is part of training in PP, as well as in other types of strength training, contributing to an increase in strength, muscle mass, and performance [2, 49]. Nevertheless, even though the progressive overload used in PP strength training is necessary, there is a possibility of generating psychological and physical stress in athletes. According to Fraga et al. [17], 5 sets of 5 repetitions at 85–95% of 1RM was enough to generate muscle damage in PP athletes.

Studies carried out with volleyball, rowing, and bodybuilding have shown that with an abrupt increase in the training load, the state of stress/recovery can be impaired; thus, the athletes presented high stress and low recovery [12, 50, 51]. In contrast, with a decrease in load, the opposite occurs: low stress and high recovery [8]. It is therefore believed that the positive psychological responses to training depend on the interrelationship between volume, intensity, and rest during the training period. The evaluation in our study was carried out over a period of progressive loading of the athletes' training. According to Almeida Monteiro de Moraes et al. [12], the imbalance between stress and recovery in the face of overload in strength training, verified through psychological indicators, must be interpreted with caution, the association of biochemical signals, such as creatine kinase, which reinforces the idea that individuals poorly recovered of the training demands with an insufficient rest period. In this sense, it is assumed that the use of questionnaires to control stress/recovery in the context of training becomes subjective, hence the need arises to obtain other parameters for evaluation, unless familiarization with the instrument is frequent [12, 52].

In contrast, the post-training sleep quality significantly increased, a fact that is associated with the contribution to the stress/recovery process and athletes' performance [53]. Despite this, the sports stress scales, as well as the sports recovery were lower after the training when compared with the baseline level. In addition to training, it is supposed that extra training factors (i.e., sleep, food, interpersonal relationships, and safety) can also influence the psychophysiological status of athletes [7]. However, the assessment of the internal training load must be based on psychological and physiological indicators, as physiological mechanisms can mediate psychological responses in a training process [8, 54]. In this study, we focused on evaluating the stress generated by training through psychological indicators owing to the practicality of the instruments; however, more sensitive physiological indicators have been used to control internal training load in PP, according to Fraga et al. [17], creatine kinase and lactate dehydrogenase to control muscle damage in a training session, as well as dry needling and immersion in ice water as recovery techniques in PP [55].

Adverse psychological effects have been observed, as revealed in the state of mood, during a period of training in athletes of strength sport [10]. In the present study, the scores in the dimensions of tension, depression, anger, fatigue, and mental confusion increased significantly after training. In turn, vigour decreased significantly. The profile in the form of an iceberg is known when the positive dimension appears with the highest values, and the negative dimensions appear with low values, with the scores differing from the average of the general population [56]. In our study, this profile decreased, indicating changes in mood after training. According to Helms et al. [57], the stress generated by training associated with impaired macronutrient intake negatively altered the mood state of weightlifters.

However, high-performance athletes without mood disorders, when assessed by using the BRUMS scale in a specific training period, reveal a profile in the form of an iceberg [10]. Through the change in mood during 12 months of preparation of bodybuilding athletes, the authors observed that 2 months before the competition, the scores of the emotional scales of tension, anxiety, and anger decreased, a fact associated with the athletes' satisfaction with the training and excitement phase for the competition; in contrast, an increase in the fatigue and tension-anxiety scales scores, and a decrease in the vigour scale score were also observed in the pre-competitive period, negatively altering the athletes' state of vigour. In our study, the pre-training vigour dimension result was above the 60th percentile; however, after the training, it was below this benchmark. All negative dimensions scored below the 40th percentile at both times, which contributes to the iceberg profile of PP athletes. Adverse changes in mood after training may have been associated with the progressive overload in this period.

In this context, the mood state has also been influenced by extra training factors, such as sleep disturbance and restriction, macronutrient restriction, a rapid loss of body mass, among others [10, 53]. Thus, the acute or chronic evaluation of training in PP, as well as in other strength training sports, must involve psychophysiological responses; for the accuracy of these variables, questionnaires and blood and salivary samples should be used [12, 51]. Besides, RHR has been applied as a physiological indicator in the control of exercise intensity [58], the use of this marker is part of the control of the internal training load in strength training sports such as powerlifting and PP [2, 39].

In the present study, there was no statistically significant difference in post-training RHR. Training sessions with loads > 80% of 1RM contribute to an increase in RHR, which appears to be caused by a reduction in cardiac output mediated by stroke volume [58]. In summary, the change in RHR concerning high training loads in powerlifting is related to an increase in sympathetic activity and reduction of parasympathetic activity in the heart [39]. In our study, the loads ranged 40–95% of 1RM; however, there was no change after the training period. De Almeida Paz et al. [2] compared 2 different sessions of strength training, 5 × 5 with 80–85% of 1RM and 5 × 3 with 90–95% of 1RM, and verified the hemodynamic responses in PP. The authors reported that the different protocols increased RHR after the training session but the values quickly returned to baseline within 50 minutes after training for both sessions. In this study, RHR was measured 72 hours after the session; therefore, it is believed that this physiological indicator can be used at both times to control the intensity of strength training in PP.

In our study, RHR and MDS exhibited significant correlations with the BRUMS and RESTQ-Sport indicators. These findings suggest that the psychophysiological variables are related to the specific performance of PP athletes, which corroborates the observations by Impellizzeri et al. [7], who state that external training stimuli will generate an internal physiological and psychological response, which may influence the athlete's perception of the environment, affecting such factors as sleep quality and mood. Thus, it is suggested that in sports training, athletes are seen as multifactorial beings, composed of physical, psychological, and sentimental parts [7, 10].

Thus, although there is a gap in studies monitoring internal training load during a period in PP, we obtained interesting results, such as an increase in MDS, positive and negative changes in the dimensions of stress/recovery and mood through the application of the RESTQ-Sport and BRUMS instruments, as well as no alteration of RHR during a period of progressive loading. There were some limitations to the study design used, such as a small sample size and the lack of more sensitive physiological indicators.

Practical applications

The scales of the RESTQ-Sport and BRUMS questionnaires and the RHR have been widely used to monitor the internal load through the psychophysiological responses of stress, recovery, mood, and heart rate of athletes. The ease, accuracy, and validity of these tools contribute to their applicability among coaches and researchers. Additionally, the relationship of the external load with the control of internal training load can be used to train athletes, as long as this association is familiarized. Therefore, our results suggest that the control of the external training load contributes to significant gains in maximum muscle strength; however, let us assume that an isolated action should not be performed. Therefore, the present study supports the use of internal training load control through RESTQ-Sport, BRUMS, and RHR to monitor individual responses during the prescription of the training load for PP athletes.

Conclusions

It is concluded that psychophysiological indicators (internal training load) combined with the specific performance of PP athletes can be related to the external training load to assist technicians and sports professionals in the load prescription and sports performance monitoring among PP athletes.

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Conflict of interest

The authors state no conflict of interest.

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