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Acute Effects of Different Training Loads on Affective Responses in Resistance-trained Men

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ABSTRACT

The main purpose of the present study was to investigate the acute effects of different training loads on ratings of perceived exertion and discomfort and feelings of pleasure/displeasure in resistance-trained men. Twelve resistance-trained men (26.7 ± 3.5 years, 85.1 ± 17.5 kg, and 174. 9 ± 9.9 cm) performed 3 sets of the bench press, squat on a hack machine, and lat pulldown, until volitional concentric failure in two separate conditions: a moderate load (MOD) consisting of a relative load of 8–12 repetitions maximum (RM), and a light load (LIT) consisting of a relative load of 25–30RM. The session rating of perceived exertion (sRPE), session rating of perceived discomfort (sRPD), and session pleasure/displeasure feelings (sPDF) were assessed after 15 min after the ending of each session. A randomized, counterbalanced, crossover study was performed with 48 h recovery afforded between sessions. Differences between conditions were observed for sRPE and sRPD, in which scores for LIT were greater than MOD (sRPE: MOD = 5.5 ± 1.0 vs. LIT = 6.4 ± 0.7; sRPD: MOD = 6.7 ± 1.7 vs. LIT = 8.7 ± 1.0). For sPDF, MOD reported feelings of pleasure (1.2), whereas the LIT presented a feeling of displeasure (–2.3). Results suggest that resistance training performed with a light load until failure induces higher degrees of effort, discomfort and displeasure compared to a moderate load.

Introduction

The rating of perceived exertion is a well-known marker of exercise intensity and is correlated with the intensity of effort [1, 2]. Therefore, the rating of perceived exertion of the session (sRPE) has been used as a simple method to rate effort in individuals during an RT session [3]. This approach allows verifying a single global rating of the difficulty level of an entire training session, and has been reported as a valid and reliable indicator of RT intensity [3].

The benefits associated with RT depend on the proper manipulation of the variables that make up the RT program [4, 5]. The RT protocols designed to induce neuromuscular fitness may differ in their organization relative to variables. Regarding training load, emerging research indicates that muscle hypertrophy is similar regardless of the magnitude of load provided that repetitions are performed until momentary concentric failure [6–9].

However, although gains in muscle mass may be similar across the spectrum of loading ranges, the acute physiological responses are different between protocols. For example, a high number of repetitions performed with lighter loads induces a greater increase in heart rate, blood pressure, and accumulation of metabolites in comparison to a low number of repetitions performed with heavier loads when sets are carried out to concentric muscular failure [10–12]. Thus, it can be hypothesized that the practitioner's feelings of pleasure/displeasure, as well as the effort and discomfort perceived, may be different according to the load and the number of repetitions performed.

The main purpose of the present study was to verify the acute effects of different training loads carried out to concentric muscular failure on ratings of perceived exertion (sRPE), discomfort (sRPD), and feelings of pleasure/displeasure (sPDF) in resistance-trained men. We hypothesized that training with a light load would produce greater sRPE and sRPD, and lower sPDF compared to moderate load RT.

Materials and Methods

Study design and participants

Participants volunteered to visit the laboratory on four separate occasions separated by intervals of 48–72 h. Anthropometric measurements and individual interviews were conducted on the first visit. Additionally, in the first and second visits, participants performed repetition maximum (RM) testing to determine the loads to be used for the experimental conditions in the bench press, hack squat, and lat pulldown exercises. During these 2 first sessions, the participants also were familiarized with the evaluation scales. Afterward, a randomized, counterbalanced, cross-over design was employed in the third and fourth visits, whereby the participants performed 3 exercises for 3 sets under a moderate load (MOD) consisting of a relative load of 8–12RM, or a light load (LIT) consisting of a relative load of 25–30RM. The experimental design is shown in ▶ **Fig. 1**.

Sessions were conducted at the same time of day to avoid any possible confounding effects of the circadian cycle. Participants were instructed to refrain from caffeinated beverages and foods 48 h prior to the sessions, and from any other ergogenic aids, supplementation, and medications for the duration of the study period.

A convenience sample of 12 men (26.7 ± 3.5 years, 85.1 ± 17.5 kg, 174. 9 ± 9.9 cm, 27.3 ± 4.4 kg/m²) with previous experience in RT (2.3 ± 0.9, range: 1–4, years of experience) were selected for participation in this research. All participants completed a detailed health history questionnaire and were included in the study if they had a minimum of one year of experience in RT, were free from orthopedic injuries that could have precluded or hindered the movements performed, and self-reported as not having previously used anabolic steroids. The participants were required to refrain from other RT sessions during the course of the study. All participants were informed of the procedures and signed a written informed consent to participate in the study. The investigation was performed according to the principles outlined in the Declaration of Helsinki and was approved by the local University Ethics Committee [13].

Procedures

Load determination

The loads employed for each condition were determined via RM testing, as described elsewhere [14]. Briefly, the test consists of executing the first and second sets at the lower end of the repetition zone (8 repetitions for MOD, and 25 repetitions for LIT), and as many repetitions as possible until voluntary exhaustion or the inability to maintain proper technique in the third set. The same weight was used to perform all three sets of each exercise. Therefore, the loads for the protocol conditions were determined using the following equations:

Upper limb exercises: $FW = WT + RE/2$

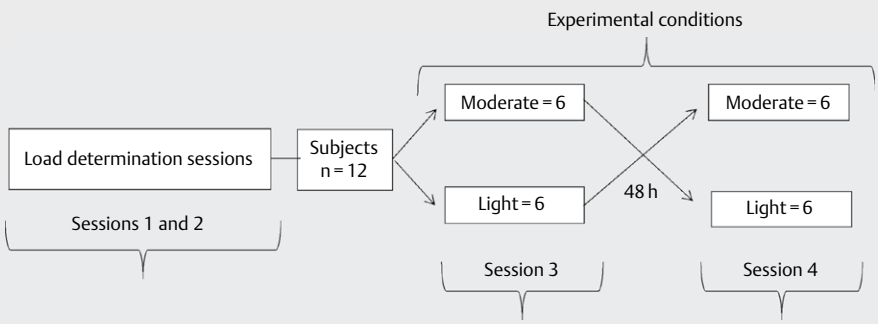
Lower limb exercises: $FW = WT + RE$

where FW = final weight (kg) used in experimental session; WT = weight used in the test (kg); RE = maximum number of repetitions performed that exceeded the lower limit (8 repetitions for MOD, and 25 repetitions for LIT) in the third set.

The weight used in the first sets was based according to previous information of the practitioners and the perception and experience of the researchers. The results of these tests were used to determine the weight used in the experimental protocols.

Testing protocol

Sessions for each loading condition were carried out on the 3 exercises in the following order: bench press, hack squat, and lat pulldown. For all exercises, participants performed 3 sets with the specific load maintaining a constant velocity of movement at a ratio of approximately 1:2 seconds for the concentric and eccentric phases, respectively. A rest period of 120 secs was afforded between sets and exercises. Repetitions for all sets were performed until volitional failure or an inability to carry out the exercise with proper technique. Participants were instructed to perform repetitions using their habitual range of motion and to avoid resting in the transition phases between repetitions (intraset rest).



▶ **Fig. 1** Experimental design of the study.

▶ **Table 1** Training load, volume-load, and session duration according to load session and exercises. Data are presented as mean and standard deviation (n = 12).

	Light	Moderate	P	Effect size
Total				
Total load (kg)	112.4 ± 19.9	176.1 ± 30.1	< 0.001	2.5
Volume-load (kg)	8959.7 ± 1942.2	6139.3 ± 1226.9	< 0.001	− 1.8
Session duration (min)	28.0 ± 4.0	24.6 ± 4.5	< 0.01	− 0.8
Bench press				
Total load (kg)	38.6 ± 9.8	63.3 ± 11.5	< 0.001	2.3
Volume-load (kg)	3103.5 ± 791.1	2089.8 ± 457.1	< 0.001	− 1.6
Squat				
Total load (kg)	41.6 ± 9.7	65.3 ± 16.4	< 0.001	1.8
Volume-load (kg)	3227.5 ± 985.3	2381.1 ± 675.3	< 0.01	− 1.0
Lat-pulldown				
Total load (kg)	32.0 ± 7.8	47.5 ± 6.5	< 0.001	2.2
Volume-load (kg)	2628.7 ± 609.2	1668.3 ± 249.2	< 0.001	− 2.2

Note: Volume-load = total load × total number of repetitions.

The 0–10 OMNI scale was employed to determine sRPE [2], in which the lowest score represents no physical exertion and the highest score the maximum perceivable effort. The sRPD was assessed with a 0–10 point scale [15], in which 0 represents no perceived discomfort, and 10 represents maximum perceivable discomfort. For both scales (sRPE and sRPD), the participants were instructed to answer the question: "How hard did you work out?". The sPDF was assessed with the Hardy and Rejeski scale [16], which uses a bipolar 11 point scale varying from −5 to + 5; a score of zero is considered neutral, positive numbers (+ 1 to + 5) represent pleasurable feelings, and negative numbers (−1 to −5) represent unpleasurable feelings. For the sPDF scale, participants were instructed to answer the question: "How was your workout?" [3, 17]. All ratings were assessed 15 min after the ending of the session.

Statistical analysis

The Kolmogorov-Smirnov test was used to determine the normality of the data. A dependent Student's t-test was used to compare the differences between sessions. The effect size (ES) was calculated as the MOD mean minus LIT mean divided by the pooled standard deviation [18]. The magnitudes of the ES were qualitatively interpreted using the Cohen's cut points. An ES of 0.00–0.19 was considered as trivial, 0.20–0.49 as small, 0.50–0.79 as moderate and ≥ 0.80 as large [18]. The quantitative chances for higher or lower differences were qualitatively assessed, according to Hopkins [19, 20]. Data analysis was performed using a modified statistical Excel spreadsheet [19]. For all statistical analyses, significance was accepted at $P < 0.05$. The data were analyzed using SPSS software version 20.0.

Results

The total load lifted, the volume load (total load × total number of repetitions), and the duration of sessions are detailed in ▶ **Table 1**. The MOD showed a greater ($P < 0.05$) total load lifted, as expected, and a shorter session duration than LIT; alternatively, LIT showed a greater volume load than MOD. ▶ **Table 1** also presents the training load and volume load according to exercises, where for all exercises MOD presented greater ($P < 0.05$) load than LIT, however the volume load was greater ($P < 0.05$) for LIT compared to MOD.

▶ **Table 2** Affective responses according to load session. Data are presented as mean and standard deviation (n = 12).

	Light	Moderate	P
RPE	6.4 ± 0.7	5.5 ± 1.0	0.03
Discomfort	8.7 ± 1.0	6.7 ± 1.7	0.01
Feeling	− 2.3 ± 1.9	1.2 ± 1.3	< 0.001

Note: RPE = rate of perceived exertion.

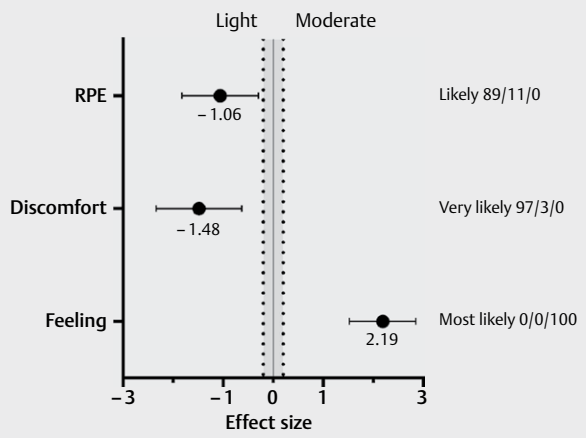
The sRPE, sRPD, and sPDF outcomes for each loading condition are displayed in ▶ **Table 2**. Differences between conditions were observed for sRPE and sRPD, in which LIT showed higher scores compared to MOD. Regarding sPDF, MOD reported feelings of pleasure, whereas the LIT presented feelings of displeasure. Effect sizes were of a large magnitude for all outcomes. ▶ **Fig. 2** presents the effects sizes, clinical inferences, and chances of results being different, whereas ▶ **Fig. 3** illustrates the individual values for sRPE, sRPD, and sPDF (Panels A, B, and C, respectively) according to loading condition.

Discussion

The main finding of our study was that RT session-based ratings of perceived effort and discomfort, as well as feelings of pleasure/displeasure, are affected by training load, in which a moderate load protocol induced lower degrees of effort and discomfort and greater feelings of pleasure compared to a light load when training is carried out until momentary muscular failure. Our results regarding sRPE agree with some previous investigations. Pritchett et al. [21] compared bouts of RT performed to failure at low (60 % of 1RM) and high (90 % of 1RM) loads, in which 12 recreationally trained (RT experience ≥ 6 weeks) men performed 3 sets of 6 exercises (leg

press, bench press, lat pulldown, shoulder press, triceps press, and biceps curl) to volitional failure. Results indicated higher sRPE for the low load condition (8.8 ± 0.8) compared with the higher load (6.3 ± 1.2). Similarly, Shimano et al. [22] showed that RPE for squat was significantly higher at 60 % of 1RM (8.8 ± 0.7) compared to both 80 % of 1RM (7.4 ± 1.4) and 90 % of 1RM (6.9 ± 2.5). Collectively, these findings suggest that sets employing lighter loads are associated with a higher perception of effort compared to heavier load sets when training is performed to muscular failure.

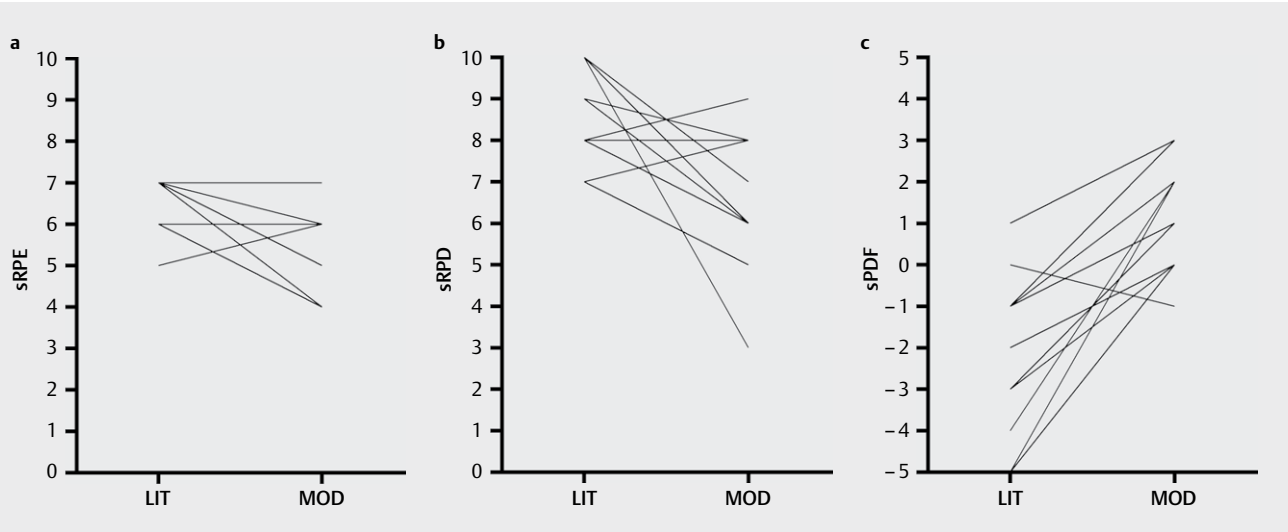
In contrast, some research has found a higher sRPE when training with heavier compared to lighter loads [1, 17, 23, 24]. In a sample of men and women (experience in RT ≥ 6 months), Day et al. [1] observed differences between performance of 1 set of RT carried out at 90 % of 1RM (4–5 repetitions), 70 % of 1RM (10 repetitions), and 50 % of 1RM (15 repetitions), whereby the sRPE was greatest for the 90 % bout. Based on the loading schemes, training was closer to failure in the heavier load conditions. Gearhart et al. [23] also observed that training with a heavier load (5 repetitions at 90 %) induced greater RPE compared to a lighter load (15 repetitions at 30 % of 1RM); importantly, the light load set was stopped well short of failure. Hiscock et al. [17] reported that 3 sets of 8 repetitions at 70 % of 1RM induced a greater sRPE (4 ± 1) compared to 3 sets of 14 repetitions at 40 % of 1RM (2.5 ± 1) when training was not taken to the point of muscular failure. Sweet et al. [24] investigated 10 men and 10 women who performed 2 sets of 6 exercises at 50 % of 1RM (15 repetitions), 70 % of 1RM (10 repetitions), and 90 % of 1RM (4 repetitions), and found that sRPE was greater for the higher load conditions; again, training was not carried out to muscular failure.



▶ **Fig. 2** Magnitude-based inferences [19, 20] from affectivity outcomes. Data are reported as effect size and 90 % confidence limits. Trivial area (grey) is established at 0.2 units of effect size, according to Cohen scores [18]. On right: chances the Moderate condition presenting lower/similar/greater values of affectivity compared to Light condition.

The key point that seemingly explains these contradictory results is the fact that participants in the studies who found greater degree of effort with higher loads [1, 17, 23, 24] employed a predetermined number of repetitions for each condition whereby the heavier load conditions were performed closer to failure compared to the lighter load conditions. Conversely, the investigations (including our experiment) in which participants performed sets until momentary muscular failure [21, 22] consistently show that the lighter loads induce a greater RPE. Given the information above, it can be postulated that load would be associated with effort when all other variables are maintained constant. Alternatively, the higher sRPE for the LIT could also be related to greater time under tension during the exercises, as indicated by Diniz et al. [25], who compared different repetition-matched RT protocols and noted a higher sRPE when exercises were performed with longer repetition durations.

In regard to perceived feelings of discomfort, our results indicate higher scores are associated with light-load training compared to training with moderate loads. Similar findings were reported by Fisher and Steele [15], who investigated perception of discomfort in seven men who performed unilateral leg extension exercises



▶ **Fig. 3** Individual values for session rate of perceived effort (Panel **a**), session rate of perceived discomfort (Panel **b**), and session pleasure/displeasure feelings (Panel **c**).

using a high load (80 % of maximal voluntary isometric torque) versus a light load (50 % of maximal voluntary isometric torque) and observed that the higher load condition induced a greater degree of discomfort (higher = 6.5 ± 2.2 vs. lower = 8.7 ± 0.9).

A unique aspect of our experiment was the assessment of feelings of exercise pleasure/displeasure between LIT and MOD. Results showed that training with a moderate load induced pleasurable feelings, whereas light-load training elicited unpleasurable feelings. The results indicate that performing fatiguing resistance exercise with a high time under tension will make the response to training less gratifying.

A possible physiological mechanism to explain our findings may be related to the body's greater internal effort to perform more repetitions with low loads. For example, Gjovaag et al. [10] compared physiological and cardiovascular parameters in 4RM versus 20RM in the performance of 4 sets of leg extensions. Results indicated that, when compared to heavy-load training, the lighter load condition elicited greater RPE assessed immediately after the end of the sets (6.3 ± 1.6 vs. 9.2 ± 1.6, respectively) and greater lactate accumulation (2.8 ± 0.7 vs. 10.3 ± 1.3 mMol/L). Moreover, cardiovascular measures (e. g., heart rate, blood pressure, cardiac output) were also more elevated in lower than higher load. Pritchett et al. [21] also reported a higher heart rate for lower load compared to higher load performed until failure. Therefore, it can be suggested that the greater accumulation of metabolites and cardiovascular demand associated with low-load training, either alone or in combination, may bring about a higher level of perceived effort, discomfort, and unpleasant feelings.

It should be noted that fatigue and exhaustion are multifactorial phenomena [26, 27]. It therefore follows that exhaustion from MOD occurred primarily as a result of more centrally mediated fatigue (a decrease in number and discharge rates of motor units), whereas momentary failure in LIT resulted more from peripheral neuromuscular fatigue (e. g., accumulation of metabolites and reduced intramuscular pH) due a longer time under tension and thus greater reliance on fast glycolysis [28]. The associated acidosis from metabolic stress would seemingly have a more negative effect on perceptual response compared to central factors of fatigue. Furthermore, we cannot rule out the possibility that results may have been related to the novelty of the stimulus. Initial interviews revealed that most participants performed RT with moderate load during their habitual routines. Thus, the unfamiliarity of training with light loads conceivably results in a greater effort and discomfort compared to a familiar stimulus. Further study is warranted to better understand this phenomenon.

Although participants performed all sets until momentary muscular failure, the sRPE scale did not reach the highest score in the scale for any protocol. It is to be expected because sRPE tends to underestimate the average perceived level of effort when reported shortly after an exercise bout [1, 3, 21, 24, 29].

The present study has some limitations that must be acknowledged. First, data were not obtained from direct measurements of internal effort, such as heart rate. Second, we did not monitor metabolite accumulation and thus cannot directly infer mechanistic explanations related to acidosis for the findings. Finally, our findings reflect acute effects; thus, we cannot rule out the possibility that the tolerance to lighter loads may improve over time because of repeated exposure to a higher number of repetitions.

Conclusion

Our results indicate that training load affects perceived effort, discomfort, and feelings of pleasure/displeasure when exercise is carried out to concentric failure. The use of light loads elicits a higher degree of effort, discomfort, and displeasure compared to a moderate load; therefore, from a practical standpoint, it can be inferred that the use of moderate loads may promote better adherence and motivation to resistance-training protocols.

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Conflict of Interest

The authors declare that they have no conflict of interests regarding the publication of this paper.

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