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ORIGINAL ARTICLE

Affective response to acute resistance exercise: a comparison among machines and free weights

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Abstract

Purpose This study aimed at investigating enjoyment, affective states (affective valence and perceived activation), and perceived exertion during acute resistance exercise with machines or free weights.

Methods Thirty recreationally strength-trained males performed two training sessions on 2 separate days using a descending pyramid training system, one performed with three machines (chest press, shoulder press machine and leg press) and the other with three free weight exercises (bench press, front military press and squat). The Physical Activity Enjoyment Scale, the Borg Scale for Rating of Perceived Exertion, the Feeling Scale, and the Felt Arousal Scale were administered at the end of each session.

Results Analyses revealed higher scores on all the variables when participants exercised with free weights ($p < 0.001$). Enjoyment was positively related to perceived exertion only in the free weight session ($r = 0.45$; $p < 0.01$). When looking at the circumplex model of affect, results showed that resistance exercise performed with free weights resulted in a pleasant activation feeling for all participants, while the machine training condition determined high-activation pleasant state for the majority but also cases of low-activation, displeasure state.

Conclusions Resistance training with free weights resulted in increased pleasantness and activation compared with machine training. The establishment of resistance training programmes should consider, close to physiological and technical aspects, also the affective response to different modalities of exercise, particularly when the aim is improving the general fitness.

Keywords Affective response · Enjoyment · Perceived activation · Resistance exercise

Abbreviations

RT Resistance training
RE Resistance exercise

Introduction

A positive affective response to exercise is a core component of exercise motivation and a significant predictor of adherence and compliance with regular exercise [1]. Affective responses, such as pleasure and enjoyment, have been investigated as main determinants of exercise participation, with the basic assumption that when an activity elicits positive affect, people are more likely to maintain the same activity [2, 3].

Resistance training (RT) plays a key role in the promotion of health and wellbeing [4] and interest in this type of exercise is continuously increasing. RT was the second top fitness trend in 2012, up from sixth position in 2007 [5]. In spite of the considerable amount of literature regarding the affective responses to aerobic exercise [6], to date relatively scant research exists regarding the affective state elicited by resistance exercise (RE). Studies examined the relationship of RE with depression [7], state anxiety [8–10], mood and psychological states [11], affects [12], anxiety and affects [13], and body image [14]. Chang and Etnier [15] examined changes in cognitive function with varying RE intensity and found that high-intensity exercise was beneficial for the speed of cognitive processing, and moderate intensity exercise for executive function. Arent et al. [12] reported a dose–response relationship between RT intensity and affective responses, with moderate intensity related to a greater improvement in affect (i.e., 70% of 10-RM), compared with low (40% 10-RM) and high-intensity exercise (100% 10-RM). Bartholomew [16] examined the effects of

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RT on manipulated pre-exercise mood and concluded that RE improves mood. Belezza et al. [17] conducted a study on the affective responses to RT sequence (large-to-small or small-to-large muscle groups), suggesting that small-to-large muscles exercise order may have greater psychological effects. Focht et al. [18] investigated the affective responses to acute RT performed by 20 recreationally trained women at self-selected and imposed loads, concluding that the two loads resulted in comparable improvements in affect.

Factor-analytic research of the interrelationships between affective valence and perceived activation has led to the development of the circumplex model of affect [19]. The model has been used in several studies to track affective changes throughout exercise sessions [20]. It represents the set of mutual relations between pleasure/displeasure feeling and arousal, by placing these dimensions in a circular order in a space formed by two orthogonal/bipolar dimensions: pleasure–displeasure and arousal–sleepiness. The circumplex model places the affect experienced by an individual during exercise into one of four quadrants: (a) activation and pleasant affect (i.e., enthusiasm, energy or excitement); (b) activation and unpleasant affect (i.e., anxiety, distress or tension); (c) deactivation and pleasant affect (i.e., calmness or relaxation); and (d) deactivation and unpleasant affect (i.e. fatigue, boredom, or depression). Using the circumplex model of affect, Hall et al. [21] and Miller et al. [22] found an increase in positive affect following RT similar to results on aerobic training reported by Hall et al. [23]. In particular, Miller et al. [22] investigated differences in affective responses during and after eccentric, concentric, and eccentric-concentric upper-body RE in 31 college-aged women. No differences by conditions of training were found; however a significant main effect of time, attributable to changes in both feeling and arousal, was reported [22].

Within the determinants of the affective response to RT, the type of resistance (e.g. bodyweight exercises, resistance belt, lifting free weights, weight machines) has not been yet considered. The purpose of the present study was to examine differences in enjoyment, affective valence, perceived activation, and perceived exertion among recreationally strength-trained individuals when performing two different modalities of RT (with machines and with free weights) at the same intensity. We hypothesised that free weight training was perceived more enjoyable and resulted in higher activated pleasant state compared to machines training.

Methods

Participants

The study involved 30 male volunteers aged between 19 and 38 years (M = 23.8, SD = 5.1), recruited from a fitness centre in North-East Italy by means of advertisements posted in the hall of the centre. All participants were recreationally strength-trained, with at least 2 years of training experience (i.e., with a regular frequency of 2–3 sessions/week) in the same fitness club, where they were familiar with the equipment used in this study. Participants provided written informed consent and received written explanations regarding the structure of the study. They were informed that they could withdraw at any time.

Measures

Participants self-completed the Italian version of the following scales.

Enjoyment

A short form of the Physical Activity Enjoyment Scale (PACES), derived from the 16-item version of the scale [24, 25], was used to assess enjoyment. The PACES discriminates between pleasant and unpleasant experience associated with physical activity. The Italian 12-item version of the scale was used [26].

Rating of perceived exertion (RPE)

The Borg 6–20 RPE scale was used for rating perceived exertion [27]. Participants were informed on how to use the RPE scale according to the American College of Sports Medicine guidelines [28].

Affective valence

To measure the affective valence in response to exercise, the Feeling Scale was used as a single-item measure [29]. Feeling is rated along a pleasure–displeasure continuum ranging from − 5 (very bad) to + 5 (very good). Anchors are provided at zero (neutral) and at all odd integers. The Feeling Scale is commonly used to measure affective response in physical activity research and is related to other measures of affective valence during physical activity [23, 30].

Perceived activation

The Felt Arousal Scale was used to evaluate perceived activation [31]. Arousal is rated on a six-point single-item scale ranging from 1 (low arousal) to 6 (high arousal).

Procedure

Participants performed two training sessions on 2 separate days, with 3 recovery days between sessions. During the recovery period, participants were asked to avoid RT while maintaining any regular aerobic-based exercise. The experimental sessions consisted of two RT sessions using a descending pyramid training system, one performed with three machines and the other with three free weight exercises. To determine the appropriate load at which participants could complete 6 and 12 repetitions of the different exercises (6 RM and 12 RM), baseline exercise testing was conducted with both resistance machines and free weights a week before the first experimental session. A trial and error modified methodology starting with 40% and then after 5 min rest increasing the resistance by 5% was used [32]. All participants were able to complete six repetitions at 80–85% of the 1 RM in the two conditions. The same methodology was used to assess the load that enabled the participants to perform 12 repetitions (65–70% 1 RM). The test–retest reliability of this methodology varies from 0.93 to 0.97 (ICC) [33]. Both the experimental sessions were carried out by participants at the same intensity. The training modality order was randomized using the ABBA counterbalancing experimental design technique. Half of the participants were assigned to the A order of execution (machines exercises in the first session and free weights training in the second) and the other half were involved with the B condition (free weights first and then machines). Questionnaires were self-completed immediately after each session. The machine exercises (Technogym Selection®, Technogym SpA., Gambettola, FO, Italy) consisted of chest press, shoulder press machine, and leg press; the free weights exercises were: bench press, front military press and squat. Each exercise was performed with the descending pyramid system, i.e., six repetitions, 115 s of rest, eight repetitions (with a lighter load), 115 s of rest, ten repetitions (with a lighter load), 115 s of rest, 12 repetitions (with a lighter load, i.e., the load obtained during the exercise trial test for 12 RM) [34].

The cadence between repetitions during both protocols was controlled. As expected, the muscle action velocity varied between training modalities. However, the average time of movement was comparable and estimated as approximately 1 s for the muscles contractile concentric phase and 2 s for the eccentric phase.

Data analysis

Cronbach's α for the negative and the positive subscale of the PACES were calculated. To test for a possible effect determined by the order of access to training modality, independent sample t tests were used to compare data on all the variables for participants that performed machines or free weights in the first session (the A or B order of execution). A series of paired sample t tests were used to examine differences in the five scales for the two conditions for the whole group. Pearson's correlations were conducted to evaluate relations among variables.

Results

Cronbach's α had an average value of .77 for the positive scale and of .84 for the negative scale of the PACES. Independent sample t test revealed no significant differences by the order of the training modality. Descriptive statistics, and results of paired sample t test and Cohen's d_z are reported in Table 1. In the comparison between the machine and free weights conditions, significant differences were found for all variables ($p < 0.01$). In particular, free weight training was perceived as more enjoyable and strenuous and resulted in higher activated pleasant state than exercise using machines.

Pearson's correlations among variables showed that enjoyment, particularly PACES-pros, was significantly associated with the Feeling Scale and the Felt Arousal Scale during the free weights training. The significant, positive correlation between PACES-pros and the Feeling Scale warrants note ($r = 0.75$, $p < 0.01$). During machine training, enjoyment was not significantly related with none of the variables (Table 2).

Concerning affective responses, RE performed with free weights resulted in a pleasant activation feeling for all participants, while the machine training condition determined high-activation pleasant state for the majority but also cases of low-activation displeasure state. In Fig. 1, the integrated affective responses to both exercise conditions are represented with the circumplex model of affect.

Table 1 Descriptive statistics, paired sample t test, and Cohen's d_z for the two conditions

	Free weights M (SD)	Weight machines M (SD)	Δ (%)	$t_{1,29}$	P	Cohen's d_z
PACES-pros	26.7 (2.2)	21.1 (4.6)	20.97	6.15	< 0.001	1.12
PACES-cons	9.5 (3.6)	13.1 (5.1)	− 37.89	− 3.06	< 0.01	0.56
RPE	16.4 (1.9)	13.4 (1.7)	18.29	7.88	< 0.001	1.43
Feeling Scale	3.8 (1.1)	1.3 (1.4)	65.79	8.98	< 0.001	1.63
Felt Arousal Scale	5.4 (0.9)	4.0 (0.9)	25.92	6.43	< 0.001	1.17

PACES Physical Activity Enjoyment Scale, *RPE* Rating of Perceived Exertion

Table 2 Pearson's correlations among variables in the two training conditions

	FS	FAS	PACES-pros	PACES-cons
Weight machines				
RPE	0.18	0.30	0.22	– 0.38*
FS		0.60**	0.19	– 0.08*
FAS			0.35	– 0.33
PACES-pros				– 0.69**
Free weights				
RPE	0.34	0.27	0.47**	– 0.57**
FS		0.66**	0.75**	– 0.47**
FAS			0.43*	– 0.43*
PACES-pros				– 0.39*

RPE Rating of Perceived Exertion, *FS* Feeling Scale, *FAS* Felt Arousal Scale, *PACES* Physical Activity Enjoyment Scale

*$P < 0.05$; **$P < 0.01$

Conclusions and discussion

Little is known about the affective responses to RE [35]. Although the relationship of RE intensity with affect and enjoyment has been considered in some studies [8, 9, 13, 15, 35], the type of resistance has not been investigated, yet in relation to positive or negative affects responses. Our study examined the influence of two commonly adopted types of RT, machines, and free weights, on affective states, enjoyment, and perceived exertion. Results supported the claim that diverse training modalities can provide different affective states in recreationally strength-trained men.

As hypothesised, RT with free weights resulted in increased pleasantness and activation. During free weights, training enjoyment and perceived exertion were significantly higher in comparison with machine training and enjoyment was positively related to affective responses and with the rating of exertion. The prescription of RT should consider, in addition to the physiological and technical aspects, also the affective responses to the different modes of training, especially when the goal is improving general fitness [36].

Since the two training modalities were performed with the same 1 RM percentage, it was foreseen that the RPE was similar during the two conditions. Therefore, the significantly higher RPE ($p < 0.001$) during the free weights training should be taken into consideration when discussing the present results. Although a higher perceived exertion has been reported, and in spite of the well-known inverse relationship between exercise intensity and positive affective responses [6, 37], enjoyment, affective valence, and perceived activation were significantly higher in comparison with values registered during machine sessions. Free weights training, i.e., moving the weight without fixed pattern or guided movements, may allow for a higher coordinative and body control demand, and, thus, facilitate greater general satisfaction and pleasantness among individuals training for health-fitness purposes. Concerning the integrated affective-activation valence in the circumplex model (Fig. 1), during free weights, training affective responses were significantly higher than during machines session, showing that participants perceived higher activation and pleasantness during free weights' training.

These findings confirm a relationship of exercise modality with affects in the context of RT, which is intuitive for coaches and instructors. Findings could have practical

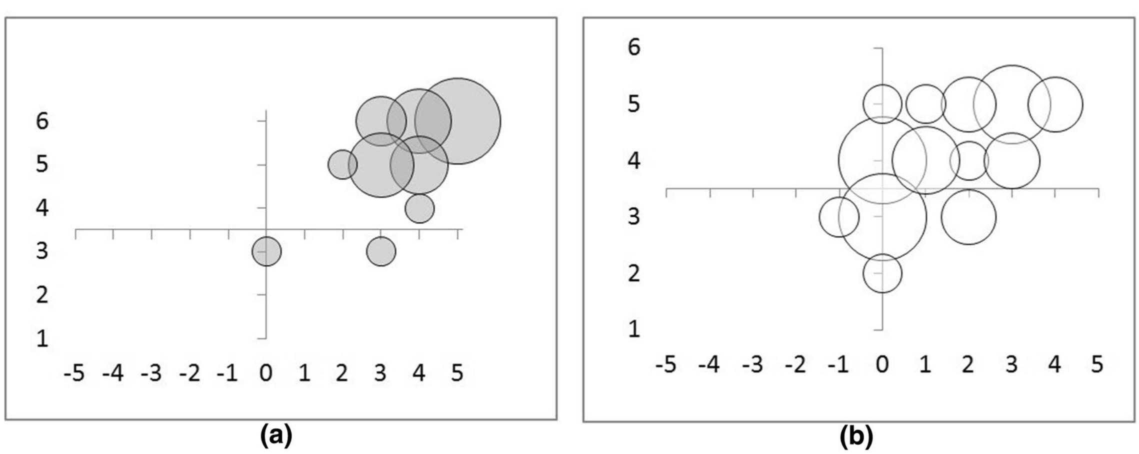

Fig. 1 Participants' affective-activation valence after free weights (**a**) and machines (**b**) acute training. Note: perceived activation, i.e., arousal as measured by the Felt Arousal Scale is reported on the *x*-axis; affective valence in response to exercise, as measured by the Feeling Scale, is reported on the *y*-axis. Circle size indicates the frequency of participants' in that position

relevance for planning training programmes, both when these are designed for experienced individuals or beginners. In particular, beginners could be trained not only in the use of machines but also in free weights exercises, to let them experience diverse training modalities, that may elicit more enjoyable, pleasant, and energizing forms of exercise, which have been suggested to be significant predictors of long-term adherence [37].

Some limitations of the present study should be taken into account. One is the characteristics of the sample, composed by young recreationally trained men. A different selection of the sample (e.g., women, middle-aged participants, or beginners) could have led to different results. For example, Focht et al. did not find significant differences in the affective response to RT in a group of women exercising at self-selected and imposed loads [18] and Miller et al. reported no differences in another group of young women during and after eccentric, concentric, and eccentric–concentric training with resistance machines [22]. Another limitation of the present study is the acute design; a different methodological approach considering different training sessions could led to diverse results. Finally, the equipment used may have influenced the results.

Further research may be needed to examine psychological and physiological mechanisms occurring for positive affective responses while engaging in RE, for instance searching for a mediation role of the affective responses between perceived exertion and enjoyment could be of interest.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest relating to the publication of this manuscript.

Ethical statement All procedures performed in studies involving human participants were in accordance with the ethical standards of the University of Padua research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Written informed consent was obtained from all individual participants included in the study.

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