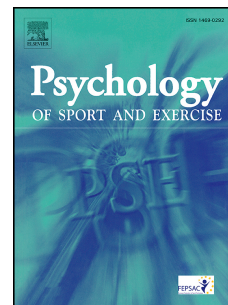


# Journal Pre-proof

Affective responses to resistance exercise: Toward a consensus on the timing of assessments

A.J. Andrade, P. Ekkekakis, A. Evmenenko, D. Monteiro, F. Rodrigues, L. Cid, D.S. Teixeira



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**Affective Responses to Resistance Exercise: Toward Consensus on the Timing of Assessments**

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**Declarations**

Nothing to declare.

## Abstract

Tailoring exercise prescriptions aimed at improving affective responses to resistance exercise may promote pleasurable experiences and thus exercise adherence. The purpose of this study was to evaluate different timing protocols for administering rating scales for the assessment of affective valence (Feeling Scale, FS) and perceived activation (Felt Arousal Scale, FAS) during resistance exercise. Thirty-three experienced male exercisers ( $M = 36.42 \pm 7.72$  years) completed the FS and FAS at different times at three percentages of one-repetition maximum (%1RM) during two exercises (bench press, squat). No differences emerged among different assessment time points and %1RM. These findings suggest that the post-exercise "affective rebound" phenomenon found in aerobic exercise may not be as pronounced in resistance exercise. Therefore, the results support the use of FS and FAS in resistance exercise, administered immediately after a set, over a wide range of %1RM and exercises. Mounting evidence suggests that the use of these scales in resistance exercise could allow researchers and practitioners to evaluate affective responses that may be important for adherence.

Keywords: Feeling Scale; Felt Arousal Scale; Resistance Training; Affective Valence; Adherence

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28

## 29 **Introduction**

30 Resistance exercise has consistently ranked among the most popular exercise  
31 modalities in surveys of fitness trends over the past five years (Batrakoulis, 2019), and  
32 confers several benefits for health and well-being (American College of Sports  
33 Medicine, 2018). In order to best serve the interests of exercise participants, exercise  
34 professionals should base their practice on the best scientific evidence, aiming to  
35 provide individualized exercise prescriptions aligned with the participants' needs and  
36 characteristics (Rodrigues et al., 2019). However, the persistently high dropout rates  
37 reported in several studies (Buckworth et al., 2013; Sperandei et al., 2016) suggest that  
38 innovative approaches should be developed to better adjust training protocols to  
39 individual needs and thus enhance the exercise experience to facilitate adherence  
40 (Carraro et al., 2018; Cavarretta et al., 2018).

### 41 *The hedonic approach to resistance exercise*

42 Given the need to devise interventions that can promote exercise adherence,  
43 several psychological frameworks have been applied to exercise settings with the aim of  
44 encouraging behavioral maintenance and dropout avoidance (Ekkekakis & Dafermos,  
45 2012; Ekkekakis & Zenko, 2016). In recent years, affective responses to bouts of  
46 exercise have been identified as predictors of future physical activity engagement and  
47 have, therefore, been targeted as constructs that should be considered in behavior-  
48 change strategies (Chen et al., 2020; Rhodes & Kates, 2015).

49 The hedonic approach to exercise postulates that participants tend to engage in  
50 activities that may bring about pleasure and avoid displeasure, and emerging evidence  
51 has supported these assumptions (e.g., Calder et al., 2020; Williams et al., 2008). The  
52 relation between exercise and affective responses is partly influenced by exercise  
53 intensity, with higher exercise intensities generally associated with lower scores of

54 pleasure or increased displeasure (Evmenenko & Teixeira, 2020; Rhodes & Kates,  
55 2015; Williams et al., 2008).

56 In the case of resistance training, few studies have focused on understanding the  
57 dynamics of intensity and pleasure/displeasure, and thus a considerable gap exists in the  
58 current knowledge of the affective consequences of resistance training. Given the  
59 worldwide popularity of resistance training, more research on this training modality and  
60 its affective consequences is urgently needed (Evmenenko & Teixeira, 2020).

61 A review by Cavarretta et al. (2018) focusing on the acute effects of resistance  
62 training on affect showed that eight of the 14 studies reported affective improvements.  
63 However, most of these studies only examined pre- to post-exercise changes, failing to  
64 assess how affective dynamics during the session are influenced by different exercise  
65 protocols. This is a limitation insofar as it has been proposed that how one feels *during*  
66 exercise is a predictor of future physical activity behavior, whereas affect ratings  
67 obtained after exercise are not (Greene & Petruzzello, 2015; Williams et al., 2008).

68 Of the 14 studies included in the review by Cavarretta et al. (2018), the majority  
69 measured affect with the Feeling Scale (FS; Hardy & Rejeski, 1989), which is a rating  
70 scale that assesses the dimension of affective valence, and the Felt Arousal Scale (FAS;  
71 Svebak & Murgatroyd, 1985), which is rating scale that assesses the dimension of  
72 perceived activation. The advantage of using these two scales together repeatedly during  
73 an exercise session is that that they allow plotting the trajectory of the affective response  
74 to a session of exercise within the two-dimensional "circumplex model" of affect (for a  
75 review, see Ekkekakis et al., 2011). However, Cavarretta et al. (2018) emphasized that,  
76 due to different measurement procedures (in particular, the timing of affect  
77 assessments), results based on FS/FAS measurements during sessions of resistance

78 exercise should be viewed with caution, since measurement time points and procedures  
79 varied across studies.

80 This issue was further addressed by Cavarretta et al. (2019a), who proposed that  
81 'timing matters' when assessing the dynamics of affect during resistance exercise. In  
82 this study, the authors examined affective responses (measured only with the FS) in the  
83 beginning, during sets, between sets, and 5 and 30 minutes after exercise. The results  
84 underscored the importance of defining distinct measurement time points for the  
85 interpretation of the data. Specifically, measurements taken during sets resulted in lower  
86 FS scores compared to measurements taken between sets. This difference was also  
87 detected in the systematic review conducted by Evmenenko and Teixeira (2020), which  
88 aimed to explore the usefulness of the FS and FAS within the framework of the  
89 circumplex model of affect. In this systematic review, five studies were found to have  
90 used these scales in resistance-exercise settings. However, it was emphasized that "more  
91 evidence is needed to understand if intra-exercise measures should be made during sets,  
92 immediately after a set, after a bout of sets, and so on" (Evmenenko & Teixeira, 2020,  
93 p. 25). In another study, by Emanuel et al. (2020), which used the FS in a repetition-by-  
94 repetition analysis, it was reported that FS scores revealed differences between the last  
95 exercise repetition and a 10-s post-set measure, with the last measurement being higher  
96 (i.e., indicating more pleasure). Therefore, previous research has underscored the  
97 importance of the timing of assessments of affect in ensuring a fuller description and  
98 more accurate interpretation of the dynamics of affective responses to resistance  
99 exercise.

100 In resistance training, the percentage of the 1-Repetition Maximum (%1RM) is  
101 the metric commonly used to express exercise intensity (< 30%: "very light"; 30% to <  
102 50%": "light"; 50% to <70%: "moderate"; 70% to <85%: "vigorous"; ≥ 85%: "near

103 maximal"; American College of Sports Medicine, 2018). Intensity is expected to  
104 influence how exercisers feel during training.

105 In a study by Greene and Petruzzello (2015), the results showed differences  
106 between the 70% and 100% 1RM in FS and FAS scores, with the higher % 1RM  
107 resulting in lower affective valence and higher perceived activation during exercise.  
108 These results were supported in the review by Cavarretta et al. (2018), in which  
109 affective improvement was detected particularly when the % 1RM was around 50-70%.  
110 In the study by Cavarretta et al. (2019b), the same trend emerged with the FS, with the  
111 affective valence response becoming less positive with higher % 1RM. In addition,  
112 Emanuel et al. (2020) showed that the pattern of FS scores supported the same intensity-  
113 affect relationship (i.e., higher exercise % 1RM – lower FS scores). With these results in  
114 mind, several authors have suggested that additional research is needed to clarify the  
115 role of differences between protocols, suggesting, for example, that moderate (i.e., <  
116 70% 1RM) and near maximal (80% and 90% 1RM) intensity conditions should also be  
117 tested for comparison, given the mixed results reported in previous literature (Bellezza  
118 et al., 2009; Emanuel et al., 2020; Greene & Petruzzello, 2015; Portugal et al., 2015).

#### 119 *Present research*

120 Considering the results of previous studies, the pattern of affective valence and  
121 perceived activation responses obtained during sessions of resistance exercise warrants  
122 methodological clarification. If there is a link between how one feels during resistance  
123 exercise and the likelihood of sustaining the behavior, a proper methodological platform  
124 must be developed as a solid foundation for future investigations. The potential from  
125 developing such a platform is considerable and includes (a) training exercise  
126 professionals and exercisers on how to properly use and interpret rating scales of  
127 affective valence and perceived activation, (b) testing the reliability of patterns across

128 different % 1RM and exercises, and (c) standardizing a timing protocol for the  
129 administration of these scales that would allow research to advance while at the same  
130 time minimizing intrusion and safeguarding ecological validity (Duda, 1998;  
131 Evmenenko & Teixeira, 2020).

132         Research with aerobic exercise has documented an *affective rebound*  
133 phenomenon, whereby a high percentage of participants experience a positive affective  
134 change immediately after the cessation of exercise that led to affective decline during  
135 the session, akin to an affective "rebound" or "relief effect" (Ekkekakis et al., 2011). If a  
136 similar phenomenon exists in resistance exercise, then affect should also be sampled  
137 during a set (i.e., while muscles are still under tension) rather than only before and  
138 immediately after the set (i.e., when muscles are no longer under tension). However,  
139 several concerns emerge from this suggestion, particularly given the following  
140 considerations. First, the literature on the topic is scarce, based on small samples, and  
141 lacking evidence of previous trainer-trainee preparation for proper application and  
142 interpretation of the FS and FAS (Evmenenko & Teixeira, 2020). Second, resistance  
143 exercise involves distinct physiological demands and results in different outcomes and  
144 adaptations compared to aerobic exercise, thus possibly entailing distinct trajectories of  
145 affective changes during the session (for example, given the inter-set rest period;  
146 Cavarretta et al., 2019a). Third, the instructions that accompany the administration of  
147 the FS (Hardy & Rejeski, 1989) and FAS (Svebak & Murgatroyd, 1985) inquire about  
148 "how one feels" and "how activated" the individual is in the present moment. Fourth, in  
149 "real-life" contexts (e.g., in gymnasias or health clubs), assessments during sets (i.e.,  
150 during muscle contraction, when transitioning from the concentric to the eccentric  
151 phase, while the muscle is under tension), will likely be considered overly obtrusive and



175           The sample size was determined through power calculations conducted with  
176 G\*Power v.3.1 (Faul et al., 2009), using the following input parameters: medium  
177 anticipated effect size for a comparison between two dependent means ( $d = .50$ ),  
178 statistical power  $1-\beta = .80$ , and  $\alpha = .05$ . Given that no study has presented results  
179 directly relevant to the effect being targeted in the present study, estimates of effect  
180 sizes pertaining to affective responses to similar experimental manipulations within the  
181 context of resistance exercise were used (e.g., Cavarretta et al., 2019b). Particularly, the  
182 comparison between muscles-under-tension vs. muscles-not-under-tension would be  
183 equivalent to the comparison between high-level resistance (e.g., 100% 10RM) vs. low-  
184 level resistance (e.g., 50% 10RM), albeit with affective ratings obtained after the  
185 repetitions. For the bench press and the squat, prior effect sizes in the reported study  
186 were found to be medium (Cavarretta et al., 2019b). Based on these calculations, the  
187 target sample size determined for present study was of 33 ( $1-\beta = 0.795$ ) or 34 ( $1-\beta =$   
188  $.808$ ).

189           A total of 33 participants were included following screening for eligibility  
190 criteria ( $M_{\text{age}} = 36.42 \pm 7.72$  years;  $M_{\text{experience}} = 12.05 \pm 7.27$  years;  $M_{\text{BMI}} = 25.17 \pm 2.23$   
191  $\text{kg/m}^2$ ). The inclusion criteria were the following: male volunteers aged 18–50 years,  
192 apparently healthy, free of injury or any contraindication to exercise, and engaging in a  
193 resistance training regimen regularly ( $> 3$  months of continuous participation). All  
194 participants read and signed an informed consent form prior to the experiment. This  
195 study protocol was approved by the Faculty of Physical Education and Sport of the  
196 Lusófona University institutional review board and was developed in accordance with  
197 the Helsinki Declaration and its later amendments.

198 *Procedures*

199 *Study protocol*

200 Study participants took part in two experimental sessions. All participants were  
201 instructed to avoid vigorous exercise for at least 48 hours prior to each session. No  
202 verbal encouragement was provided during the sessions, in order to standardize the  
203 experimental conditions and limit the influence of the researcher on perceptual and  
204 affective responses.

205 In the first session, participants were briefed about the upcoming procedures,  
206 completed questionnaires, and were tested to estimate their 1-repetition maximum  
207 (1RM) for the bench press and squat exercises, following the regression equations  
208 developed by Reynolds et al. (2006) for 4- to 8-RM. Based on individual performances,  
209 60% (moderate), 75% (vigorous), and 90% (near maximal) of 1RM were then  
210 calculated (American College of Sports Medicine, 2018). This was done after a brief  
211 general warm-up on a treadmill (low-to-moderate intensity; 5-7 min), and a specific  
212 warm-up for the two resistance exercises (adjusted for 8-10 repetitions).

213 The second session started with the same general and specific warm-up  
214 procedures as the first. The exercise volume for the three % 1RM conditions was  
215 equated based on the interaction of sets x repetitions x load (total volume ranged  
216 between 1,800 and 2,250 kg). Specifically, for 60% 1RM, there were 2 sets of 15-17  
217 repetitions, for 75% 1RM, there were 3 sets of 8-10 repetitions, and for 90% 1RM, there  
218 were 4 sets of 5-6 repetitions, following the recommendations of previous studies (e.g.,  
219 Cavarretta et al., 2019a). The intra-set measurement time point was taken near the  
220 midpoint of the volume determined for each % 1RM condition. Specifically, affect was  
221 sampled at the 14th-to-15th repetition of the first set for 60% 1RM, at the 4th-to-5th  
222 repetition of the second set for 75% 1RM, and at the 4th-to-5th repetition of the second  
223 set for 90% 1RM. A second measurement was taken immediately after the end of the  
224 last set of each % 1RM condition. A 10-s post-set affective-recall measurement was also

225 collected. The rest period was 90 s between sets and 3 min between %1RM conditions.  
226 The exercise cadence was defined at 2:2. The upper body exercises were performed first  
227 for all %1RM conditions (ordered from lower to higher: 60%, 75%, 90%).

228       Following the recommendations by Duda (1998) and Evmenenko and Teixeira  
229 (2020) on the use of psychometric scales, the standardized instructions and item stems  
230 were read to the participants, and several examples were given to explain what the  
231 instruments were intended to assess. In the examples, the exercisers were asked to recall  
232 activities they were using in their current training that would approximate the extreme  
233 and the middle parts of the bipolar rating scales (i.e., the FAS and FS). Additionally, the  
234 warm-up activities used in the first and second sessions (e.g., prior to the determination  
235 of %1RM in the first session), were used to familiarize the participants with the  
236 psychometric instruments, emphasizing that the ratings of affective valence and  
237 perceived activation should represent these feelings experienced *in the present moment*  
238 (e.g., immediately after the set).

239       During warm-up activities, the researchers explained how and when the  
240 measures of affective valence (FS) and perceived activation (FAS) would be  
241 administered. Specifically, ratings were collected at three time points during each  
242 %1RM condition for each exercise, including (a) an intra-set measurement (obtained  
243 during a brief pause with the muscles still under tension and at the point of transition  
244 from the concentric to the eccentric phase), (b) an end-of-set measurement (taken  
245 immediately after load removal), and (c) a recall measurement (obtained 5 to 10 s post-  
246 set, with the instruction "how did you feel during this last set?").

247       Data collection was carried out by two of the researchers. Both were trained on  
248 the administration of the psychometric instruments on a small independent sample prior  
249 to the beginning of the study, following the instructions provided by the developers of

250 the instruments, as well as other relevant studies pertaining to related psychometric  
251 assessments (e.g., Russell et al., 1989).

## 252 *Instruments*

### 253 *Feeling Scale and Felt Arousal Scale*

254 Affective valence was measured with the Feeling Scale (FS; Hardy & Rejeski,  
255 1989). The FS is an 11-point bipolar rating scale ranging from -5 (I feel "very bad") to  
256 +5 (I feel "very good"). The FS has been widely used to assess affective valence during  
257 exercise and has demonstrated satisfactory validity (Hardy & Rejeski, 1989) through  
258 correlations with other measures of affective valence (Evmenenko & Teixeira, 2020).  
259 Perceived activation was measured with the Felt Arousal Scale (FAS; Svebak &  
260 Murgatroyd, 1985). The FAS is a 6-point single-item bipolar rating scale, ranging from  
261 1 to 6 with verbal anchors of (1) "low arousal" and (6) "high arousal." The FAS has  
262 been used in exercise research in conjunction with the FS (Evmenenko & Teixeira,  
263 2020) to assess the two dimensions of the circumplex model (i.e., perceived activation  
264 and affective valence, respectively). Both scales were translated to Portuguese and were  
265 found to demonstrate acceptable validity (Brito et al., in press).

## 266 *Data analysis*

267 Descriptive statistics (means and standard deviations) were calculated for all  
268 variables. The Shapiro-Wilk and Levene's tests were used to verify normality and equal  
269 variances, respectively. A 2 (exercises: bench press, squat) by 3 (% 1RM: 60%, 75%,  
270 90%) by 3 (time points: intra-set, end-of-set, post-set) repeated-measures ANOVA was  
271 conducted to examine differences in the dependent variables (FS, FAS). For these  
272 analyses, Mauchly's test was used to examine the assumption of sphericity for the two  
273 independent variables with three levels (i.e., % 1RM, time). In case of sphericity

274 violations, ANOVA results based on Greenhouse-Geisser-adjusted degrees of freedom  
 275 are reported, as suggested by Ho (2014), and are indicated by decimal degrees of  
 276 freedom. The Greenhouse-Geisser adjustment was selected because it is more  
 277 conservative compared to the Huynh-Feldt. Significant ANOVA main effects and  
 278 interactions were followed up by Bonferroni-adjusted post-hoc tests to analyze pairwise  
 279 comparisons. It should be noted that, for ease of interpretation, the uncorrected  $p$  values  
 280 resulting from the pairwise comparisons were multiplied by the number of pairwise  
 281 comparisons, so the reported  $p$  values can be evaluated by the customary criterion of  $p <$   
 282  $.05$ . Finally,  $\eta^2_p$  effect sizes were calculated for the ANOVAs ("small" effect =  $.01$ ,  
 283 "medium" effect =  $.06$ , "large" effect =  $.14$ ; Cohen, 1988). For comparisons between  
 284 means, we used  $d$  based on the formulas proposed by Cohen (1988, Section 2.3.5, p. 48)  
 285 for one-sample differences between paired observations ("small" effect =  $.20$ , "medium"  
 286 effect =  $.50$ , "large" effect =  $.80$ ). Specifically:

$$287 \quad d_{rm} = \frac{\bar{x}_1 - \bar{x}_2}{S_{rm}}$$

288 where

$$289 \quad S_{rm} = \frac{S_z}{\sqrt{2(1-r)}}$$

290 and, in turn,

$$291 \quad S_z = \sqrt{S_1^2 + S_2^2 - 2rS_1S_2}$$

## 292 **Results**

293 A preliminary examination revealed no missing values. In addition, no violations  
 294 of the assumption of distributional normality were detected, since the results from

295 Shapiro-Wilk tests were higher than .05, ensuring appropriate conditions for the use of  
296 parametric tests (Ho, 2014).

297 The characteristics of the participants are presented in Table 1. As can be seen,  
298 the male exercisers in the present sample had a mean age of 36 years, averaged over 12  
299 years of experience, and had slightly above-normal body mass index. Additionally, their  
300 mean 1RM bench-press performance reflected an excellent ratio (1.19) of weight  
301 pushed to body weight (American College of Sports Medicine, 2018). The  
302 corresponding squat ratio was 1.57 (no normative values exist for this test for  
303 recreational exercisers).

304 < Insert Table 1 About Here >

305 The descriptive statistics related to FS and FAS ratings during the experimental  
306 conditions are presented in Table 2. The end-of-set FS and FAS ratings across the three  
307 %1RM conditions were compared as a manipulation check (Table 2). The FS and FAS  
308 differed significantly among the %1RM conditions for both exercises (all  $p < .001$ ).  
309 Bonferroni-adjusted comparisons showed that the only non-significant comparison was  
310 for the FAS between 75% 1RM and 90% 1RM (mean difference = -0.424,  $p = 0.225$ ).

311 < Insert Table 2 About Here >

312 < Insert Figure 1 About Here >

313 The results of the repeated-measures ANOVAs for the FS and FAS ratings are  
314 shown in Table 3 (also see Figure 1). For both dependent variables, all three main  
315 effects (exercise, %1RM, time) were significant but none of the two- and three-way  
316 interactions was significant.

317 < Insert Table 3 About Here >

318 For FS, examination of the marginal means showed (1) a lower rating associated  
319 with the squat (-0.300, 95% CI -0.972 to 0.373) than the bench press (0.465, 95% CI -  
320 0.227 to 1.156), with a mean difference of 0.764 ( $p = .040$ ), (2) a progressive decline  
321 from 60% 1RM (1.338, 95% CI 0.905 to 1.772) to 75% (0.162, 95% CI -0.500 to  
322 0.823), to 90% (-1.253, 95% CI -2.171 to -0.334), with significant declines from 60% to  
323 75% ( $p < .001$ ) and from 75% to 90% ( $p < .001$ ), and (3) a V-shaped pattern in ratings  
324 over time, with a marginal mean of 0.318 intra-set (95% CI -0.191 to 0.827), -0.126 at  
325 end-of-set (95% CI -0.795 to 0.543), and 0.056 at 10-s post-set recall (95% CI -0.548 to  
326 0.659). Although the 10-s post-set recall was in-between the two previous ratings and  
327 did not differ significantly from either one (mean difference of 0.262,  $p = 0.217$ ,  $d =$   
328 0.17; and mean difference of -0.182,  $p = 0.056$ ,  $d = -0.10$ , respectively), the overall  
329 average of intra-set ratings differed from the overall average of end-of-set ratings (mean  
330 difference of 0.444,  $p = 0.028$ ,  $d = 0.27$ ).

331 For FAS, examination of the marginal means showed (1) a higher rating  
332 associated with the squat (4.616, 95% CI 4.333 to 4.900) than the bench press (4.306,  
333 95% CI 4.060 to 4.553), with a mean difference of 0.310 ( $p = 0.027$ ), (2) a gradual  
334 increase across the levels of % 1RM, from 60% (3.646, 95% CI 3.359 to 3.934), to 75%  
335 (4.601, 95% CI 4.376 to 4.827), to 90% (5.136, 95% CI 4.863 to 5.409), and (3) an  
336 inverted-V-shaped pattern in ratings over time, with a marginal mean of 4.263 intra-set  
337 (95% CI 4.039 to 4.486), 4.581 at end-of-set (95% CI 4.315 to 4.847), and 4.540 at the  
338 10-s post-set recall (95% CI 4.297 to 4.784). The mean differences from the intra-set  
339 assessment to end-of-set (-0.318,  $p = 0.007$ ,  $d = -0.46$ ) and 10-s post-set recall (-0.278,  $p$   
340 = 0.004,  $d = -0.42$ ) were both significant. On the other hand, the mean difference from  
341 end-of-set to the 10-s post-set recall was not (0.041,  $p = 1.000$ ,  $d = 0.06$ ).

342

## Discussion

343           The aim of the present study was to evaluate the role of obtaining ratings of  
344 affective valence (FS) and perceived activation (FAS) at different time points during a  
345 resistance exercise protocol at intensities ranging from moderate to near maximal in  
346 both upper- and lower-body movements in a sample of male health-club exercisers. We  
347 had hypothesized that we would find no significant differences between the intra-set and  
348 the immediate end-of-set assessments of affect. The rationale for this hypothesis was  
349 that we predicted an attenuated or absent "affective rebound" phenomenon in the  
350 context of resistance exercise, unlike the robust affective rebound commonly found in  
351 studies investigating cardiovascular exercise. Indeed, we found no evidence of an  
352 affective rebound in 5 of the 6 conditions we tested (two exercises, each performed at  
353 three levels of % 1RM). The only exception was a small (mean difference of -0.27 units,  
354  $d = -0.15$ ) change toward a more positive FS rating (from  $1.61 \pm 1.54$  intra-set to  $1.88 \pm$   
355  $1.96$  at end-of-set) in the bench press at 60% 1RM.

356           On the other hand, contrary to our prediction that we would find no significant  
357 differences between the intra-set and the immediate end-of-set assessments of affect, we  
358 did find significant main effects of time and significant mean differences for both the  
359 FS and FAS between the intra-set and the end-of-set assessments. Moreover, the  
360 changes were not in the direction of an affective rebound but rather in the direction of a  
361 worsening of affect, evidenced by a decline in affective valence (overall mean of FS  
362 ratings: 0.318 intra-set to -0.126 at end-of-set) and an increase in perceived activation  
363 (overall mean of FAS ratings: 4.263 intra-set to 4.581 at end-of-set). This phenomenon,  
364 namely the worsening affect from intra-set to the end-of-set assessments, did not vary  
365 significantly by type of exercise or % 1RM since time exhibited no interactions with  
366 these independent variables.

367           The absence of an affective rebound stands in contrast to voluminous previous  
368 findings from cardiovascular exercise (Ekkekakis et al., 2011), as well as a limited body  
369 of evidence that has emerged from resistance exercise (Cavarretta et al., 2019a;  
370 Emanuel et al., 2020; Evmenenko & Teixeira, 2020; Portugal et al., 2015). It is  
371 important to underscore that, in the present study, the end-of-set measurement was  
372 taken immediately after load removal. It is, therefore, possible that one reason for the  
373 discrepant findings might be the exact sampling time, since the passage of additional  
374 time since load removal (perhaps even only a few additional seconds) might have  
375 resulted in the emergence of a detectable affective rebound. For example, the study by  
376 Cavarretta et al. (2019a) included administrations of the FS during the set (with muscles  
377 under tension), "after" the completion of the final repetition (but without specifying the  
378 exact timing), and 5 min post-set. The study by Emanuel et al. (2020) included  
379 administrations of the FS after each repetition and 10 s after the last repetition. It is,  
380 therefore, possible that the presence or absence of evidence for an affective rebound  
381 depends on the number of seconds that elapse from the cessation of a set until the  
382 administration of the FS and FAS.

383           In general, it seems clear from previous studies (e.g., Bellezza et al., 2009;  
384 Cavarretta et al., 2018) that ratings of affect tend to become more positive after the end  
385 of an activity that induced affective decline, and that this effect tends to become more  
386 pronounced over time (e.g., 5 min vs. 30 min post-exercise). However, in order to  
387 assess core affective valence and perceived activation (i.e., feeling pleasure or  
388 displeasure with relatively low contribution from reflective thought and relevant  
389 cognitive appraisals), measurements should be taken in as close temporal proximity to  
390 the end of the activity as is technically feasible, in order to preserve the contribution of  
391 interoceptive signals and homeostatic perturbations to the affective state (Ekkekakis et

392 al., 2011, 2019). In contrast, it is assumed that, when post-exercise assessments are  
393 taken several minutes after the completion of exercise, ratings of affective state will  
394 reflect the strong influence of reflective cognition and, in particular, the interpretation of  
395 the preceding exercise performance for the self-evaluation and sense of self-worth of the  
396 individual (e.g., "I think I did well, so I am feeling good"). Conceivably, the post-  
397 exercise cognitive interpretation of the situation may even lead to affect ratings after an  
398 exercise bout that are antithetical to affective experiences that occurred while the  
399 exercise was ongoing (e.g., "this set was really hard, I struggled to finish, so I am now  
400 satisfied that I challenged myself to get stronger"; see Ekkekakis et al., 2011;  
401 Ekkekakis, 2013).

402         The present results suggest that, at least for loads of 75% 1RM or higher, an end-  
403 of-set assessment of affect taken immediately after load removal, in conjunction with a  
404 baseline assessment, might be sufficient to represent the changes that take place during  
405 a set. It appears that, at least above a certain critical threshold or resistance, affect  
406 deteriorates (valence declines and perceives activation increases) in progressive fashion  
407 during a set. Assuming that the trend is indeed linear, researchers and practitioners  
408 could capture it with an assessment of affect taken immediately after the final repetition.

409         If this finding is replicated, it could have interesting implications for research  
410 and practice. From a research-methodological perspective, this means that additional,  
411 potentially intrusive, intra-set assessments (e.g., asking participants to report their  
412 affective state during the final muscular contraction) may not be necessary. In turn, this  
413 would increase the generalizability and ecological validity of studies investigating  
414 affective responses to resistance exercise. For exercise practitioners, this means that a  
415 valid record of the affective experiences of participants can be obtained with minimal  
416 disruption. In turn, such assessments can be used to tailor resistance-exercise intensity

417 prescriptions to individuals and to track longitudinal changes in affective experiences  
418 (e.g., in response to overload).

419         It should also be noted that, as can be seen in Table 2 and Figure 1, the 10-s  
420 post-set recalls of affect (obtained with the instruction "how did you feel during this last  
421 set?") similarly did not exhibit evidence of an affective rebound. In most cases, the 10-s  
422 recall was a reasonably close representation of the average of the intra-set and end-of-  
423 set assessments. For FS, the average discrepancy between the 10-s post-set recall and  
424 the average of the intra-set and end-of-set assessments was  $-0.04 \pm 0.15$ , with the largest  
425 discrepancy for the 60% 1RM of the squat ( $-0.29$ ) due to an apparent recency effect  
426 (i.e., the post-set assessment being close to the end-of-set assessment but farther away  
427 from the intra-set assessment). For FAS, the average discrepancy between the 10-s post-  
428 set recall and the average of the intra-set and end-of-set assessments was  $0.12 \pm 0.03$ ,  
429 with no individual discrepancy exceeding 0.15 FAS units. These small discrepancies  
430 suggest that even 10-s post-set recall assessments could be useful indicators of affective  
431 responses to resistance training for exercise practitioners.

432         Another noteworthy observation from the present study was an apparent  
433 stepwise increase in the interindividual variability of affective valence ratings in  
434 response to increasing level of resistance. Specifically, as can be seen in Table 2, in the  
435 bench press, compared to the variance in FS ratings at 60% 1RM, the variance ( $S^2$ )  
436 doubled (x 2.11) at 75% 1RM and tripled (x 3.21) at 90% 1RM. Likewise, in the squat,  
437 variance doubled (x 1.83) at 75% 1RM and quadrupled (x 3.95) at 90% 1RM.  
438 Remarkably, no such phenomenon emerged for FAS ratings, where the variance  
439 exhibited no pattern of systematic escalation. Considering that resistance was  
440 individualized (i.e., set as a percentage of the individually determined 1RM for each  
441 exercise), the observation of progressively escalating variance in ratings of affective

442 valence is likely an indication of individual differences in the modulation of  
443 interoceptive afferents, as theorized by Ekkekakis et al. (2005). Specifically, Ekkekakis  
444 et al. (2005) introduced the constructs of exercise intensity preference, defined as the  
445 predisposition to choose a particular level of exercise intensity when given the  
446 opportunity, and exercise intensity tolerance, defined as the ability to tolerate an  
447 imposed level of intensity that is unpleasant or uncomfortable. These individual-  
448 difference dispositions, assessed by the Preference for and Tolerance of the Intensity of  
449 Exercise Questionnaire (PRETIE-Q), have been found to account for significant  
450 portions of the variance in affective valence responses to exercise (e.g., Box &  
451 Petruzzello, 2020; Jones et al., 2018), and may have implications for the affect-  
452 adherence relationship (Faria et al., 2021; Teixeira et al., 2022). Given the present  
453 finding of escalating variance in affective valence responses to increasing levels of  
454 resistance, it is reasonable to suggest that further investigations of the relation of  
455 affective valence ratings with intensity-preference and, especially, intensity-tolerance  
456 are warranted.

457 In evaluating the results of the present investigation, critical readers should  
458 consider the following limitations. First, it should be clear that the present results are  
459 limited by the fact that the participants were all male health-club exercisers who were  
460 experienced in resistance training, and the experimental protocol consisted of only two  
461 exercises (bench press, squat) and three levels of resistance (60%, 75%, 90% 1RM).  
462 Therefore, any extrapolations should take these limitations into account.

463 Moreover, the experimental protocol had to balance two competing  
464 considerations. On the one hand, it was necessary for the purpose of our study to assess  
465 affect during the set, in order to obtain an indication of the trend of affective change as  
466 the set unfolds. On the other hand, it was also important to preserve the ecological

467 validity of the study as much as possible, so that any conclusions would be relevant to  
468 how resistance exercise is practiced in realistic settings. These two needs cannot be met  
469 simultaneously, so a compromise had to be sought. Resistance exercise is performed in  
470 a series of repetitions, during which afferent information changes continuously in a  
471 cyclical manner (i.e., through a series of concentric and eccentric contractions). Since  
472 core affect is theorized to respond dynamically to the changing physiological condition  
473 of the body, presumably affect would show a similar oscillatory pattern. In addition,  
474 affect may show longer-term trends, from the first to the last contraction within a set,  
475 and from the first to the last set, as a result of accumulating fatigue (e.g., incomplete  
476 local clearance of metabolites in the working muscles). Obtaining a faithful  
477 representation of this complex pattern would necessitate numerous repeated assessments  
478 of affect, in close temporal proximity. However, such an assessment protocol would be  
479 overly intrusive and logistically challenging, fundamentally altering the nature of the  
480 affective experience. In addition, asking the same questions repeatedly is known to elicit  
481 various artifacts (e.g., reactivity to testing, variance carry-over effects). Therefore, in the  
482 present study, as a reasonable compromise, we opted to acquire one "intra-set" and one  
483 "end-of-set" assessment per experimental condition. These two time points enabled us  
484 to obtain an estimate of linear trends but precluded a more fine-grained depiction of  
485 changes from repetition to repetition and from set to set. In the future, researchers  
486 should seek to devise novel methodologies that would address this limitation, allowing  
487 more frequent assessment of affect while preserving ecological validity (Ekkekakis et  
488 al., 2019).

489         In addition, taking the intra-set assessments near the mid-point of the volume of  
490 weight lifted at each % 1RM introduced an inconsistency in terms of the position of  
491 these assessments within a set. Specifically, (a) for 60% 1RM, the measurement was

492 taken near the end of a set (14th-15th repetition out of 15-17 repetitions in the first set),  
493 (b) for 75% 1RM, the measurement was taken near the middle of a set (4th-5th  
494 repetition out of 8-10 repetitions in the second set), and (c) for the 90% 1RM, the  
495 measurement was taken near the end of a set (4th-5th repetition out of 5-6 repetitions in  
496 the second set). It is conceivable that knowledge of the proximity to the end of the set  
497 might have influenced the intra-set reports of affect.

498 Finally, readers should keep in mind that this was a study with a primarily  
499 methodological focus, whose purpose was to evaluate whether assessments of affect  
500 taken immediately upon the conclusion of a set would differ from assessments taken  
501 during a set of resistance exercise. We addressed this question under several different  
502 experimental conditions (two exercises, each performed at three levels of % 1RM) in  
503 order to evaluate the robustness of the observed results. To reduce intragroup variance  
504 and, therefore, preserve statistical power, we did not counterbalance or randomize the  
505 order of presentation of the six combinations of experimental conditions. Instead, these  
506 were presented in fixed order (as noted in the Methods, the bench press was performed  
507 first and the squat second, and, for each exercise, the % 1RM conditions were performed  
508 from lowest to highest, namely 60%, 75%, 90%). Because of the fixed order of  
509 presentation of the experimental conditions, readers are cautioned to not interpret the  
510 results as representing valid comparisons of affective responses to upper-body (bench  
511 press) and lower-body (squat) exercises or between low (60% 1RM), middle (75%  
512 1RM), and high (90% 1RM) levels of resistance. For example, as reported in the  
513 Results, we did find declines in affective valence (FS) and increases in perceived  
514 activation (FAS) from the bench press to the squat and from the lightest to the heaviest  
515 level of % 1RM. However, given the experimental protocol employed in the present

516 study, it is not possible to decipher whether, or to what extent, the reported patterns  
517 were the result of order effects.

518 In conclusion, in the present study, comparisons between intra-set and  
519 immediate end-of-set assessments of affect across six resistance-exercise experimental  
520 conditions (two exercises and three levels of % 1RM) produced no evidence of an  
521 "affective rebound". These findings suggest that, given proper familiarization of the  
522 participants with the FS and FAS, administration of these scales immediately upon the  
523 cessation of a set of resistance exercise may suffice to provide a meaningful  
524 representation of the affective changes that occur during resistance exercise. If  
525 confirmed, this finding may simplify assessments of affective responses to resistance  
526 exercise, reducing the need for intrusive intra-set assessments. For exercise  
527 practitioners, this suggests that they may be able to use the FS and FAS in monitoring  
528 the affective experiences of participants and tailoring resistance-exercise prescriptions  
529 to individuals, with the goal of optimizing affect and, by extension, encouraging long-  
530 term adherence in accordance with hedonic models of motivation.

531

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#### 535 **Authors' contributions**

536 AA, DT, AE and DM developed the design, collect and analysed the data. DT, AA and  
537 PE wrote the manuscript. FR, LC and AE reviewed and critiqued the manuscript. All  
538 authors approved the final version of the manuscript.

#### 539 **CRedit authorship contribution statement**

540 **Ana J. Andrade:** Conceptualization, Methodology, Formal analysis, Investigation,  
541 Writing – original draft. **Panteleimon Ekkekakis:** Writing – original draft, Validation,  
542 Supervision. **Anastasiia Evmenenko:** Conceptualization, Visualization, Writing –  
543 review & editing. **Diogo Monteiro:** Methodology, Formal analysis. **Filipe Rodrigues:**  
544 Visualization, Writing – review & editing. **Luís Cid:** Writing – review & editing. **Diogo**  
545 **S. Teixeira:** Conceptualization, Methodology, Investigation, Formal analysis, Writing –  
546 original draft, Supervision, Project administration.

#### 547 **Declaration of interest**

548 The authors have no conflicts of interest.

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680

681 **Figure Caption**

682

683 Mean ( $\pm$  standard errors) ratings on the Feeling Scale (FS; left panel) and Felt Arousal

684 Scale (FAS; right panel) obtained intra-set and end-of-set across the six experimental

685 conditions (two exercises: bench press, squat; three levels of resistance: 60%, 75%, 90%

686 1RM). The grey dashed lines indicate the mean of 10-s post-set recalls obtained in

687 response to the question "how did you feel during this last set?"

688

Table 1. Descriptive statistics (means, standard deviations) for participant characteristics

	<i>M</i>	<i>SD</i>
Age (years)	36.42	7.72
Body mass (kg)	77.88	8.20
Body Mass Index (kg/m <sup>2</sup> )	25.17	2.23
Experience (years)	12.05	7.27
1RM bench press (kg)	95.66	9.52
1RM squat (kg)	122.27	15.13

Table 2. Means ( $\pm$  standard deviations) of Feeling Scale (FS) and Felt Arousal Scale (FAS) ratings for all experimental conditions. Raw-score differences ( $\Delta$ ) and Cohen's effect sizes ( $d$ ) for the mean differences between the intra-set and end-of-set ratings are also shown.

		Intra-set	End-of-set	Post-set	$\Delta$ , $d$ intra-end
<i>Feeling Scale (FS)</i>					
Bench-press	60% 1RM	1.61 $\pm$ 1.54	1.88 $\pm$ 1.96	1.70 $\pm$ 1.65	$\Delta = -0.27$ ; $d = -0.15$
	75% 1RM	0.94 $\pm$ 2.32	0.30 $\pm$ 2.76	0.55 $\pm$ 2.44	$\Delta = 0.64$ ; $d = 0.25$
	90% 1RM	-0.88 $\pm$ 2.93	-1.12 $\pm$ 3.25	-0.79 $\pm$ 3.10	$\Delta = 0.24$ ; $d = 0.08$
Squat	60% 1RM	1.46 $\pm$ 1.52	0.64 $\pm$ 1.83	0.76 $\pm$ 1.56	$\Delta = 0.82$ ; $d = 0.48$
	75% 1RM	0.06 $\pm$ 2.08	-0.55 $\pm$ 2.40	-0.33 $\pm$ 2.19	$\Delta = 0.61$ ; $d = 0.27$
	90% 1RM	-1.27 $\pm$ 2.82	-1.91 $\pm$ 3.50	-1.55 $\pm$ 3.45	$\Delta = 0.64$ ; $d = 0.20$
<i>Felt Arousal Scale (FAS)</i>					
Bench-press	60% 1RM	3.18 $\pm$ 1.01	3.64 $\pm$ 0.99	3.52 $\pm$ 0.91	$\Delta = -0.46$ ; $d = -0.45$
	75% 1RM	4.15 $\pm$ 0.87	4.67 $\pm$ 0.86	4.55 $\pm$ 0.79	$\Delta = -0.52$ ; $d = -0.60$
	90% 1RM	4.85 $\pm$ 0.80	5.09 $\pm$ 1.31	5.12 $\pm$ 1.24	$\Delta = -0.24$ ; $d = -0.22$
Squat	60% 1RM	3.70 $\pm$ 1.16	3.91 $\pm$ 1.23	3.94 $\pm$ 1.12	$\Delta = -0.21$ ; $d = -0.18$
	75% 1RM	4.58 $\pm$ 1.00	4.88 $\pm$ 0.93	4.79 $\pm$ 0.93	$\Delta = -0.30$ ; $d = -0.31$
	90% 1RM	5.12 $\pm$ 0.96	5.30 $\pm$ 1.05	5.33 $\pm$ 0.86	$\Delta = -0.18$ ; $d = -0.18$

Table 3. Results of main effects and interactions from the 2 (exercises: bench-press, squat) by 3 (%1RM: 60%, 75%, 90%) by 3 (time points: intra-set, end-of-set, post-set recall) repeated-measures analyses of variance (ANOVAs) for Feeling Scale (FS) and Felt Arousal Scale (FAS) ratings.

	$\epsilon$	$df_1$	$df_2$	$F$	$p$	$\eta_p^2$
<i>Feeling Scale (FS)</i>						
Main effect of exercise	1.000	1.000	32.000	4.592	<b>0.040</b>	0.125
Main effect of %1RM	0.620	1.240	39.673	29.775	<b>&lt; .001</b>	0.482
Main effect of time	0.663	1.326	42.433	5.846	<b>0.013</b>	0.154
Exercise by %1RM	0.659	1.318	42.169	0.116	0.803	0.004
Exercise by time	0.618	1.237	39.573	3.509	0.060	0.099
%1RM by time	0.452	1.806	57.797	0.900	0.403	0.027
Exercise by %1RM by time	0.801	3.203	102.502	2.386	0.069	0.069
<i>Felt Arousal Scale (FAS)</i>						
Main effect of exercise	1.000	1.000	32.000	5.387	<b>0.027</b>	0.144
Main effect of %1RM	0.671	1.342	42.947	90.731	<b>&lt; .001</b>	0.739
Main effect of time	0.648	1.295	41.448	10.495	<b>0.001</b>	0.247
Exercise by %1RM	0.778	1.555	49.767	0.431	0.602	0.013
Exercise by time	0.713	1.426	45.616	1.241	0.288	0.037
%1RM by time	0.573	2.291	73.297	0.588	0.580	0.018
Exercise by %1RM by time	0.459	1.836	58.737	0.183	0.815	0.006

Note:  $\epsilon$  is the Greenhouse-Geisser epsilon indicating the severity of the violation of the assumption of sphericity,  $df_1$  are the degrees of freedom for the numerator of the  $F$  ratio,  $df_2$  are the degrees of freedom for the denominator (error) of the  $F$  ratio,  $F$  is the value of the  $F$  ratio,  $p$  is the probability of  $F$ ,  $\eta_p^2$  is the partial eta-squared effect size.

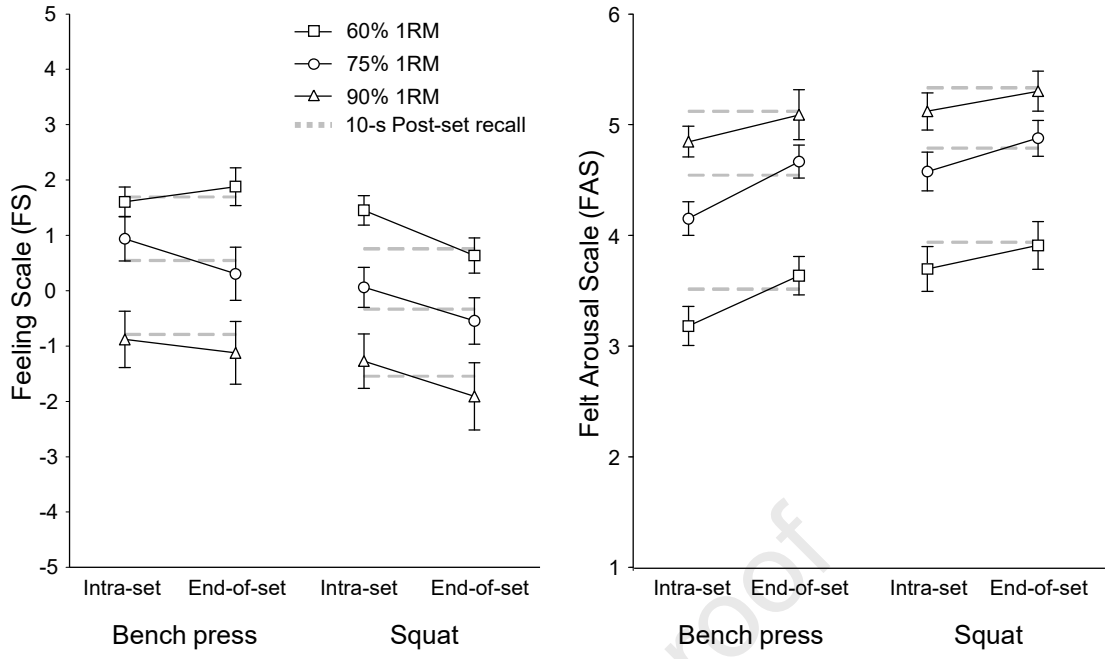


Figure 1

## Highlights

### **Affective Responses to Resistance Exercise: Toward a Consensus on the Timing of Assessments**

- Promoting pleasurable experiences in resistance exercise may promote adherence.
- Timing of affective assessments does matter in resistance exercise.
- Affective rebound may not be as pronounced as reported in resistance exercise.

## **Affective Responses to Resistance Exercise: Toward a Consensus on the Timing of Assessments**

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### **Declaration of interest**

The authors have no conflicts of interest.