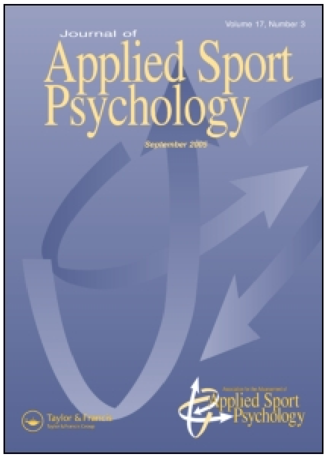

Journal of Applied Sport Psychology
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713768823

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Online Publication Date: 01 July 2007
To cite this Article: Arent, Shawn M., Alderman, Brandon L., Short, Evan J. and Landers, Daniel M. , (2007) 'The Impact of the Testing Environment on Affective Changes Following Acute Resistance Exercise', Journal of Applied Sport Psychology, 19:3, 364 - 378
To link to this article: DOI: 10.1080/10413200701345486
URL: http://dx.doi.org/10.1080/10413200701345486

JOURNAL OF APPLIED SPORT PSYCHOLOGY, 19: 364–378, 2007

ISSN: 1041-3200 print / 1533-1571 online
DOI: 10.1080/10413200701345486

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The Impact of the Testing Environment on Affective Changes Following Acute Resistance Exercise

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Research has demonstrated the anxiolytic and affective changes following resistance exercise. However, several studies have allowed the participants to leave the testing facility and return at a later time to complete psychological assessments. This weakens internal validity, making it impossible to interpret findings as due to exercise per se. To address this issue, 23 male participants were randomly assigned to either a "stay" or "go" group. Within each group, all participants completed a non-exercise control session and a weight-training session based on 50% of their one repetition maximum for each of five exercises. All participants remained in the laboratory for 60 minutes following each session, at which time only those in the "go" group left the laboratory and returned at 90 and 120 minutes for their remaining affective assessments. The results indicate that despite transient disruptions in mood, an acute bout of resistance exercise results in positive psychological changes that occur within 60 minutes after completion of the exercise session and which persist up to 120 minutes post-exercise. Allowing participants to leave the laboratory or requiring them to remain in the testing environment was found to lead to different patterns of affective responses during the post-exercise assessment period. Future researchers must take into account such methodological issues when designing acute exercise studies requiring extended periods of post-exercise assessment.

It is clear that participation in physical activity results in physical as well as psychological benefits. Compelling evidence exists supporting the role of physical activity in reducing anxiety (Landers & Petruzzello, 1994; Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991), and improving mood (Arent, Landers, & Etnier, 2000). However, the early evidence supporting the role of physical activity in reducing anxiety has primarily been based on aerobic forms of exercise and, until recently, the evidence supporting the anxiolytic (i.e., anxiety reducing) effects of more anaerobic (e.g., resistance or weight-training) forms of

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exercise has been limited. Petruzzello and colleagues (1991) conducted a meta-analysis of the effects of acute and chronic exercise on anxiety and found significantly larger effect sizes for aerobic forms of exercise compared with the effects for anaerobic exercise. These results were considered tentative in regards to anaerobic exercise due to the relative paucity of research incorporating resistance exercise, inappropriate combination of other activities (e.g., stretching) with weight-lifting, and the use of inappropriate and inconsistent resistance exercise prescriptions (i.e., intensities and durations).

Given the growing popularity of resistance training as a form of recreational activity, more research attention has recently been devoted to the psychological effects of this type of exercise. Emerging evidence indicates that an acute bout of resistance training results in reductions in state anxiety (Arent, Landers, Matt, & Etnier, 2005; Bartholomew, 1999; Focht & Koltyn, 1999; O'Connor, Bryant, Veltri, & Gebhardt, 1993) and enhancements in mood (Bartholomew, Moore, Todd, Todd, & Elrod, 2001); however, not all studies are in agreement (Koltyn, Raglin, O'Connor, & Morgan, 1995; Raglin, Turner, & Eksten, 1993). The inconsistent findings in the literature may be a result of the use of inadequate time periods and inappropriate methodologies during the post-exercise assessment period.

O'Connor and colleagues (1993) followed the time course of state anxiety responses for 120 minutes following the cessation of an acute bout of resistance exercise performed at 40%, 60%, and 80% of 10 repetition maximum (RM) in novice female weight-lifters. The only significant differences in state anxiety were found between the 90- and 120-minute assessment periods in the 60% 10RM condition. This post-exercise reduction in state anxiety suggests that the timing of the anxiety response following resistance exercise may differ from what is typically seen following aerobic exercise. It is important to note that the participants were allowed to leave the laboratory environment during the final two post-exercise assessment periods, thus leading the investigators to conclude that "... the anxiety reductions observed cannot be attributed to the weight lifting *per se*." Although these results may be considered more ecologically valid, a more controlled study (i.e., one with high internal validity) is warranted to determine if the reductions in anxiety are a direct result of the resistance exercise.

More recently, Focht and Koltyn (1999) examined the influence of resistance exercise on state anxiety and included a longer post-exercise assessment period (i.e., 180 minutes). The participants were required to remain in the testing environment for 60 minutes post-exercise, after which they were allowed to leave the testing room to resume their normal daily activities. Each participant then returned to the testing facility to complete a 120- and 180-minute assessment. The results indicated that an acute bout of resistance exercise performed at 50% of 1RM was associated with significant reductions in state anxiety at 180 minutes. While the participants were asked to refrain from ingesting any mood-altering substances (e.g., coffee, tea, alcohol, and drugs) or performing any additional physical exercise outside of the testing environment, there is no way to account for other factors that may have influenced the significant decrease in state anxiety at 180 minutes. Similar to the findings of O'Connor et al. (1993), these authors were unable to directly attribute the observed reductions in state anxiety to the acute bout of exercise since the participants were allowed to leave the laboratory setting during the post-exercise assessment period. This shortcoming may potentially confound any conclusions regarding the anxiolytic effects of resistance exercise due to other contributing variables (e.g., environmental factors).

Conclusions regarding the effects of resistance training on subsequent psychological responses appear to be limited by a number of factors associated with the post-exercise assessment periods. Several investigators have limited their post-exercise assessment period to 45 minutes (Bartholomew & Linder, 1998; Bartholomew et al., 2001), which may not be a sufficient time period in which to observe changes in psychological states following resistance exercise. Furthermore, investigators who have included assessment periods up to 180 minutes post-exercise have allowed the participants to leave the laboratory setting (Focht, Koltyn, & Bouchard, 2000; Focht & Koltyn, 1999; Raglin et al., 1993) and, as noted above, this has reduced the internal validity of these studies. Furthermore, many of the resistance exercise studies to date have shown that improvements in affect result near the end of the laboratory testing sessions (e.g., Bartholomew et al., 2001; O'Connor et al., 1993). It is possible, therefore, that the improvements in affect reflect more of an anticipation of completing the study rather than a time course of affective changes following resistance exercise participation. It is important to delineate whether the delayed changes in affect are due to a behavioral artifact of anticipation of escape from the laboratory or if it is a result of exercise per se.

The results of previous research examining the psychological responses following resistance training have led to the premature conclusion that this form of exercise does not result in similar anxiolytic and mood-enhancing benefits that result from more traditional aerobic forms of exercise. Specifically, this is due to the delayed anxiolytic responses following resistance exercise consistently reported in the literature. However, the magnitude and time course of psychological responses following resistance exercise have yet to be delineated due to methodological discrepancies in the extant literature. Therefore, the purposes of this study were to examine the affective responses resulting from a resistance training session in advanced resistance-trained males utilizing a load of 50% 1RM as well as to determine the potential methodological consequences of having participants stay in or leave the lab during the recovery period.

METHOD

Participants

Participants included 23 male undergraduate students, between the ages of 18 and 30, recruited from exercise science classes at a large southwestern American university. All participants were required to have at least one year of continuous weight-lifting experience. Continuous experience was defined as participating in weight training at least 2–3 times per week for one year. The use of this inclusion criterion helped to ensure the safety and accuracy of 1RM testing (Baechle, Earle, & Wathen, 2000), an issue that has been previously overlooked when utilizing 1RM testing protocols. During the pilot testing phase of this study, only one female student volunteered to participate. Therefore, males were used because it was easier to recruit participants with at least one year of continuous weight training experience. Males have also been shown to demonstrate a greater likelihood of developing a negative mood state following resistance exercise and thus it has been argued that using males may provide a more challenging test of the mood-enhancing benefits of resistance exercise (Bartholomew, 1999). It should be noted, however, that previous research has indicated that both males and females experience similar psychological changes following either an acute bout of aerobic (Petruzzello et al., 1991) or resistance (Raglin et al., 1993) exercise. All participants completed an informed consent form that was approved by the University Institutional Review Board.

Procedure

Participants completed three different testing sessions and were instructed not to participate in any resistance exercise for 48 hours prior to each session. The first session involved the completion of medical and exercise history questionnaires followed by familiarization with the exercises to be utilized. Each participant then completed a one repetition maximum (1RM) test for each of the following exercises: bench press, shoulder press, lat pull-down, leg press, and dead-lift. These exercises represent primarily core lifts for both the upper and lower body. The 1RM testing session began with a warm-up on a cycle ergometer for 5 minutes to increase blood flow and prepare them for the maximal tests. Procedures outlined by Baechle et al. (2000) were used for the 1RM testing protocol. Participants began with five to eight repetitions with a self-selected, light weight. They performed progressively heavier warm-up sets until they felt prepared for a 1RM lift. If the initial 1RM attempt was successfully completed, additional weight was added until a weight allowing *only* one repetition (completed in good form) was successfully lifted or until the participant indicated that he could not lift any more weight. A rest period of 2 to 4 minutes was allowed between attempts to ensure adequate recovery. This same procedure was followed for determination of the 1RM for each of the five lifts.

To assess the effects of resistance exercise on affective responses compared to a sedentary control as well as to determine whether staying or leaving the testing facility influences affective responses, a mixed factorial 2 × 2 × 7 design was used. The first factor was a between-subjects factor. Specifically, at the end of the first testing session, participants were randomly assigned to one of two conditions: (a) those who would remain in the laboratory for 120 minutes post-exercise ("stay" group, n = 12), and (b) those who would remain in the laboratory for 60 minutes ("go" group, n = 11), then be allowed to leave the laboratory and instructed to return at 90 and then again at 120 minutes post-exercise. Each participant was informed as to the condition he was assigned ("stay" versus "go") to prepare him for the total time commitment and allow him to bring study/reading materials to be used during the post-exercise assessments. The second factor was a within-subjects factor and consisted of the exercise and control conditions. The third factor was also a within-subjects factor that was comprised of the seven assessment time points (pre, 5, 15, 30, 60, 90, and 120 minutes post-condition). All of the participants in the "go" group took advantage of the opportunity to leave the laboratory and returned at approximately 90 and 120 minutes. The order of participation in the exercise and control conditions was counterbalanced among the participants within each group.

The control condition consisted of each participant watching a 30-minute video on resistance-training techniques. The exercise condition consisted of each participant completing an approximately 30-minute resistance-training exercise session. The exercise workload was 50% of the participant's 1RM for each of the five exercises (completed in the same order as during maximal testing). To remain consistent with previously employed lifting protocols in this area (Focht & Koltyn, 1999), participants completed three sets of 12 to 20-repetitions for each exercise. A 90-second recovery interval was maintained between each set.

Dependent Variables

State anxiety and arousal/activation were assessed using Spielberger's (1983) short version of the State Anxiety Inventory (SAI) and Thayer's (1986) Activation Deactivation Adjective Checklist (AD-ACL), respectively. Participants completed these measures immediately prior to and at 5, 15, 30, 60, 90, and 120 minutes following both the exercise and control conditions. The SAI (short form) consists of 10 questions to which participants respond regarding their anxiety level. Internal consistency α for the SAI during recovery from exercise has been reported to range from.66 (Rejeski, Hardy, & Shaw, 1991) to.80 (Ekkekakis, Hall, & Petruzzello, 1999), and has shown adequate test-retest reliability (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). The short form of the SAI has also been used more recently in a study of the affective responses to short bouts of walking (Ekkekakis, Hall, VanLanduyt, & Petruzzello, 2000). The

AD-ACL is comprised of two primary dimensions of energetic arousal and tense arousal. Each of these dimensions is further divided into energy/tiredness, and tension/calmness, respectively. Thayer (1978, 1986) has reported that the AD-ACL has adequate reliability and validity and has been validated and used in a number of studies in exercise psychology. The SAI and AD-ACL each assess transitory psychological states by asking how the participant feels "at this moment."

During the assessment of the time course of psychological states, participants were allowed to sit quietly, read, or study following both the exercise and control conditions. To eliminate potential behavioral artifacts, minimal conversation was allowed between the participants and the investigators. Each participant who left and returned to the lab ("go" group) was instructed not to participate in any type of physical activity or consume any mood altering substances (e.g., coffee, tea, alcohol, drugs) while outside the laboratory until after completion of the entire session.

Statistical Analysis

A mixed factorial $2 \times 2 \times 7$ design was utilized for this research study. The between-subject measure was the "stay" or "go" group factor. The within-subject measures consisted of the exercise and control conditions as well as the seven assessment time points (pre, 5, 15, 30, 60, 90, and 120 minutes post-condition). The dependent measures consisted of five different affect measures: state anxiety, energetic arousal, tiredness, calmness, and tension. Due to the potential relatedness of the variables, a $2 \times 2 \times 7$ (group $\times$ condition $\times$ time) multivariate analysis of variance (MANOVA) with repeated measures on the last two factors was performed first. Significant multivariate effects were followed by $2 \times 2 \times 7$ (group $\times$ condition $\times$ time) analyses of variance (ANOVAs) with repeated measures on the last two factors for each of the five affective measures. Significant two-way interactions were followed-up with simple effects and simple contrasts comparing post-exercise responses to baseline. Significant three-way interactions were partitioned into separate 2×7 (group $\times$ time) univariate follow-ups with repeated measures on the second factor for each of the conditions. Finally, to examine potential "anticipatory" effects of staying in or leaving the laboratory, planned 2×2 (group $\times$ condition) ANOVAs with repeated measures on condition were used to examine affective responses at the 60-minute time point. To adjust for baseline values that could potentially bias this analysis, change scores were used for each affective variable by subtracting baseline values from responses at the 60-minute time point.

For each of the univariate analyses, the assumption of sphericity was tested using the Huynh-Feldt (H-F) epsilon for the general model (Huynh & Feldt, 1976). If the statistic was larger than.75, sphericity had been met and the unadjusted univariate tests of significance were used. When epsilon was less than.75, it was considered a violation of the assumption of sphericity and the H-F adjusted statistic was used to test significance.

RESULTS

MANOVA results revealed a nearly significant main effect for group, Wilks' $\Lambda = .59$, $F(5,17) = 2.37$, $p = .08$, and significant main effects for condition, Wilks' $\Lambda = .36$, $F(5,17) = 6.19$, $p < .01$, and time, Wilks' $\Lambda = .46$, $F(30,490) = 3.52$, $p < .001$. Significant condition $\times$ time, Wilks' $\Lambda = .50$, $F(30,490) = 3.09$, $p < .001$, and group $\times$ condition $\times$ time, Wilks' $\Lambda = .69$, $F(30,490) = 1.56$, $p < .05$, interaction effects also emerged. Due to the significant multivariate findings, univariate follow-ups were performed for each of the affective variables.

Table 1
Mean psychological responses (M ± SD) for each of the four conditions

	Stay		Go	
	Exercise	**Control**	**Exercise**	**Control**
State Anxiety				
Pre	16.50 ± 3.58	16.83 ± 4.08	17.18 ± 4.09	15.27 ± 4.42
P-5	20.83 ± 2.62	15.16 ± 2.40	19.63 ± 4.50	15.45 ± 2.77
P-15	18.58 ± 2.20	15.83 ± 2.71	18.81 ± 2.42	15.54 ± 3.45
P-30	16.50 ± 2.54	15.41 ± 2.96	17.45 ± 2.38	15.00 ± 3.31
P-60	15.00 ± 4.04	15.00 ± 3.69	16.00 ± 4.89	16.27 ± 2.68
P-90	15.08 ± 3.11	15.41 ± 2.35	16.45 ± 2.84	16.72 ± 3.00
P-120	15.08 ± 3.72	16.20 ± 3.54	16.54 ± 2.11	16.36 ± 2.65
Calmness				
Pre	11.83 ± 3.45	11.08 ± 3.42	9.54 ± 3.07	11.00 ± 2.56
P-5	8.75 ± 2.37	13.33 ± 2.49	9.54 ± 3.26	13.27 ± 3.28
P-15	11.00 ± 3.43	13.91 ± 2.84	11.45 ± 2.58	12.81 ± 4.04
P-30	12.41 ± 3.31	13.50 ± 2.23	11.00 ± 2.04	12.09 ± 3.04
P-60	13.50 ± 3.94	12.83 ± 3.24	12.54 ± 2.65	11.81 ± 3.15
P-90	12.91 ± 3.89	12.83 ± 3.45	11.09 ± 2.25	10.63 ± 3.00
P-120	13.00 ± 4.11	12.66 ± 3.70	11.27 ± 2.72	11.45 ± 3.50
Energy				
Pre	11.25 ± 3.62	10.75 ± 3.76	14.36 ± 3.41	11.36 ± 3.04
P-5	13.91 ± 3.91	9.50 ± 4.35	11.00 ± 2.82	9.27 ± 2.93
P-15	10.41 ± 3.34	9.08 ± 3.70	11.36 ± 3.32	9.72 ± 3.52
P-30	9.08 ± 3.26	9.16 ± 4.34	10.54 ± 3.64	9.81 ± 3.65
P-60	10.33 ± 3.65	7.75 ± 3.30	9.90 ± 4.08	10.18 ± 3.28
P-90	10.33 ± 3.77	8.33 ± 3.49	10.63 ± 3.77	11.18 ± 3.77
P-120	10.41 ± 3.75	8.41 ± 3.62	11.36 ± 3.66	11.18 ± 3.31
Tiredness				
Pre	10.58 ± 4.12	10.91 ± 4.29	8.09 ± 2.62	9.81 ± 3.99
P-5	8.00 ± 2.66	12.08 ± 4.66	9.72 ± 2.61	13.18 ± 3.09
P-15	11.66 ± 4.05	11.81 ± 3.99	10.81 ± 2.96	11.81 ± 2.44
P-30	12.91 ± 4.25	11.41 ± 3.82	11.18 ± 3.09	12.36 ± 2.57
P-60	10.58 ± 3.20	12.00 ± 4.43	12.45 ± 2.58	10.00 ± 2.93
P-90	9.91 ± 2.77	11.33 ± 4.20	10.54 ± 2.65	10.45 ± 3.20
P-120	9.83 ± 3.78	11.58 ± 4.44	10.18 ± 3.28	9.90 ± 3.08
Tension				
Pre	6.66 ± 1.87	6.58 ± 1.62	7.00 ± 2.19	6.36 ± 1.28
P-5	9.16 ± 1.99	6.00 ± 1.34	9.90 ± 2.54	5.72 ± 1.19
P-15	7.66 ± 1.23	5.58 ± 0.79	8.72 ± 1.73	6.72 ± 1.73
P-30	6.08 ± 1.16	5.41 ± 0.66	7.72 ± 1.55	7.18 ± 3.42
P-60	5.66 ± 0.88	5.25 ± 0.45	6.45 ± 1.12	6.72 ± 2.05
P-90	5.66 ± 0.98	5.33 ± 0.65	6.63 ± 1.28	6.63 ± 1.62
P-120	5.83 ± 1.19	5.66 ± 0.98	6.90 ± 1.28	6.27 ± 1.00

Means and standard deviations for each affective variable at each time point as a function of group and condition are presented in Table 1.

State Anxiety

Significant main effects were found for condition, $F(1, 21) = 5.53$, $p < .05$, and time, $F(6, 126) = 4.07$, $p < .01$. The main effect for group was nearly significant ($p = .081$). A significant condition × time interaction also emerged, $F(6, 126) = 9.41$, $p < .001$ (see Figure 1).

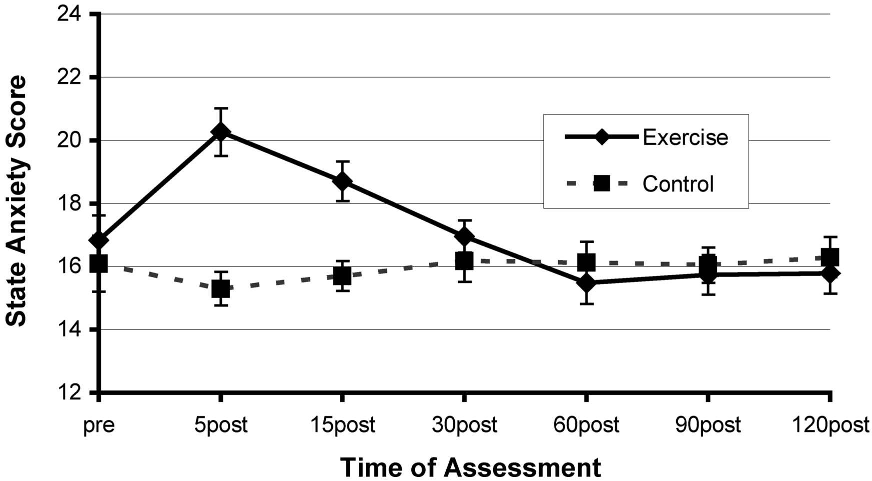

Figure 1. State anxiety responses before and following 30 minutes of resistance exercise.

To determine changes in state anxiety as a function of each condition, the simple effects of time within condition were examined. There were significant changes in state anxiety over time in the resistance-training condition, $F(3.7,82.2) = 13.09$, $p < .001$, but no changes in the control condition, $p = .74$. Simple contrasts were conducted in the resistance training condition to compare state anxiety scores following exercise to the baseline scores. There was a significant increase in state anxiety immediately after exercise, $F(1,22) = 15.3$, $p < .01$, ES = 0.91, that persisted up to 15 minutes post-exercise, $F(1,22) = 5.6$, $p < 05$, ES = 0.50, before returning to baseline values by 30 minutes post-exercise (ES = 0.04). The decreases in anxiety at 60, 90, and 120 minutes post-exercise approached significance, $p < .08$ (ESs = −0.36, −0.29, and −0.28, respectively). Results of the planned comparisons at 60 minutes post-exercise indicated no significant differences in state anxiety as a function of group, $p > .34$.

Calmness

Significant main effects were found for condition, $F(1,21) = 10.74$, $p < .01$, and time, $F(4.2,87.5) = 2.52$, $p < .05$, and a significant condition × time interaction also emerged, $F(6,126) = 8.06$, $p < .001$ (see Figure 2). This interaction was partitioned into simple effects of time within condition to determine changes in calmness as a function of resistance exercise or control. There were significant changes in calmness over time as a result of resistance training, $F(4.4,97.4) = 8.09$, $p < .001$. Changes in calmness over time in the control condition approached significance, $p = .082$, likely due to transient increases in calmness at 5 and 15 minutes post-exercise, ES = 0.59 and 0.62, respectively, before returning towards baseline. Simple contrasts in the resistance training condition indicated a significant transient decrease in calmness immediately post-exercise, $F(1,22) = 5.25$, $p < .05$, ES = −0.47, before returning to baseline values at 15 and 30 minutes post-exercise, $p > 0.10$, ES = 0.14 and 0.29, respectively. This was followed by significant increases in calmness compared to baseline at 60, $F(1,22) = 10.63$, $p < .01$, ES = 0.67, and 120 minutes post-exercise, $F(1,22) = 5.34$, $p < .05$, ES = 0.42. The increase in calmness at 90 minutes was nearly significant, $p = .071$, ES = 0.38. Results of the planned comparisons at 60-minutes post-exercise indicated no significant

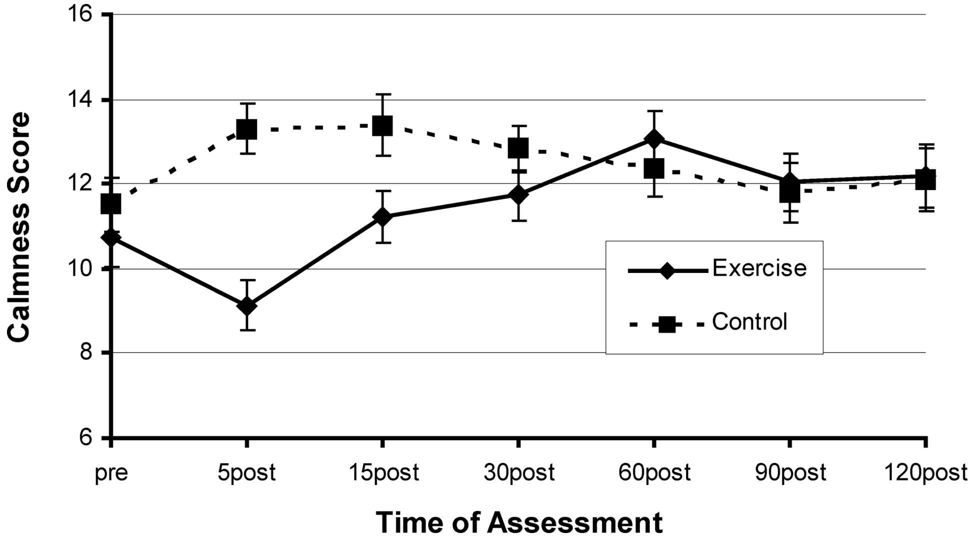

Figure 2. Activation Deactivation Adjective Checklist calmness subscale responses before and following 30 minutes of resistance exercise.

differences in calmness as a function of group, $p > .12$. This was somewhat surprising given the different trends for the stay and go groups. The exercise (ΔCalmness $= 1.67 \pm 1.0$) and control (ΔCalmness $= 1.75 \pm 1.3$) conditions had similar changes from baseline in the stay group, with both increasing above baseline. In contrast, there was a large increase in calmness for the exercise condition (ΔCalmness $= 3.0 \pm 1.03$) and a slight decrease for the control condition (ΔCalmness $= -0.19 \pm 1.3$) in the go group.

Tension

Significant main effects were found for condition, $F(1,21) = 26.59$, $p < .001$, and time, $F(4.1,86.2) = 11.93$, $p < .001$, and a significant condition $\times$ time interaction also emerged, $F(6,126) = 12.25$, $p < .001$ (see Figure 3). Simple effects of time within condition were calculated to examine the differences in tension over time as a result of resistance training or control. Results indicated a significant change in tension over time in the exercise condition, $F(3.6,79.4) = 20.83$, $p < .001$. There was no change in tension over time in the control condition, $p = .52$. Further examination of the changes in the resistance training condition using simple contrasts showed that there was a significant, large transient increase in tension above baseline immediately following exercise, $F(1,22) = 18.04$, $p < .001$, ES $= 1.06$. After returning towards baseline at 15 and 30 minutes post-exercise (ES $= 0.41$ and -0.21, respectively), tension was significantly reduced compared to baseline at 60 minutes, $F(1,22) = 10.00$, $p < .01$, ES = -0.60, 90 minutes, $F(1,22) = 8.17$, $p < .01$, ES = -0.56, and 120 minutes, $F(1,22) = 5.32$, $p < .05$, ES $= -0.46$, post-exercise. After adjusting for baseline values, results of the planned comparisons at 60 minutes revealed a nearly significant group $\times$ condition effect, $p = .054$. This appeared to be due primarily to different responses for the control conditions. Examination of mean changes and 95% confidence intervals (95% CI) revealed a significant decrease in tension compared to baseline at 60 minutes following the control condition in the stay group (Δtension $= -1.33 \pm 0.4$). In contrast, a slight, non-significant increase in tension

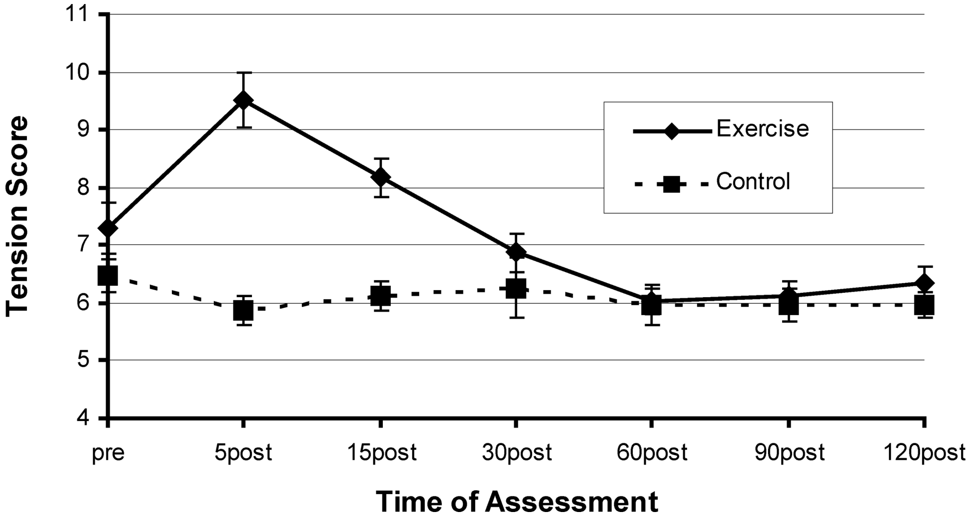

Figure 3. Activation Deactivation Adjective Checklist tension subscale responses before and following 30 minutes of resistance exercise.

was seen after the control condition in the go group (Δtension = 0.36 ± 0.5). Exercise appeared to produce relatively similar changes from baseline regardless of whether the participant was staying in the lab (Δtension = −1.00 ± 0.6) or getting ready to leave (Δtension = −1.55 ± 0.6), though the change in the go group was the only one significantly different from baseline.

Energetic Arousal

Significant main effects were found for condition, $F(1,21) = 10.75$, $p < .01$, and time, $F(3.6,75.9) = 4.94$, $p < .01$, and a significant condition × time interaction was also evident, $F(4.1,\ 85.1) = 3.00$, $p < .05$. This interaction, though, was superseded by a three-way interaction of group × condition × time, $F(6,126) = 2.70$, $p < .05$ (see Figure 4). Due to the significant 3-way interaction, group × time effects were examined as a function of condition. A significant time × group interaction was found for the resistance training condition, $F(6,126) = 2.29$, $p < .05$. Examination of graphic trends indicated that the go group began with higher energetic arousal (ES = 0.88). Additionally, there was a transient increase in energetic arousal immediately after exercise in the stay group ($ES_5 = 0.74$) before declining below baseline at all other time points ($ES_{15} = -0.23$, $ES_{30} = -0.60$, $ES_{60} = -0.25$, $ES_{90} = -0.25$, $ES_{120} = -0.23$). These decreases were all small-to-moderate in magnitude. In contrast, there was an initial decrease in energetic arousal in the go group (ES = −0.69) that continued throughout the initial 60-minute recovery period before beginning to rebound by 120 minutes ($ES_{15} = -0.89$, $ES_{30} = -1.12$, $ES_{60} = -1.30$, $ES_{90} = -1.09$, $ES_{120} = -0.88$). The time × group interaction approached significance for the control conditions, $p = 0.9$. Though both the stay and go groups had decreased energy immediately post-treatment (ES = -0.33 and −0.69, respectively), the stay group continued to decrease in energy throughout the assessment period while the go group began to reverse this trend by 15 minutes post-exercise and returned towards baseline.

Results of the planned contrasts at 60 minutes post-treatment indicated that there were different levels of energetic arousal between groups as a function of condition, even after

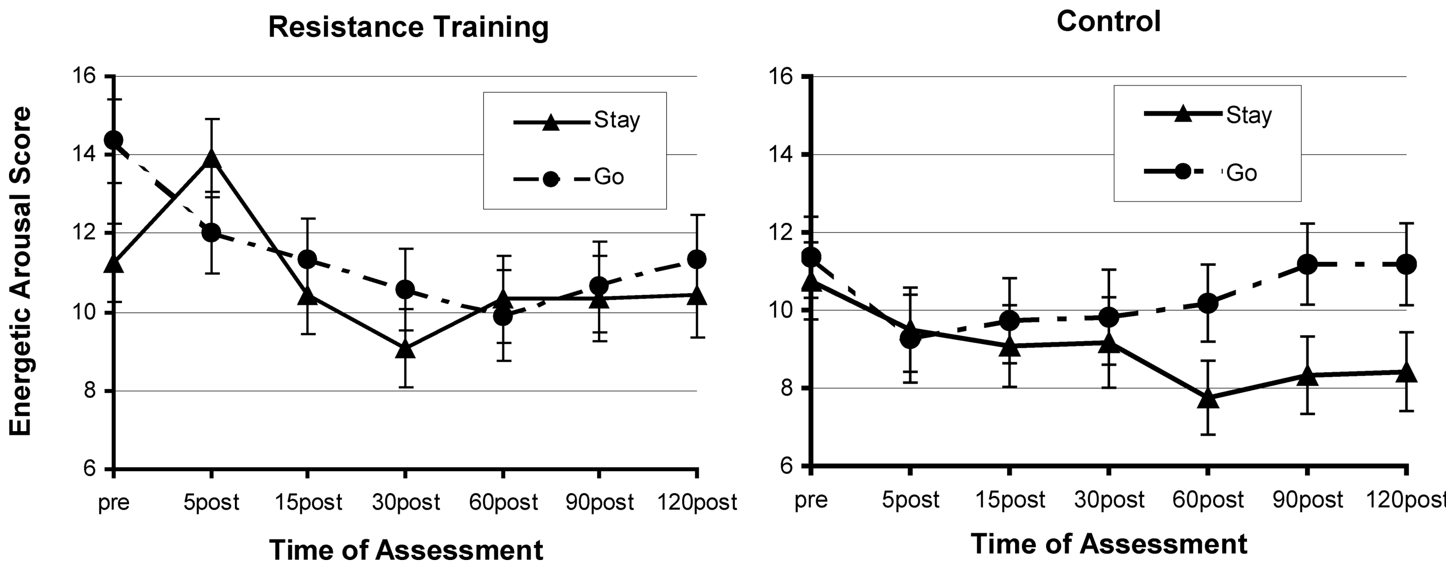

Figure 4. Activation Deactivation Adjective Checklist energetic arousal subscale responses before and following 30 minutes of resistance exercise.

adjustments for baseline values, due to a significant condition × group interaction, $F(1,21) = 6.79$, $p < .05$. There was a larger decrease in energy from baseline in the control condition (Δenergy = -3.00 ± 1.0) than in the resistance training condition (Δenergy = −0.92 ± 1.1) for those in the stay group. In contrast, the largest decrease in energy in the go group was seen in the exercise condition (Δenergy = −4.46 ± 1.1) compared to the control condition (Δenergy = −1.2 ± 1.0). Examination of 95% CI indicated that the change in energetic arousal at 60 minutes was significantly different from baseline for stay/control and go/exercise.

Tiredness

A significant main effect was found for time, $F(4,84.8) = 4.60$, $p < .01$, and the main effect for group was nearly significant, $p = .059$. A significant condition × time interaction was also found, $F(6,126) = 4.47$, $p < .001$, but this interaction was superseded by a three-way interaction of group × condition × time, $F(6, 126) = 3.50$, $p < .01$ (see Figure 5). Therefore, group × time effects were examined for each condition. A significant group × time interaction emerged for the resistance training condition, $F(6,126) = 2.99$, $p < .01$. Further examination of the exercise condition in each group revealed significant time effects for both the stay and go groups, $p < .01$. At baseline, those participants in the stay condition had higher tiredness scores than did those individuals in the go condition, ES = 0.71. However, immediately after exercise those in the stay group experienced a transient decrease in tiredness (ES = −0.63) followed by an increase above baseline by 30 minutes post-exercise (ES = 0.57) before returning to baseline levels from 60 to 120 minutes post-exercise ($ES_{60} = 0$, $ES_{90} = -0.16$, $ES_{120} = -0.18$). On the other hand, those in the go group had moderate to large increases in tiredness immediately following exercise that persisted throughout the recovery period, peaking at 60 minutes post-exercise and beginning to return toward baseline after release from the lab ($ES_5 = 0.62$, $ES_{15} = 1.03$, $ES_{30} = 1.17$, $ES_{60} = 1.66$, $ES_{90} = 0.94$, $ES_{120} = 0.79$). Though the effects of staying in or leaving the lab were not significant in the control condition, $p > .16$, there did appear to be emerging differences at the 60-minute time point, ES = 0.53, with tiredness higher in the stay group.

A significant condition × group effect emerged for the planned 60 minute post-condition comparisons, even after adjusting for baseline values, $F(1,21) = 5.74$, $p < .05$. There was no change in tiredness from baseline at 60 minutes following exercise (Δtiredness = 0.00 ± 1.0), but an increase was seen following the control condition (Δtiredness = 2.08 ± 1.2) in the stay group. However, those in the go group had a significant increase in tiredness compared to baseline at 60 minutes following exercise (Δtiredness = 4.36 ± 1.1) while a smaller, non-significant increase was seen following the control condition (Δtiredness = 1.18 ± 1.3).

DISCUSSION

The purposes of this study were to examine the affective responses resulting from a resistance training session in advanced resistance-trained males utilizing a load of 50% 1RM as well as to determine the potential methodological consequences of having participants stay in or leave the lab during the recovery period. Consistent with much of the research in the resistance training and affect area, the results of the current study indicate that resistance exercise results in transient anxiogenic effects, as well as temporary increases in tension and energetic arousal and decreases in calmness. However, most of these effects were reversed within 60 minutes of recovery from the exercise bout. Compared to baseline, nearly significant reductions in state anxiety were seen from 60 to 120 minutes post-exercise. Calmness was significantly improved over baseline values at 60 and 120 minutes as well. Tension followed

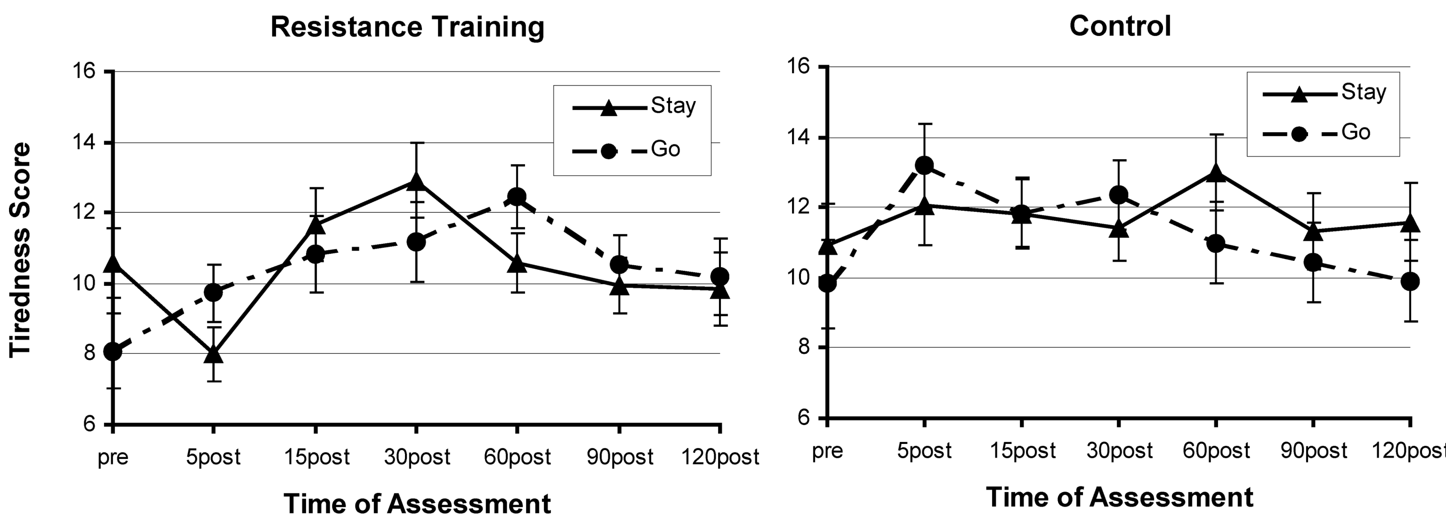

Figure 5. Activation Deactivation Adjective Checklist tiredness subscale responses before and following 30 minutes of resistance exercise.

a similar pattern to that seen for state anxiety and was reduced below baseline values after 60 minutes of recovery. The overall effects of resistance exercise on energetic arousal and tiredness were more complicated to interpret due to the interaction with the group effects of staying in or leaving the laboratory. For example, compared to the initial increase in energetic arousal seen following resistance training in the stay group, those in the go group evidenced an immediate and lasting decrease in energy. These interactions were not limited to the exercise condition, however. In fact, affect also varied as a function of group for the control condition, but not necessarily in a consistent manner.

Results of the planned comparisons at 60-minutes post-exercise (the time-point corresponding to when those in the go group left the lab) revealed what we considered to be a rather surprising finding. Namely, differences due to staying in or leaving the lab were not simply group effects. Staying or going, when it made a difference, resulted in different responses for the experimental and control conditions. For example, there were larger decreases in energetic arousal at 60 minutes compared to baseline for control than for the resistance training condition in the stay group. The opposite trend was found in the go group, with larger decreases in energetic arousal found in the exercise condition. Likewise, compared to baseline, tiredness was not changed at 60 minutes post-exercise in the stay group, but was increased following the control condition. For the go group, however, significant increases in tiredness resulted from exercise with a smaller, non-significant increase associated with the control condition.

The fact that there are differences as a function of staying in or leaving the laboratory, particularly at the time-point corresponding to release, provides some initial evidence that there may a certain degree of "anticipation" associated with affective changes due to leaving the lab. One possibility for the increased tiredness and decreased energy associated with the control condition at 60 minutes post-exercise for the stay group is that those participants may simply be bored with having sat there for almost two hours with an additional hour remaining. On the other hand, those in the go group may be responding to the "last questionnaire" before they get to leave for a while. In light of some initial baseline differences, it might also be the case that these anticipatory effects start as early as pre-treatment depending upon the instructions given. Additionally, it is possible that allowing participants to leave the laboratory but to return to complete psychological measures introduces a potential confound due to their inability to return to their normal activities of daily life. Regardless, future researchers in the exercise and affect area need to take these issues into account when considering the approach to take when examining extended post-exercise recovery periods. While letting participants leave the lab certainly increases convenience and external validity, it appears that some degree of experimental control is lost and this may impact affective outcomes and conclusions, particularly for time-course effects and underlying mechanisms.

The lack of agreement across studies (e.g., Focht & Koltyn, 1999; O'Connor et al., 1993; Raglin et al., 1993) regarding the time-course of affective responses following resistance training appears to be one major reason for the inability to provide definitive support for the anxiolytic benefits of this type of exercise, particularly in comparison to aerobic exercise. Based on the results of this study as well as recent research on dose-response effects of resistance training (Arent et al., 2005), it appears that these previous inconsistencies in the literature may be partly due to methodological issues rather than ineffectiveness of the exercise mode itself. In addition to the potential confounds of letting participants leave the lab during the recovery assessment period, it is also likely that the delayed anxiolytic and calming effects (as well as the increased tiredness and decreased energy later in recovery) may be the result of inappropriately defined "intensity" of the resistance training bout. As noted by Arent et al. (2005), there has been a tendency to use load and intensity interchangeably in most of the research in this area. However,% 1RM is more accurately defined as load, not intensity (Arent et al., 2005;

Kraemer & Ratamess, 2004). In an effort to remain consistent with previous studies in this area (e.g., Focht & Koltyn, 1999; Raglin et al., 1993) and so that similar protocols were used to evaluate stay/go effects to draw comparisons, we chose to rely on %1RM as the method of exercise assignment. Traditionally, 50% 1RM has been considered low to moderate resistance training intensity. However, the increases in anxiety and tension over the first 60 minutes of recovery in the current study are actually consistent with the effects seen for high intensity, rather than moderate intensity, resistance training (Arent et al., 2005). The American College of Sports Medicine (ACSM) has recently supported the distinction between load and intensity for resistance training (ACSM, 2006). Though we did not directly assess ratings of perceived exertion or physiological responses as Arent et al. (2005) did, it was our observation that most of the participants were taking sets to momentary muscular failure or near failure. Given that our repetition range was established based on previous research in the area, it is likely that "intensity" has not been as low in these studies as initially thought. This would actually help explain the delayed affective benefits seen for resistance training (e.g., Bartholomew et al., 2001; Focht & Koltyn, 1999) compared to aerobic exercise and also underscores the importance of accurately and systematically manipulating the applied stressor (i.e., resistance exercise) when examining psychological responses.

It should be noted that there are several limitations to the current findings. Specifically, the current findings may not be generalizable to females or untrained individuals. However, Focht and Koltyn (1999) reported that trained and untrained individuals report similar psychological changes to a comparable resistance exercise bout to the one used in the current study. Similarly, several studies did not find gender differences in affective responses to resistance training (Arent et al., 2005; Raglin et al., 1993). Previous investigators (Bartholomew et al., 2001), though, have pointed out potential areas of future research on individual differences in affective responses to resistance exercise. For instance, it is possible that gender or novice differences would emerge for fatigue, self-efficacy, or other personality factors (extraversion or neuroticism) that may influence responses to weight training. Future research should continue to examine individual differences in psychological responses to resistance exercise while paying careful attention to the safety and reliability of 1RM testing (Baechle et al., 2000). Moreover, factors such as whether a participant reaches muscular failure and ratings of perceived exertion should be considered in light of recent evidence of the concept of resistance exercise intensity (Arent et al., 2005).

In summary, the present findings indicate that an acute bout of weight training performed at a moderate to high intensity temporarily increases state anxiety and tension and decreases calmness. However, these negative effects disappear by 60 minutes post-exercise and are replaced by generally positive affective responses that persist for at least another hour. Positive psychological benefits from resistance training are seen in both participants who are required to remain in the laboratory as well as those who are allowed to leave the testing environment and return to complete psychological testing. However, there are differences in the time course and magnitude of some of these affective responses depending upon whether participants stayed in or left the lab. Such differences call previous findings into question and highlight the importance of controlling for extraneous variables when investigating the exercise and affect relationship. Future research in this area should take assessment and methodological considerations into account and also strive to more accurately address the time-course and intensity issues related to psychological responses following acute resistance training. This may help elucidate potential mechanisms underlying the affective responses to exercise as well as lead to a more robust endorsement of the efficacy of physical activity in general for inducing an anxiolytic response.

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