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Delayed Anxiolytic Effect Associated with an Acute Bout of Aerobic Exercise

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RICHARD H. COX, TOM R. THOMAS, AND JOSEPH E. DAVIS. **Delayed Anxiolytic Effect Associated with an Acute Bout of Aerobic Exercise. JEP**online, 3(4):59-66, 2000. The purpose of this investigation was to test the hypotheses that (a) state anxiety fluctuations following an acute bout of aerobic exercise would be associated with exercise intensity as well as mode of exercise; and (b) a delayed anxiolytic effect would be observed following an acute bout of aerobic exercise. Participants (N=24) were randomly assigned and habituated to exercise on either a Quinton 18-60 treadmill, or a Precor 714 stationary stepper. Participants completed 30 min of exercise on their assigned apparatus (jogging or stepping) at an intensity of either 50% or 75% predicted VO_2max. State anxiety was measured, using Spielberger's SAI, prior to exercise, and at 5, 30, and 60 min after exercise. Perceived exertion was measured at 9, 19, and 29 min during the 30 min exercise bout. Heart rate was monitored throughout the exercise bout and recorded at the end of each 60 s. Relative to state anxiety, an intensity by mode by time (2 x 2 x 4) ANOVA resulted in a significant main effect for time, F (3,60)=6.18, p=0.001 (Eta^2_a=0.24). Comparing baseline state anxiety with measures taken at 5, 30, and 60 min after exercise revealed significant differences between the baseline measure and the 30 (p=0.01, Eta^2_a=0.28) and 60 min (p=0.005, Eta^2_a=.33) measures, but not the 5 min measure (p=0.25, Eta^2_a=0.07). The results of this investigation clearly demonstrate the delayed anxiolytic effect of an acute bout of exercise. Exercising for 30 min at an estimated intensity of 50% or 75% predicted VO_2max does not immediately result in a reduction in state anxiety. However, a decrease in state anxiety is observed 30 and 60 minutes following the cessation of exercise.

Key Words: Exercise Intensity, Modes of Exercise, Perceived Exertion, State Anxiety

INTRODUCTION

It has been documented that acute bouts of aerobic exercise are associated with reductions in state anxiety (1). This is referred to as the anxiolytic effect of aerobic exercise. Research results have differed somewhat relative to the effects of exercise intensity upon state anxiety reductions. Earlier investigations indicated that power outputs of less than 60% VO_2 max were not associated with reductions in state anxiety, whereas moderate to high levels of exercise intensity were effective in reducing state anxiety (2,3,4). More recently, in an investigation in which exercise duration and intensity were carefully controlled, Raglin and Wilson (5) reported that exercise intensities of 40%, 60%, and 70% of VO_2max were equally effective in reducing state anxiety. Using the Profile of Mood States (6) to assess negative mood, Steptoe and Cox (7) reported slightly different results. Their results suggest that reductions in negative mood occur following acute bouts of low and moderate aerobic exercise, but actually increase following high intensity exercise. Kerr and Svebak (8) reported similar results relative to low intensity jogging and high intensity competitive rugby. The increase in negative mood following rugby, however, may have been due to factors other than the intensity of the exercise.

Reductions in state anxiety are not necessarily observed immediately following exercise. Delays of greater than 30-min may be required before a decrease in state anxiety is actually observed (5,9,10,11). Following bouts of high intensity exercise, the delay in observing a decrease anxiety may be noticeably longer than in less intense bouts (5). While acute bouts of aerobic exercise are associated with immediate or delayed anxiolytic effects this does not seem to be the case with resistance exercises such as recreational weight lifting (11,12).

In some of our own research we hypothesized that different modes of exercise may elicit differential responses relative to mood states. In a study reported by Thomas et al. (1994) it was observed that an acute 60% VO_2max bout of aerobic exercise on the stationary cycle resulted in increased fatigue and decreased vigor compared to jogging. In a similar study involving the exercise modes of treadmill jogging, stationary skier, shuffle skier, stepper, stationary cycle, and stationary rower, no such differences among modes were observed, although, exercise generally resulted in decreased depression and increased fatigue immediately following submaximal exercise bouts (14).

In related research , Berger and Owen (15) compared baseline differences and changes in mood for students enrolled in a semester of body conditioning, swimming, fencing, or yoga. A decrease in negative mood was reported for yoga and fencing students. Based upon their results, these authors proposed an exercise taxonomy for stress reduction. Modes that are more aerobic, noncompetitive, more predictable, and repetitive are believed to promote a greater degree of stress reduction. Morgan, Horstman, Cymerman, and Stokes (16), however, reported that anxiety reduction following exercise was independent of exercise mode, in the sense that walking and running at the same power output yielded similar anxiety reduction effects. It is debatable, however, if walking and running can be considered to be different modes of exercise in the same sense that running and cycling or stepping would be.

In the current research we extend the body of knowledge by conducting an investigation in which modes of exercise and intensity of exercise are manipulated to determine their combined effect upon state anxiety. Furthermore, in those instances in which anxiety reduction was not apparent immediately following exercise, we tested for the delayed anxiolytic effect. The purpose of this investigation was to test the hypotheses that (a) state anxiety fluctuations following an acute bout of aerobic exercise would be associated with exercise intensity as well as mode of exercise; and (b) a delayed anxiolytic effect would be observed following an acute bout of aerobic exercise. Relative to exercise intensity, it was specifically hypothesized that a higher exercise intensity would result in lower levels of state anxiety. For exercise mode, it was hypothesized that exercisers would differ in state anxiety as a function of exercise mode. In the absence of established theory, we did not predict which mode would result in the greatest level of state anxiety.

METHODS

Participants

Participants were 24 male university students with an average age of 28.3±8.3 years who had an established history of engaging in some form of vigorous physical activity on the average of three times per week for 30-60 min each time they exercised. They were, however, recreational exercisers and not highly trained athletes. Participants provided informed consent and IRB approval was obtained for research using human participants.

Materials

Measuring heart rate

The Polar Vantage Heart Rate Monitor (Model #1901001), with chest strap and wrist watch monitor, were used to measure participant’s heart rate (HR) before, during, and following an experimentally manipulated acute bout of exercise. The chest strap was fastened around the back of the subject with elastic bands. These bands came from the back, around each side, to the front (the chest) and attached to a flat plastic heart monitor with a signal transmitter inside. The strap was worn by the participant just below the nipples, with the flat heart rate monitor fitted just below the sternum. Rather than having the participant wear the wrist watch, it was fitted onto the handle of the exercise apparatus directly in front of the participant where it could be easily observed, read, and monitored by the experimenter.

Measuring state anxiety
State anxiety was measured using the state anxiety component of Spielberger's State-Trait Anxiety Inventory (STAI) (17). The state anxiety inventory (SAI) component of the STAI is composed of 20 items designed to provide a unidimensional measure of state anxiety. The reported internal reliability of the SAI, for male college age students, is r=0.91. For working male adults, the reported internal reliability of the instrument is r=0.93.

Perceived exertion
Perceived exertion was measured using Borg's Rating of Perceived Exertion (RPE) scale (18), which requires participants to rate, on a 15-point scale, their perceptions of exertion. For the present study, participants were asked to provide ratings of perceived exertion at the 9, 19, and 29-min points of a 30-min bout of acute exercise. An overall RPE was calculated by taking the average of these three data points. Measurement of perceived exertion provided a manipulation check for intensity of exercise as well as a way to re-distribute exercise intensity as a function of perceived exertion.

Modes of exercise
Two modes of exercise were used in this investigation. Treadmill jogging was controlled through the use of a Quinton 18-60 Treadmill. Stepping was controlled through the use of a Precor 714 Stationary Stepper.

Procedures
The procedures for this research may be grouped into four basic steps. For purposes of clarity, these steps will be explained in sequential order.

Orientation and screening
During the orientation and screening session, participants filled out a prepared inventory which requested information about exercise habits. Based upon results of this inventory, participants who were either sedentary (no regular exercise) or who exercised vigorously on a daily basis for more than 90-min were excused from the study. Additionally, participants who report taking medication for hypertension, epilepsy, or depression were excused from further participation in the study. This screening process resulted in excusing two prospective participants. Participants were informed that when they reported for subsequent testing they should avoid food, and beverages containing caffeine, for two hours prior to the exercise sessions. Participants who were retained for the investigation completed a consent form and were randomly assigned to a treatment condition involving exercise on a Quinton 18-60 treadmill (jogging), or a Precor 714 stationary stepper.

Habituation training
Participants were randomly assigned to one of four treatment conditions: low intensity jogging, high intensity jogging, low intensity stepping, high intensity stepping. Based upon assignment to treatment condition, participants reported to the Exercise Physiology Laboratory (EPL) on a flexible schedule to practice on the exercise mode to which they were assigned. There was no time limit on the habituation training. Participants practiced on their assigned apparatus until they felt psychologically comfortable while exercising on it.

Determining target heart rate
Target heart rate (THR), equivalent to estimated VO_2max of 50% and 75%, was calculated using ACSM published guidelines (19). The first step in this process was to determine the participant's estimated maximum heart rate (MHR). For the treadmill participants, MHR was calculated as 220 minus age (220-age). For the stepper, MHR was calculated as 220 minus age minus 5 (220-age-5). According to ACSM guidelines, 50% VO_2max is equivalent to 67% MHR, and 75% VO_2max is equivalent to 83% MHR. Therefore, the estimated THR associated with 50% VO_2max was calculated to be .67 times MHR, and the estimated THR associated with 75% VO_2max was calculated to be .83 times MHR. For example, a 25 year old male exercising on the treadmill at 75% VO_2max would have an estimated MHR of 195 and a THR of 162. During exercise, for this example participant, a constant THR of 162 would have been maintained throughout the 30-min exercise

period. The measurement error for estimating MHR is 10-12 bpm and for estimating submaximal exercise HR it is about 7-8 bpm (ACSM Guidelines, p.274).

Experimental exercise testing

Following habituation and estimation of THR, participants reported to the EPL for experimental testing. Prior to being fitted for HR monitoring, the participants completed State Anxiety Inventory (SAI) relative to how they felt at that moment. The SAI was administered at a table in the EPL in the same room with exercise equipment. Following assessment of state anxiety, participants were fitted for heart rate monitoring and prepared for exercise.

Consistent with assigned mode, each participant exercised for 30-min at one of two exercise intensities (50%, or 75% of predicted VO_2max). These two exercise intensities were selected as being within the range prescribed for improving cardiovascular fitness (19). Treadmill speed or stepper cadence was increased until the participant reached his THR criterion for 50% (67% maximum HR) or 75% (83% maximum HR) of predicted VO_2max. This was accomplished during the first 2-3 min of the 30 min bout. Heart rate was monitored and recorded at the end of each min of the 30 min exercise bout. Work load was monitored/adjusted in order to maintain exercise intensity at the prescribed intensity level (THR). During the 30 min exercise bout, the participant was asked to provide a rating of perceived exertion (RPE), using the Borg Scale, at 9, 19, and 29 min. Five, 30, and 60 min after the completion of the exercise bout, participants again completed the SAI. After the 30 min exercise bout, the heart rate monitor was removed and participants allowed to read or rest until the completion of the session.

RESULTS

Analysis of variance procedures (ANOVA) with repeated measures on the time variable were utilized in all analyses. F-ratios were evaluated with an alpha level of 0.05 for all main effects and post-hoc comparisons. Probability levels associated with repeated measures of an independent variable were corrected for violations of sphericity by applying the Huynh-Feldt (20) correction as recommended by Kepple (21). Effect size, or strength of relationship associated with tests of significance, were reported using a measure of variance accounted for (Eta^2_a) (22).

Baseline Analyses

Analyses indicated that significant differences did not exist for baseline measures of state anxiety or for age of participants across different intensity or exercise mode conditions. An intensity by mode of exercise (2 x 2) analysis of variance (ANOVA) on the baseline measure of state anxiety revealed nonsignificant F-ratios for the main effect of intensity ($p=0.74$, $Eta^2_a=0.01$), the main effect of mode ($p=0.14$, $Eta^2_a=0.10$), and their interaction ($p=0.13$, $Eta^2_a=0.11$). An intensity by mode of exercise (2 x 2) ANOVA on the dependent variable of age of participant revealed nonsignificant F-ratios for the main effect of intensity ($p=0.31$, $Eta^2_a=0.05$), the main effect of mode ($p=0.81$, $Eta^2_a=0.00$), and their interaction ($p=0.38$, $Eta^2_a=0.02$). Table 1 illustrates state anxiety means and standard deviations displayed as a function of exercise intensity, exercise mode, and time of measurement.

Table 1: State Anxiety Means and Standard Deviations Associated with Mode and Exercise Intensity

		TIME			
Mode	**Intensity**	Baseline	+5 min*	+30 min*	+60 min*
Stepper	50 % Est. VO_2max	26.3±2.7	28.0±3.6	27.8±3.0	26.5±4.0
	75 % Est. VO_2max	30.8±4.0	27.5±5.4	26.0±4.0	25.0±3.6
Treadmill	50 % Est. VO_2max	37.7±12.7	32.7±5.0	29.7±6.4	29.2±5.8
	75 % Est. VO_2max	30.7±11.8	28.8±7.0	25.3±6.0	25.2±5.2

* after end of 30-min exercise bout

Manipulation Check for Intensity

Participants were randomly assigned to a 50% or a 75% predicted VO_2max exercise condition. It was expected that these two conditions would differ as a function of HR and RPE measured during the 30 min acute exercise bout. An intensity by time (2 x 6) ANOVA, with repeated measures on the time factor and using HR as the dependent variable, resulted in significant main effects for intensity, F (1,22)=113.28, p=0.0001 (Eta^2_a=0.84); time, F (5,110)=18.66, p=0.0001 (Eta^2_a=0.46); and the intensity by time interaction, F (5,110)=4.97, p=0.02 (Eta^2_a=0.18). In this analysis, the 30 measures of HR were consolidated into six 5-min HR blocks. The average HR across time for the 50% VO_2max condition was 126.5±6.2 beats/min, while for the 75% VO_2max condition it was 156.4±7.5 beats/min. The presence of an interaction between intensity and time raised the possibility that HR differences may have varied as a function of time and/or intensity. To investigate this possibility, separate one factor ANOVA's were calculated to look at the simple effects of time at the two different levels of intensity. The simple effect of time at an intensity level of 50% was not significant, F(5,55)=3.28, p=0.08 (Eta^2_a=0.23). The simple effect of time at an intensity level of 75% was significant, F(5,55)=16.30, p=0.001 (Eta^2_a=0.60). Comparisons among means for the 75% intensity group revealed that HR measured during the first 5 min was significantly lower than that measured at times 2-6. In addition, HR measured during time 6 was significant higher than that measured at times 1-5. No differences in HR were noted among times 2-5. These differences are partially explained by the fact that it took exercisers an initial 2-3 min of the total 30 min of exercise to reach their assigned exercise intensity. Average HR measured at the different periods of time are displayed in Table 2.

Table 2: Means and Standard Deviations for Heart Rate (HR) Obtained at Different Periods of Time and Exercise Intensity.

	TIME					
Intensity	1	2	3	4	5	6
50% Est. VO_2max	$121.9 \pm 12.8_a$	$127.5 \pm 6.1_a$	$127.3 \pm 4.8_a$	$126.7 \pm 5.2_a$	$127.4 \pm 6.0_a$	$128.1 \pm 6.3_a$
75% Est. VO_2max	$142.2 \pm 16.3_a$	$158.0 \pm 7.6_b$	$158.7 \pm 7.1_b$	$159.3 \pm 7.6_b$	$159.3 \pm 7.2_b$	$161.0 \pm 6.1_c$

Note: Means in a row (50% or 75%) having different subscripts are significantly different from each other (p<0.05).

An intensity by time (2 x 3) ANOVA, with repeated measures on the time factor and using RPE as the dependent variable, resulted in significant main effects for intensity, F=21.11, p=0.0001 (Eta^2_a=0.49); and time, F (2,44)=14.42, p=0.0002 (Eta^2_a=0.40). The intensity by time interaction was not significant F(2,44)=0.22, p=0.69 (Eta^2_a=0.01). The average RPE score for the 50% VO_2max condition was 10.8±1.3, while for the 75% VO_2max condition it was 13.5±1.7. Collapsing across intensity, the average RPE score at 9 min was 11.5±2.2, at 19 min it was 12.0±2.0, and for 29 min it was 12.9±2.2. Significant differences were noted between 9 and 19 min (p=0.03, Eta^2_a=0.20), between 9 and 29 min (p=0.001, Eta^2_a=0.42), and between 19 and 29 min (p=0.0001, Eta^2_a=0.49). Taken together, these findings verify that the intensity manipulation resulted in significant differences in HR and RPE as would be expected.

Intensity by Mode by Time Analysis for State Anxiety

An intensity by mode by time (2 x 2 x 4) ANOVA, with repeated measures on the time factor and using state anxiety as the dependent variable, resulted in nonsignificant main effects for intensity, F(1,20)=1.27, p=0.27 (Eta^2_a=0.06); and mode, F(1,20)=1.67, p=0.21 (Eta^2_a=0.08); but a significant main effect for time, F (3,60)=6.16, p=0.001 (Eta^2_a=0.24). All interactions among main effects were not significant. The Eta^2_a for the three 2-way interactions and the one 3-way interaction ranged from 0.01 to 0.07. Collapsing across intensity and mode of exercise, state anxiety scores for time are displayed in Figure 1. As can be observed in Figure 1, a general decline in state anxiety scores occurred across the four measurement times. Contrasting the baseline measure of state anxiety with measures taken 5, 30, and 60-min after the completion of the 30-min exercise bout revealed significant differences between the baseline measure and the 30-min (p=0.01, Eta^2_a=0.28) and 60-min (p=0.005, Eta^2_a=0.33) measures. A significant difference was not observed between the baseline measure of state anxiety and 5-min after the end of the exercise bout (p.25, Eta^2=0.07). This reduction in SAI, late in recovery, illustrates the delayed anxiolytic effect.

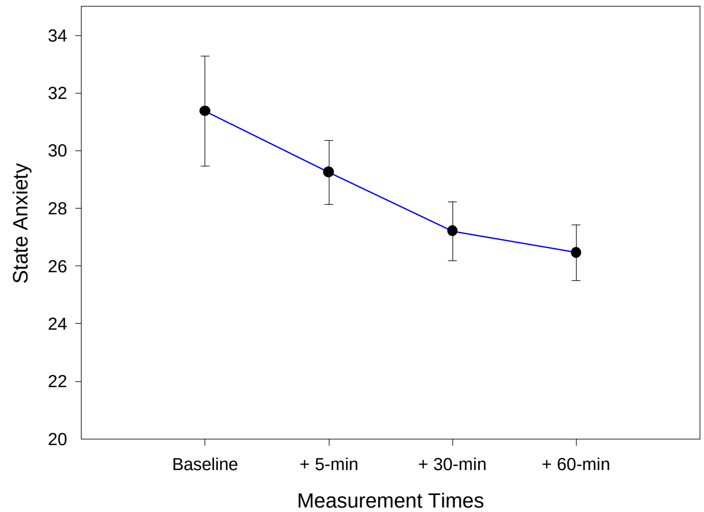

Figure 1: State anxiety means and standard errors plotted across four measurement times.

Sufficient power was available to detect differences in state anxiety for the time variable, but not for intensity or mode of exercise. The effect size (23) for intensity of exercise was 0.45, while for mode of exercise it was 0.55. These are both medium size effect sizes that would require approximately 128 participants, as opposed to 24, to detect a significant difference (power=0.80, α=0.05). A typical intensity of exercise effect size for this kind of research is about 0.35 (5).

DISCUSSION

The hypothesis that a change in state anxiety, following an acute bout of aerobic exercise, would be associated with exercise mode was not supported. Effect size, calculated as Eta^2=0.08, indicated that a small percent of the variance of state anxiety was accounted for by differences in mode. These results are consistent with Morgan et al. (16), but inconsistent with Berger and Owen (15) in that state anxiety following exercise was independent of exercise mode.

The hypothesis that state anxiety, following an acute bout of aerobic exercise, would be associated with exercise intensity was not supported. Exercising at 75% predicted VO_2max as opposed to 50% predicted VO_2max did not result in lower post exercise levels of state anxiety. These results are consistent with Raglin and Wilson (5) who reported that exercise intensities of 40%, 60%, and 70% of VO_2max are equally effective in reducing post exercise state anxiety. Several earlier studies, however, had reported that only exercise intensities of greater that 60% VO_2max are effective in reducing state anxiety following exercise (2, 3, 4). Conversely, some studies have suggested that high exercise intensities lead to an increase in negative mood (6, 7, 8). In this regard, Raglin et al. (11) and Bartholomew and Linder (24) reported that high intensity resistance exercise leads to an immediate increase in state anxiety. Results of the present investigation suggest that when an acute bout of aerobic exercise is based upon predicted VO_2max that both 50% and 75% levels of exercise intensity lead to reductions in state anxiety. Based upon these results, we conclude that acute moderate to moderately high exercise intensities lead to delayed reductions in state anxiety.

As hypothesized, the delayed anxiolytic effect was observed following an acute bout of aerobic exercise. As illustrated in Figure 1, state anxiety decreased over time, following a 30-min bout of acute aerobic exercise. State anxiety measured 5-min after the 30-min bout of exercise was not significantly different from a baseline measure of state anxiety. However, 30 and 60-min after exercise, the delayed anxiolytic effect was present. Consistent with earlier research (5,9,10,11) an acute bout of aerobic exercise resulted in a decline in state anxiety that is delayed by between five to 30-min and persists at least 60-min and perhaps longer. Coupled with research that shows that chronic aerobic exercise may reduce trait anxiety (25), the findings of this study and others shows promise for the clinical use of exercise to reduce anxiety. Future research should continue to investigate the dose effect of acute aerobic exercise on state anxiety as well as such factors as age, gender, persistence of the anxiolytic effect, mode of exercise and exercise intensity. While mode of exercise was not an important determinant of the anxiolytic effect, it has not been sufficiently tested under controlled exercise conditions and should not be completely ruled out as an exercise variable associated with differential levels of state anxiety.

The indirect estimation of the submaximal target intensities could have confounded the results of this study. However, previous work in our laboratory suggests that the error of estimate would be similar for jogging and stepping exercise (26). It is likely that the underestimates and overestimates of the target intensity were somewhat evenly distributed in both groups. Thus, the indirect estimation of exercise intensity should not have affected the comparisons between these two modes of exercise. In addition, the time variable in this study was repeated measures (i.e., a given subject underwent the state anxiety testing before and after the same exercise session). Therefore, even if the exercise intensity for a given subject was not exact, this same exercise bout was associated with each state anxiety assessment over time. It is possible that if the true target intensity was slightly higher or lower than the estimate, a subject may have answered test items differently. However, the approximate 25% difference between the two intensities ensured that even with estimates, the intensities were substantially different in physiological and perceptual responses. This contention is supported by the approximate 30 beats/min difference in heart rate between intensities and the RPE responses which averaged 10.8 for the low intensity and 13.5 for the higher intensity.

REFERENCES

1. Raglin JS. Anxiolytic effects of exercise. In WP Morgan (Ed.), **Physical activity and mental health** (pp. 107-126). Washington, DC: Taylor & Francis, 1997.
2. Farrell PA, Gustafson AB, Morgan WP, Pert CB. Enkephalins, catecholamines, and psychological mood alterations: Effects of prolonged exercise. **Med Sci Sports Exerc** 1987;19:347-353.
3. Morgan WP, Roberts JA, Feinerman AD. Psychologic effect of acute physical activity. **Arch Phys Med Rehabil** 1971;52:422-425.
4. Sime WE. A comparison of exercise and meditation in reducing physiological response to stress. **Med Sci Sports Exerc** 1977;9:S55.
5. Raglin JS, Wilson M. State anxiety following 20 minutes of bicycle ergometer exercise at selected intensities. **Int J Sports Med** 1996;17:467-471.
6. McNair DM, Lorr M, Droppleman LF. **Profile of mood state manual**. San Diego: Educational and Industrial Testing Service, 1981.
7. Steptoe A, Cox S. Acute effects of aerobic exercise on mood. **Health Psychology** 1988;4:329-340.
8. Kerr JH, Svebak S. The acute effects of participation in sport on mood: The importance of level of antagonistic physical interaction. **Personality and Individidual Differences** 1994;16:159-166.
9. Morgan WP, Horstman DH. Anxiety reduction following acute physical activity. **Med Sci Sports Exerc** 1976;8:62.
10. O'Connor PJ, Bryant CX, Veltri JP, Gebhardt SM. State anxiety and ambulatory blood pressure following resistance exercise in females. **Med Sci Sports & Exerc** 1993;25:516-521.
11. Raglin JS, Turner PE, Eksten F. State anxiety and blood pressure following 30 min of leg ergometry or weight training. **Med Sci Sports Exerc** 1993;25:1044-1048.
12. Koltyn KF, Raglin JS, O'Connor PJ, Morgan WP. Influence of weight training on state anxiety, body awareness and blood pressure. **Int J Sports Med** 1995;16:266-269.
13. Thomas TR, Londeree BR, Lawson DA, Ziogas G, Cox RH. Physiological and psychological responses to eccentric exercise. **Can J Appl Physiol** 1994;19:91-100.

14. Russell WD, Cox RH, Thomas TR, Ziozas G, Smith TD, Zhang Q, Londeree BR. Mood response to six modes of submaximal exercise. **Med Sci Sports Exerc** 1994;26:S139.
15.Berger BG, Owen DR. Stress reduction and mood enhancement in four exercise modes: Swimming, body conditioning, hatha yoga, and fencing. **Research Q Exerc Sport** 1988;59:56-67.
16. Morgan WP, Horstman DH, Cymerman A, Stokes J. Exercise as a relaxation technique. **Primary Cardiology** 1980;6:48-57.
17. Spielberger CD, Gorsuch RL, Lushene RE, Vagg PR, Jacobs GA. **Manual for the State-Trait Anxiety Inventory (Form Y)**. Palo Alto, CA: Consulting Psychologists Press, 1983.
18. Borg GAV. Simple rating methods for estimation of perceived exertion. In G Borg (Ed.), **Physical work and effort**. New York, NY: Pergamon Press, 1977.
19. ACSM. **ACSM's guidelines for exercise testing and prescription**. Edited by W Kenney. Baltimore, MD: Williams & Wilkins, 1995:153-176, 269-287.
20. Huynh, H., & Feldt, LS. Conditions under which mean square ratios in repeated measurements designs have exact F-distributions. **J Amer Statist Assoc** 1970;65:582-589.
21. Kepple G. **Design and analysis a researcher's handbook** (3rd ed.). Upper Saddle River, NJ: Prentice Hall, 1991;352-353.
22. Tabachnick BG, Fidell LS. **Using multivariate statistics**. HarperCollins College Publishers, 1996;53-54.
23. Cohen J. A power primer. **Psycho Bull** 1992;112:155-159.
24. Bartholomew JB, Linder DE. State anxiety following resistance exercise: The role of gender and exercise intensity. **J of Behav Med** 1998;21:205-219.
25. Petruzello SJ, Landers DM, Hatfield BD, Kubitz KA, Salazar W. A meta-analysis on the anxiety reducing effects of acute and chronic exercise. **Sports Med** 1991;11: 143-182.
26. Londeree BR, Thomas TR, Ziogas G, Smith TD, Zhang JQ. %VO_2max versus %HRmax regressions for six modes of exercise. **Med Sci Sports Exerc** 1995;27:458-461.

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