The Acute Effects Of Increasing Levels Of Aerobic Exercise Intensity On Mood States[1]

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INTRODUCTION

A consistently growing body of empirical evidence seems to corroborate the common anecdotal observation that acute aerobic exercise results in anxiety reduction and overall mood enhancement (Morgan, 1987; Petruzzello, Landers, Hatfield, Kubitz & Salazar, 1991; Tuson & Sinyor, 1993). There is also evidence that such affective benefits are closely associated with a resultant sense of enjoyment (Wankel & Sefton, 1989) which, in turn, plays a decisive positive role in exercise adherence (Scanlan & Simons, 1992; Wankel, 1985).

However, as Dishman (1986) has noted, "it seems unlikely that all types, volumes and settings of exercise will affect all aspects of mental health for all people" (p. 328). In fact, studies examining the effect of single bouts of aerobic exercise on mood have not yielded uniformly consistent results (Tuson & Sinyor, 1993), and several authors emphasize the importance of controlling for a number of subject and task characteristics which may dramatically alter the quality of the exercise stimulus (Berger & McInman, 1993). Specifically, exercise intensity, despite having received little direct attention in published research, is recognized as a crucial factor in this respect (Raglin, 1990). For example, Steptoe and Cox (1988) noted that working on a bicycle ergometer against a load of 25W for 8 minutes resulted in increases in vigor and exhilaration, whereas working against a load of 100W increased tension and fatigue. Similarly, swimming at an average of 81% of age-adjusted maximum heart rate does not produce any positive mood change; on the contrary, it brings about an increase in fatigue (Berger & Owen, 1992). Other studies, however, using either very small and highly trained samples or only low-to-moderate intensities, partially contradict these findings (see Tuson & Sinyor, 1993, for a review).

The American College of Sports Medicine (1991) recently recommended that, in order to develop and maintain cardiorespiratory fitness, healthy adults should exercise within 40%-85% of their VO_2 max or 55%-90% of their maximal heart rate. These figures illustrate that significant physiological benefits can derive from exercising at a broad range of intensities, although perhaps at different rates. Therefore, it remains to examine the differential effects of

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increasing levels of aerobic exercise intensity on mood, given that a physiologically beneficial intensity is not necessarily a psychologically beneficial one.

Thus, the purpose of this study is to address this issue, in an ecologically valid context, by manipulating aerobic exercise intensity to levels roughly corresponding to 40%, 60%, and 80% of age-adjusted maximum heart rate reserve. Moreover, it seemed interesting to examine a group of volunteers allowed to select their preferred pace. Finally, the present study not only examines the pre- and post-exercise levels of mood, but also the affective reactions during exercise. The effects of exercise are contrasted to the effects of a lecture and a relaxation procedure.

METHOD

The study employs a 6 (groups) by 2 (pre-post) design, with repeated measures on the last factor, for the measures of mood. It also employs a similar 4 (groups) by 3 (time points) design, for the examination of affective reactions during exercise.

Subjects

The sample of this study consisted of 123 female students from a Physical Education and Sport Science Department, ranging in age from 20 to 23 years. The subjects were randomly assigned to (a) a low-intensity aerobic exercise condition (n1=21), targeted at approximately 40% of the group's age-adjusted maximum heart rate (HR_{max}) reserve, (b) a moderate intensity condition (n2=20), targeted at approximately 60% of HR_{max} reserve, (c) a high intensity condition (n3=19), targeted at approximately 80% of HR_{max} reserve, and (d) a double control condition (n4=53). An additional group of volunteers agreed to form a self-selected exercise intensity condition (n5=10).

Measures

The abbreviated version of the Profile of Mood States (POMS; NcNair, Lorr & Droppleman, 1971), proposed by Shacham (1983), was used as a measure of Tension/Anxiety, Depression/ Dejection, Anger/Hostility, Vigor/Activity, Fatigue/Inertia, Confusion/Bewilderment, and Total Mood Disturbance. The rigorous psychometric properties of the 65-item original questionnaire seem to be well preserved in this 37-item easier-to-administer form (Grove & Prapavessis, 1992). Five additional items were included, measuring Exhilaration. Moreover, state anxiety was measured by the 20-item state-anxiety subscale of the State-Trait Anxiety Inventory (SAI; Spielberger, Gorsuch & Lushene, 1970). In all cases, POMS and SAI were administered in a counterbalanced order, which was reversed at the posttest.

The Physical Activity Enjoyment Scale (PACES; Kendzierski & DeCarlo, 1991) was administered only to subjects in the treatment groups, to assess post-exercise degree of enjoyment. The same subjects also responded to the Rating of Perceived Exertion (RPE; Borg & Noble, 1974) and the Feeling Scale (FS; Hardy & Rejeski, 1989), at the 10th, 20th, and 30th minute of exercise.

All the psychological instruments used in this study were translated in Greek following a standard procedure involving the discussion of multiple alternative wordings by a group of five bilingual experts.

Procedure

A group of twenty female students volunteered to serve as assistants in the study and were given thorough instructions on the procedure. Moreover, subjects in all four treatment groups received one-hour preparatory sessions, on methods of heart rate measurement and procedural details. The psychological instruments were also presented and the instructions were explained for each one of them. The need for absolute honesty and precision was particularly emphasized. The subjects were also informed in advance of the respective target heart rate of their group and were advised to monitor their exertion during exercise from poster-size RPEs that were placed on the walls around them.

The subjects in the three controlled-intensity treatment groups participated in the study in hours normally scheduled for the requisite course of Dance. A few students denied participation for medical reasons. The subjects in the self-selected exercise intensity group were all students from the same year who volunteered to participate on a weekend, in order to gain "inside" experience in research procedures.

All exercise sessions were conducted under the instructions of the third investigator, who holds a doctorate in Sport Pedagogics and has extensive practical experience in aerobics. The experiment took place in a comfortable and appropriately equipped gymnasium, and all groups were tested in morning hours. One assistant was assigned to each subject, to discretely ensure that all procedures were followed correctly. Just before the exercise, the subjects filled-in the POMS and SAI and then self-measured their baseline heart rates during two 15-sec periods. The actual exercise sessions lasted for 30 minutes. After the 10th, the 20th, and on the 30th minute, the sessions were interrupted for periods of no longer than 2:00 to 2:30-min, during which the subjects measured their heart rates and recorded their responses to RPE and FS. After the 30th minute, they also completed the POMS, SAI and PACES. During the interruptions, the pre-trained assistants supervised the heart rate measurements and provided individualized feedback, so as to direct intensity within predetermined range. Heart rate was intended to reach a peak at the 20th minute, at which point it should be 110-130 bpm, 140-160 bpm, and 170+ bpm, for each of the three controlled-intensity groups, respectively. The subjects in the self-selected intensity condition received no feedback, but were instead advised to "find and follow their own pace". The exercise routine for this group was so designed, as to allow for personal control over the intensity of performance, and the potential for intensifying each exercise was displayed, but the instructor himself performed at moderate levels at all other times.

The format of the exercise was the typical found in aerobics, without pauses and accompanied by disco music. The whole procedure (pretest, exercise, posttest) covered in all cases a total of 60-min.

The two control conditions consisted in (a) a Sport Psychology lecture on "Leadership in Sport" in the auditorium, lasting for approximately 45-min, and (b) subsequently, a composite relaxation program, combining elements of progressive muscle relaxation and autogenic training. The duration of the relaxation program was 30-min. Both procedures were conducted by the first investigator, who has extensive graduate training and experience in relaxation techniques. The POMS and SAI were filled-in three times: (a) just before the lecture, (b) after the lecture and just before the relaxation program, and (c) immediately after the relaxation program.

RESULTS

The results obtained from the treatment and the control conditions appear in Tables 1 and 2, respectively. For the purposes of further analysis, the responses given after the lecture were treated both as posttest for the lecture and as pretest for the relaxation procedure. Therefore, six (four treatment plus two control) conditions were considered. At baseline conditions, the one-way analyses of variance (ANOVAs) across the four samples showed that there was significant inter-group variance in the cases of Tension (p<.001) and Confusion (p<.05). *Post hoc* analyses by means of *Scheffe* tests revealed that significant differences among groups existed only for Tension, where the self-selected intensity group exhibited a considerably elevated pretest mean.

To examine the effectiveness of the procedure which was followed for the manipulation of exercise intensity, a 4 (conditions) by 4 (time-points) multivariate analysis of variance (MANOVA), with repeated measures on the last factor, was conducted on heart rate data obtained throughout the exercise sessions (baseline conditions, 10th, 20th, and 30th minute). The results of this analysis indicated that the effect of intensity conditions, the effect of phase of exercise, and their interaction were highly significant (p<.001). At the peak of exercise (20th minute) all three controlled-intensity groups differed significantly, with mean heart rate values at 106.48 bpm, 153.00 bpm, and 168.11 bpm for the low-, the moderate-, and the high-intensity groups, respectively (Figure 1). At the 20th minute, the highest mean heart rate was reached by the self-selected intensity group (M=170.80 bpm). Only the low-intensity group reached its highest mean heart rate at the 10th minute of exercise (M=115.33).

Initial 6 (conditions) by 2 (pre-post) multivariate analyses of variance (MANOVAs) with repeated measures on the last factor for all the factors of POMS, the Total Mood Disturbance score, and SAI, showed that the effect of phase of measurement (pre-post) was highly significant (p<.001) for all the dependent variables, while the interaction between conditions and phase of measurement was significant in the cases of Tension (p<.05), Depression (p<.01), Vigor (p<.05), Fatigue (p<.001), and Exhilaration (p<.001). These analyses were followed by univariate analyses of covariance (ANCOVAs) for the posttest values of all dependent variables across conditions, using the respective pretest values as covariates. The univariate Fs were significant for all the dependent variables, except Confusion.

TABLE 1. Means and Standard Deviations for the Treatment Groups

	LOW (n=21)		MID (n=20)		HIGH (n=19)		FREE (n=10)	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
Tension								
M	4.43	4.14	5.20	3.65	5.53	4.95	10.70	7.50
SD	3.56	4.50	5.45	2.89	5.37	4.43	7.32	6.17
Depression								
M	3.90	2.43	5.20	0.90	3.00	1.37	6.00	3.20
SD	5.08	5.16	6.43	1.62	4.93	3.53	8.27	6.00
Anger								
M	2.95	2.57	2.95	0.60	2.89	2.63	3.30	1.90
SD	3.71	5.08	3.94	0.94	4.57	4.75	5.03	3.00
Vigor								
M	14.48	13.86	13.05	15.95	15.68	18.26	14.10	16.40
SD	4.43	5.22	5.50	4.81	4.63	4.21	4.53	3.53
Fatigue								
M	2.71	2.33	3.30	4.85	2.63	6.37	0.80	5.60
SD	3.36	3.43	3.63	4.44	3.80	4.17	1.40	4.60
Confusion								
M	5.19	4.05	3.15	1.95	3.21	2.32	6.00	4.10
SD	2.91	3.38	3.20	1.70	2.42	3.09	3.43	2.08
Total								
M	104.71	101.67	106.75	96.00	101.58	99.37	112.70	105.90
SD	18.42	21.35	20.59	9.66	19.76	17.96	26.99	20.27
Exhilaration								
M	8.35	9.90	8.35	14.30	10.37	14.89	7.30	13.10
SD	4.97	5.60	5.32	4.40	4.46	4.94	4.06	4.01
SAI								
M	37.38	35.86	37.70	32.50	39.11	34.21	46.80	41.20
SD	8.37	8.92	8.81	5.68	12.49	7.41	13.04	10.34
PACES								
M		90.81		109.55		108.42		114.40
SD		20.39		12.76		15.94		7.50

By including only the four treatment groups in the analyses, the ANOVA yielded significant results only in the cases of Vigor ($p<.05$), Fatigue ($p<.01$), and Exhilaration ($p<.05$). The main effect of intensity condition was also highly significant for enjoyment after exercise ($p<.001$), with *Scheffe* test indicating that the responses of the low-intensity group were significantly lower than those of all the other groups. Post-exercise enjoyment was higher for the self-selected intensity condition group, but the difference was not significant compared to the moderate- and the high-intensity groups. Multiple paired *t*-tests among pretest and posttest means in all groups yielded the following results: the low-intensity condition resulted in significant improvements in Depression ($p<.05$) and Confusion ($p<.05$). The moderate-intensity condition reduced Depression ($p<.01$), Anger ($p<.01$), SAI ($p<.05$) and increased Vigor ($p<.05$) and Exhilaration ($p<.001$). The high-intensity condition brought about an increase in Fatigue ($p<.01$), but also increased Vigor ($p<.05$) and Exhilaration ($p<.01$). Finally, the self-selected intensity condition, despite raising Fatigue ($p<.01$), reduced Tension ($p<.05$), Depression ($p<.10$), Confusion ($p<.05$) and increased Vigor ($p<.10$) and Exhilaration ($p<.001$), considering $p<.10$ as the level of statistical significance, due to the small sample size (n=10).

TABLE 2. Means and Standard Deviations for the Control Group

	Before Lecture	After Lecture Before Relaxation	After Relaxation		Before Lecture	After Lecture Before Relaxation	After Relaxation
Tension				Confusion			
M	3.73	3.34	0.92	*M*	4.22	3.17	2.09
SD	3.79	3.95	1.25	*SD*	3.02	2.87	2.31
Depression				Total			
M	3.53	2.21	1.09	*M*	101.55	98.79	90.02
SD	4.83	3.89	2.31	*SD*	18.23	18.00	10.71
Anger				Exhilaration			
M	2.16	1.81	0.60	*M*	9.00	8.80	12.34
SD	4.13	4.11	1.54	*SD*	4.79	5.42	5.62
Vigor				SAI			
M	14.94	14.74	16.19	*M*	35.33	34.53	27.55
SD	4.78	5.95	5.53	*SD*	8.15	8.65	6.63
Fatigue							
M	2.86	3.00	1.49				
SD	3.60	3.84	2.23				

The effectiveness of the control conditions was separately examined by *stepdown F-tests*, which indicated significant effects of the factor of condition on all dependent variables. Multiple paired *t*-tests showed that while the lecture lowered Depression ($p<.001$), Confusion ($p<.001$), and Total Mood Disturbance ($p<.01$), the relaxation procedure brought about dramatic changes in the whole range of dependent variables: Tension ($p<.001$), Depression ($p<.001$), Anger ($p<.05$), Vigor ($p<.05$), Fatigue ($p<.001$), Confusion ($p<.01$), Total Mood Disturbance ($p<.001$), Exhilaration ($p<.001$), and SAI ($p<.001$).

Four (exercise intensity conditions) by 2 (pre-post) MANOVAs with repeated measures on the last factor were employed to analyze the RPE and FS data obtained during exercise (Figures 2 and 3). For RPE, the effect of intensity condition, the effect of phase of exercise (10th, 20th, 30th minute) and their interaction were all significant, and this pattern was not affected by considering FS as a covariate. On the other hand, for FS, only the effect of phase of exercise was significant, and this effect was suppressed when considering RPE as a covariate. Especially on the 20th minute of exercise, the two constructs share 25% of their variance ($r=-.50$, $p<.001$).

However, it appears that this relationship is not uniform across different intensity conditions (Figure 4). At the peak of exercise, the correlations between RPE and FS were -.00, -.56, and -.84 in the low-, moderate- and high-intensity conditions, respectively. In the self-selected intensity condition, however, it was slightly positive ($r=.27$). The equivalent values between HR and FS were -.03, -.26, -.43, and .29. Similarly, effort is appraised differently by the four groups: the correlations between HR and RPE were .03, .46, .66, and only .22, for the low-, moderate-, high- and self-selected intensity conditions, respectively. In all four groups, the correlation between HR and RPE reached $r=.65$ ($p<.001$).

Multiple regression analysis showed that objective (HR) and subjective (RPE) exercise intensity accounted for 33% of post-exercise enjoyment (*Multiple* $R=.57$), 13% of Tension

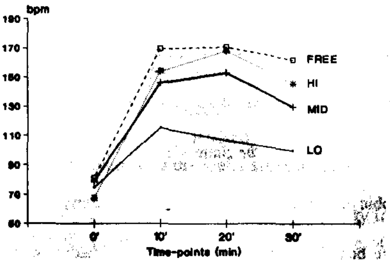

Fig. 1. Self-Measured Heart Rates in the Four Exercise Intensity Conditions

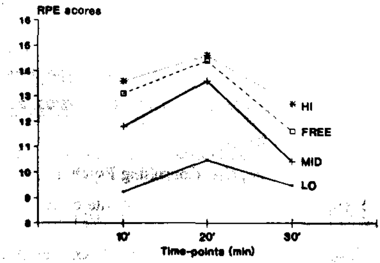

Fig. 2. Perceived Exertion During Exercise in the Four Exercise Intensity Conditions

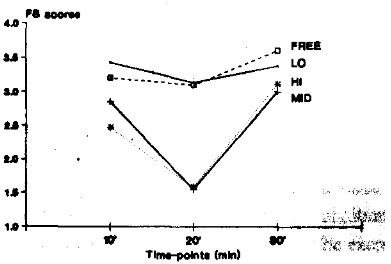

Fig. 3. Responses to the Feeling Scale in the Four Exercise Intensity Conditions

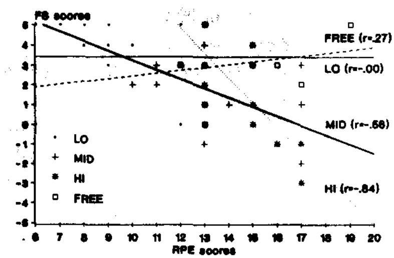

Fig. 4. Correlations between RPE and FS in the Four Exercise Intensity Conditions at the Peak of Exercise

(*Multiple R* =.36), 10% of Anger (*Multiple R* =.33), 10% of Vigor (*Multiple R* =.32), 28% of Fatigue (*Multiple R* =.53), 10% of Confusion (*Multiple R* =.31), 15% of Exhilaration (*Multiple R* =.39), and 9% of SAI (*Multiple R* =.30).

DISCUSSION

The primary objective of the present study was to examine whether increasing levels of aerobic exercise intensity result in differential effects on levels of affect during exercise and levels of mood and enjoyment post-exercise, in an ecologically valid context. Moreover, the effectiveness of aerobic exercise in enhancing mood was contrasted with that of traditional relaxation techniques.

The results overall indicate that aerobic exercise indeed possesses mood-enhancing properties, which are comparable, at least quantitatively, to those of a composite relaxation procedure. However, as hypothesized, the picture is not uniform across varying levels of exercise intensity. Keeping in mind the preliminary nature of these findings, they appear to be suggestive of an inverted-U relationship between exercise intensity and global effectiveness in enhancing mood. If this pattern is replicated, and the parameter of duration is also taken into consideration, then we would be able to establish some guidelines of particular practical significance for exercise adherence.

During exercise, increasing intensity led to increased perceived exertion and decreased responses to FS. However, the negative correlation between RPE and FS at the peak of exercise increased in absolute terms from the low- to the high-intensity groups; while in the low-intensity group the two constructs appear dissociated, in the high-intensity group they are closely associated. It is thus speculated that the more subjective intensity increases, the more it gains control of affect.

These findings also emphasize the importance of taking the intensity of exercise into account when designing future theory-testing research on the mechanisms underlying exercise-induced mood enhancement and anxiety reduction (see Petruzzello *et al.*, 1991, for a review). Different mechanisms might be operating at different levels of intensity. For example, physiological data suggest that the "endorphin hypothesis" could not account for such effects in low-to-moderate intensities, since no alterations in the concentration of beta-endorphins - at least in the blood - are noted in exercise with intensity lower than 60% of VO_2 max and of duration of less than 30 to 45-min. On the other hand, psychological mechanisms, such as the "distraction hypothesis", could provide viable explanations for low-to-moderate intensities.

A striking finding was the divergent pattern of responses exhibited by the self-selected-intensity group. This group not only reached the highest mean heart rate at the peak of exercise, but also exhibited very positive responses in most factors of mood, had the highest mean enjoyment score after exercise, and seemed to respond positively to both subjective (RPE) and objective (HR) intensity during exercise. It is evident that these findings require replication, given the small sample size in this group (n=10). Even at this point, however, they seem to constitute a phenomenon worthy of some additional attention.

Whether this pattern of responses is attributable to the volunteering nature of participation in this group or to the fact that these subjects felt more at freedom cannot be determined. If we are to attribute this phenomenon to the former factor, then such a finding would have considerable methodological implications. If, on the other hand, we are to attribute it to that latter factor, then we would have reached a conclusion of great practical significance. An alternative hypothesis would be to adopt a reversal theory perspective, as suggested by Kerr and Vlaswinkel (1990); perhaps, the subjects in the controlled-intensity groups, especially those in the high-intensity group, were operating in a telic metamotivational state, having been instructed to work within some imposed range of intensity. On the other hand, the subjects who were free to follow their preferred level of intensity and were, in addition, provided with options to regulate the intensity of exercise by taking initiatives may have operated in a more playful or paratelic state. It would also appear that an exercise-specific form of sensation seeking might play a role in this respect; that is, certain individuals, probably of an above-average aerobic capacity, choose to work at higher levels of exercise intensity, since they interpret somatic arousal positively. These hypotheses are, apparently, speculative at this point, but are of considerable theoretical interest and are open to future research.

Another important question refers to the interaction between intensity and frequency of exercise; that is, to what extent is the pattern of reactions described herein reproducible in consequent exercise sessions? Some preliminary findings from our group suggest that while for the low- and the self-selected-intensity groups the picture was largely similar two days later, the moderate- and the high-intensity groups exhibited some symptoms of accumulated fatigue and their responses to an analogous exercise stimulus were less favorable.

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