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ABSTRACT

This study investigated the effects of a six-week, high-intensity cycling program on anaerobic threshold (AT) in ten women. Subjects trained four days a week using high-intensity interval-type cycle exercises. Workouts included six 4-minute intervals cycling at 85 percent maximal oxygen uptake (VO sub 2 max), separated by 3-minute intervals of lower intensity cycling at 25% VO sub 2 max. AT and VO sub 2 max were assessed prior to and immediately following the 6-week program, and VO sub 2 max was reassessed weekly in the exercise group. A significant interaction effect was found for cycle ride time and for AT expressed in liters, mililiters, work rate, and as a percentage of max. Further analysis of the significant interaction effects revealed no significant pretest to posttest differences in any variable in the control group, while the exercise group showed significant differences in these variables from pretest to posttest. Results suggest that, in women, high-intensity cycling exercise significantly increases physical work capacity (cycle ride time) and AT measures without substantial changes in VO sub 2 max parameters. (Author/CB)

EFFECT OF SHORT-TERM, HIGH-INTENSITY EXERCISE ON ANAEROBIC THRESHOLD IN WOMEN

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ABSTRACT

The purpose of this study was to investigate the effects of a six-week, high-intensity cycling program on "anaerobic threshold" (AT) in women. Ten women were randomly assigned to a control or exercise group. Women in the exercise group trained four days/week using high-intensity, interval-type cycle exercise. Workouts included six, four-minute intervals cycling at 85% $\dot{V}O_2$ max, separated by three-minute intervals of lower intensity cycling at 25% $\dot{V}O_2$ max. Maximal oxygen uptake and anaerobic threshold were assessed prior to and immediately following the six-week program. $\dot{V}O_2$ max was reassessed weekly in the exercise group. AT was determined non-invasively as the point of an increase in $\dot{V}E/\dot{V}O_2$ without an increase in $\dot{V}E/\dot{V}CO_2$. No significant group, test or group X test interaction ($p>.05$) was found for $\dot{V}O_2$ max in $l \cdot min^{-1}$ or $ml \cdot kg^{-1} \cdot min^{-1}$. A significant interaction effect was found for cycle ride time and for AT expressed in liters, milliliters, work rate and as a percentage of max ($p<.05$). Further analysis of the significant interaction effects revealed no significant pretest to posttest differences in any variable in the control group, while the exercise group showed significant differences in these variables from pretest to posttest. It was concluded that, in women, short term, high-intensity cycling exercise significantly increases physical work capacity (cycle ride time) and AT measures without substantial changes in $\dot{V}O_2$ max parameters.

INTRODUCTION

Though the ventilatory response to exercise has been described by numerous investigators, the term associated with the well-known inflection point, "anaerobic threshold" (AT), and the mechanisms underlying the hyperventilatory response to exercise remain controversial (Powers and Beadle, 1985). The existence of an anaerobic threshold in metabolism is accepted, however, the best procedure for its identification is controversial.

Despite these controversies, AT, or the percent of $\dot{V}O_2$ max at which one can maintain long-term exercise, has been shown to be highly correlated to endurance performance (Conconi et al., 1982; Rhodes and McKenzie, 1984; Tanaka et al., 1984) and to maximal aerobic capacity (Davis et al., 1976). The usefulness of the AT in predicting success in endurance performance, for prescription of exercise, and as a criterion of submaximum fitness has also been noted (McLellan and Skinner, 1981; Weltman et al., 1978; Yoshida et al., 1982). In addition, the response of the AT to endurance-type conditioning programs has been investigated. Several investigators (David et al., 1976, 1979; Ready and Quinney, 1982; Williams et al., 1967) have shown that the work rate at which the AT occurs is increased with endurance-type conditioning as is the AT-$\dot{V}O_2$. The increases in AT-$\dot{V}O_2$ have been found to be greater than the increases in $\dot{V}O_2$ max. The majority of the research to date has focused on male performers or elite athletes. Few studies have examined the training response of AT in women and fewer studies have examined the effects of short-term, high-intensity training on AT parameters.

PURPOSE

The purpose of this study was to investigate the effects of a six-week, high-intensity cycling program on "anaerobic threshold" in women.

METHODS

Subjects. The subjects were ten women who were in moderately good physical condition though none were on a cycling program at the time of the study. Their physical characteristics (mean ± SD) were: age, 27.7 ± 3.6 years; height, 166.7 ± 5.2 cm; and weight, 56.54 ± 5.36 kg. All subjects were given a detailed description of the experiment and procedures to be used prior to giving their oral and written informed consent.

Research Design. Subjects were assigned randomly to either a control or experimental group. The control group maintained normal daily routines and did not engage in any systematic endurance training during the six-week program. Subjects in the experimental group trained four days/week for six weeks on a Monark cycle ergometer. Workouts included six exercise bouts of four minutes duration, using a work rate estimated to elicit 85% $\dot{V}O_2$ max. Each work bout was separated by three minutes of lower intensity cycling (25% $\dot{V}O_2$ max). Each week $\dot{V}O_2$ max was reassessed in the exercise group and used to adjust the exercise workload to maintain exercise intensity. Selected physiological parameters were assessed for all subjects the week prior to and the week immediately following the conditioning program.

Work Capacity Test. A continuous, load-incremented cycle ergometer test was utilized to assess maximal oxygen uptake and anaerobic threshold. The test began with a work rate of 60 watts and increased 30 watts after each two-minute interval. Pedal rate was maintained at 60 rev/min throughout the test. The subject continued until exhausted and unable to maintain pedal rate. The criteria for determining attainment of $\dot{V}O_2$ max were: evidence of a plateau in $\dot{V}O_2$ or an increase in $\dot{V}O_2$ of less than 150 $ml \cdot min^{-1}$ between workloads; R>1.1; HR at or above age estimated max. The duration of the test was used as a measure of physical work capacity.

A semiautomated gas collection system (Wilmore and Costill, 1974) was used to analyze expired air samples every 30 seconds throughout the test. The volume of expired air was measured using a Parkinson-Cowan CD-4 dry gas meter and temperature was measured by a thermistor inserted in the inlet hose of the gas meter. Percentages of oxygen and carbon dioxide in the expired air were determined using Beckman OM-11 and LB-2 electronic gas analyzers, respectively. Previously analyzed gases (micro-schollander technique) were used to calibrate the analyzers prior to each test session. Heart rate was determined by electrocardiogram readings obtained during the last ten seconds of each minute of the test using a CM5 bipolar lead arrangement.

Anaerobic threshold was determined by two independent investigators using gas exchange variables plotted against power output at each work level. The criterion for determination of AT was a systematic increase in the ventilatory equivalent for oxygen ($\dot{V}E/\dot{V}O_2$) without an increase in the ventilatory equivalent for carbon dioxide ($\dot{V}E/\dot{V}CO_2$). In addition, $\dot{V}E$, FEO_2, and $\dot{V}CO_2$ as well as R were plotted against power output to enable AT_{ge} determination in cases where the change in the ventilatory equivalent variables were not apparent (Davis et al., 1979). The reliability and validity of the use of gas exchange variables for determination of AT has been reported (Davis, Vodak and Wilmore, 1976; David et al., 1979).

Statistical Analysis. A two-way (group x test) analysis of variance with repeated measures on the test factor was used to determine the significance of differences between the control group and the experimental group over the treatment period. A significant interaction indicated that the change in the physiological variable tested was significantly different between the control and experimental groups. A dependent t test was used to test for simple main effects. An alpha level of .05 was used for all tests of significance.

RESULTS

The conditioning program produced a training effect as evidenced by changes in $\dot{V}O_2$ max and work capacity. Mean increases in the experimental group in $\dot{V}O_2$ max (10%) and work capacity or ride time (22%) were substantial, whereas changes in the control group were minimal, 2% and -2% respectively.

Means and standard deviations of the physiological variables assessed during the cycle ergometer tests are presented in Table 1. No significant group effect across time ($p>.05$) was revealed for any dependent measure. The within factor of test showed a significant main effect for cycle ride time (RT), $p<.05$. A significant group x test interaction was revealed for HR and RT, $p<.05$. Further analysis of the significant interaction effects revealed a significant difference in HR max from pretest to posttest in the control group, while no difference was detected in the HR max measures for the experimental group. Control group data for the two test periods indicated that a maximal effort had been attained inspite of the heart rate differences between test periods. No significant difference between pretest and posttest RT were found in the control group, while a significant difference ($p<.01$) was found between pretest and posttest RT in the experimental group.

Means, standard deviations and percent changes of the anaerobic threshold variables are presented in Table 2. A significant group effect across time was revealed for anaerobic threshold expressed in liters (ATVOL), as a percentage of $\dot{V}O_2$ max (ATPVOL), and as work rate (ATWR). Significant test effects and group x test interactions were found for ATVOL, ATVOML, ATPVOL, and ATWR. Further analysis of the interaction effects revealed no significant pretest to posttest differences in any variable in the control group. On the other hand, the experimental group showed a significant difference from pretest to posttest in ATVOL ($p < .05$), ATVOML ($p < .05$), and ATWR ($p < .005$).

CONCLUSION

Short-term, high-intensity cycle ergometer exercise significantly increases physical work capacity and measures of anaerobic threshold in women without a significant change in maximal oxygen uptake. Anaerobic threshold expressed in liters and as work rate increase significantly as a result of short-term, high-intensity exercise.

TABLE 1.

MEANS AND STANDARD DEVIATIONS OF PHYSIOLOGICAL VARIABLES ASSESSED DURING CYCLE ERGOMETER STRESS TESTS

VARIABLE	GROUP[a]	PRETEST		POSTTEST		% CHANGE
		MEAN	SD	MEAN	SD	
VO_2(liters·min^{-1})	C	2.26	.30	2.32	.32	2.7
	E	2.53	.35	2.78	.19	9.9
VO_2(ml·kg^{-1}·min^{-1})	C	41.7	7.2	42.6	7.9	2.4
	E	43.5	6.7	48.0	4.5	10.3
HR(b·min^{-1})	C	184	10.7	178	9.0	-3.0
	E	185	12.4	185	8.4	0.0
R	C	1.18	.05	1.15	.07	-2.5
	E	1.13	.11	1.11	.06	-1.8
RT(min)	C	10.1	2.4	9.9	1.7	-2.0
	E	10.8	1.6	13.2	.8	22.2

[a] C=Control Group; E=Experimental Group

TABLE 2.

MEANS AND STANDARD DEVIATIONS OF ANAEROBIC THRESHOLD VARIABLES ASSESSED DURING CYCLE ERGOMETER TESTS

VARIABLES	GROUP[a]	PRETEST MEAN	PRETEST SD	POSTTEST MEAN	POSTTEST SD	% CHANGE
AT-VOL($l\cdot min^{-1}$)	C	1.37	.18	1.41	.18	2.8
	E	1.61	.23	1.99	.21	19.1
AT-PVOL(% max)	C	60.8	5.0	60.8	3.3	0.0
	E	63.9	6.0	73.0	3.1	14.2
AT-VOML($ml\cdot kg^{-1}\cdot min^{-1}$)	C	25.4	4.9	25.9	5.1	1.9
	E	27.6	3.3	33.9	1.4	22.8
AT-WR(WATTS)	C	90	13.7	90	13.7	0.0
	E	105	11.2	135	13.7	28.6

[a] C=Control Group; E=Experimental Group

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