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THE INFLUENCE OF SHORT-TERM TRAINING ON THE MAXIMUM OXYGEN UPTAKE AND ENDURANCE CAPACITY OF MALE AND FEMALE SUBJECTS

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Maximum oxygen uptake ($\dot{V}O_2$ max) is commonly used as an indicator of fitness in general and endurance capacity in particular. Furthermore, $\dot{V}O_2$ max has often been the only criterion used to assess the efficacy of various training programmes. Available evidence suggests that while training may produce only modest improvements in $\dot{V}O_2$ max they are accompanied by large improvements in endurance capacity (Williams, 1981). Therefore the aim of the present study was to re-examine the relationship between the improvements in $\dot{V}O_2$ max and endurance capacity which occur with training.

Sixteen physical education students (10 female and 6 male) trained 3 times a week for 6 weeks on a treadmill at a speed equivalent to 90% of their pre-training $\dot{V}O_2$ max. In addition to the $\dot{V}O_2$ max tests, respiratory and metabolic responses to an endurance test were determined before, during and after the 6 weeks of training. The endurance test involved continuous running at speeds equivalent to 60%, 70% and 80% $\dot{V}O_2$ max for 4 minutes at each speed, and then at 90% $\dot{V}O_2$ max for as long as possible. Expired air and blood samples were collected after 4 minutes running at each speed and also at exhaustion. The overall improvements in $\dot{V}O_2$ max and endurance capacity for the females were 4.5% and 178% (Table I) whereas the values for the males were 3.7% and 223% respectively. These results suggest that $\dot{V}O_2$ max is an insensitive indicator of the training-induced improvements in endurance capacity of active male and female subjects.

Reference

Williams, C., 1981. J.biosoc.Sci., Suppl. 7: 103-112.

TABLE I

A summary of the results of the female subjects (values are mean ± SD)

$\dot{V}O_2$ max Test (7 mph)	Pre (0 wks)	Mid (3 wks)	Post (6 wks)
Run Time (min)	7.22 ± 2.11	8.33 ± 1.60*	8.85 ± 1.71†**
$\dot{V}O_2$ max (ml.kg.$^{-1}$ min.$^{-1}$)	48.9 ± 5.2	50.0 ± 5.0	51.0 ± 5.2†**
$\dot{V}E$ (L.min.$^{-1}$)	84.4 ± 9.4	91.1 ± 10.9*	89.8 ± 8.6
HR max (bpm)	194 ± 8	190 ± 8	188 ± 6**
Endurance Test			
Run Time (min)	8.59 ± 4.61	22.31 ± 10.46*	23.88 ± 15.59**
% $\dot{V}O_2$ max	88.2 ± 2.1	85.5 ± 2.8	84.6 ± 4.2
HR (bpm) at ETI	192 ± 6	184 ± 9	187 ± 7**
$\dot{V}E$ (L.min.$^{-1}$) at ETI	74.5 ± 10.2	71.2 ± 12.6	69.7 ± 11.9**

ETI denotes measurements made at the end of the first endurance test and at the equivalent time during the subsequent two endurance tests. *denotes significant differences ($p < 0.05$) pre-mid; †mid-post and **pre-post.

THE INFLUENCE OF TRAINING ON THE METABOLIC RESPONSES TO SUBMAXIMAL EXERCISE

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Improvements in endurance have been attributed in part to a shift from carbohydrate metabolism towards fat metabolism. A recent report (Henriksen et al, 1981) appears to support the proposal that increased oxidation of fat leads to an accumulation of citrate which inhibits phosphofructokinase.

Endurance at 83% $\dot{V}O_2$ max was evaluated as the work time to exhaustion on a cycle ergometer. Subjects

TABLE I

(Mean ± sem)

	Pre-training		**Post-training**	
	Pre-ex	**5' Post**	**Pre-ex**	**5' Post**
Blood lactic acid	.48 ± .07	4.63 ± .48	.50 ± .06	2.24 ± .41†
Plasma citrate	.118 ± .006	.163 ± .009	.106 ± .005	.138 ± .004†
Plasma glycerol	.083 ± .019	.243 ± .031	.081 ± .017	.166 ± .017*
Plasma FFA	.46 ± .05	.66 ± .07	.40 ± .04	.65 ± .07

significantly different pre-post training *$p < 0.05$, †$p < 0.01$

(n=13) trained for 6 weeks at work loads eliciting more than 83% $\dot{V}O_2$ max. After training the initial performance test was replicated: concentrations of metabolites (mM) are compared before and after training in Table I.

$\dot{V}O_2$ max increased by 16 ± 2% and endurance by 251 ± 28% (both $p < 0.01$). Submaximum $\dot{V}O_2$ and minute ventilation were reduced ($p < 0.01$) but the fall in respiratory exchange ratio was not significant. Additional observations of a sub-group (n=8) showed that the fall in plasma citrate and plasma glycerol concentrations was complete after 3 weeks training, whereas blood lactic acid concentration showed a further fall between weeks 3 and 6. Thus training increased oxidative metabolism but concentrations of fat metabolites remained unchanged or fell. The observations provide no evidence of a citrate-mediated reduction of glycolysis.

Reference

Henriksen, J. M., Toftegaard Neilsen, T. and Dahl, R., 1981 "Effects of physical training on plasma citrate and exercise-induced asthma". Scand.J.Clin.Lab.Invest. 41: 225-229.

METABOLIC AND HORMONAL RESPONSES TO GRADED EXERCISE WITH TRAINING ABOVE AND BELOW THE ANAEROBIC THRESHOLD

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The aim of this study was to investigate the metabolic and hormonal response to graded exercise in two groups of subjects training at two different work intensities, above and below the anaerobic threshold (Kindermann et al, 1979).

Eight normal, healthy subjects with no previous endurance training experience volunteered for this study. After a two-week familiarisation period each subject performed an incremental work test to exhaustion on a cycle ergometer. Venous blood samples were obtained throughout the test by means of a 19-gauge indwelling catheter inserted into a prominant forearm vein. Blood samples were withdrawn every one minute for blood lactate and every three minutes for the determination of blood glucose, NEFA, pyruvate, nor-adrenaline and cortisol. The subjects were then assigned randomly to training above (group A) or below (group B) the anaerobic threshold. The subjects trained for a period of eight weeks, five days per week and the bicycle test repeated. An overall increase in maximal oxygen uptake of 7.4% ($p < 0.01$) was observed after training, with a greater increase for group B (11.2 vs. 4.5%; $p < 0.05$). Changes in the $\dot{V}O_2$-related anaerobic threshold were 6.5% overall ($p < 0.01$) and greater for group A than for group B (7.8 vs. 4.3%; $p < 0.05$). Heart rate and systolic blood pressure were lowered with training ($p < 0.01$), but no difference was observed between the groups. No significant change was found in blood glucose with training, but an overall increase in NEFA was observed ($p < 0.01$) which was greater in group A than in group B ($p < 0.01$). A reduction in catecholamine secretion with training was observed ($p < 0.01$) but no significant difference was observed between the groups. Plasma cortisol was seen to increase with training ($p < 0.05$) in both groups with no difference between the two groups.

It is concluded that there are significant differences in the metabolic and hormonal responses to graded exercise with training at work intensities above and below the anaerobic threshold. It would seem that training above the An-T, whilst producing a smaller increase in max $\dot{V}O_2$, produced a greater metabolic response in terms of higher circulating NEFA and lower blood lactate.

Reference

Kindermann, W., Simon, G. and Keul, J., 1979 "The significance of the aerobic-anaerobic transition for the determination of work load intensities during endurance training". Eur.J.Appl.Physiol. 42: 25-34.

RESPIRATORY AND HAEMATOLOGICAL RESPONSES TO TRAINING

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The effectiveness of physical training programmes is usually assessed by changes in VO_2 max. However, this commonly used measure is essentially descriptive. More useful diagnostic information may be obtained from closer examination of each specific system which makes up the oxygen uptake chain. This project examines two of the more accessible components, namely lung function and venous blood.

Thirteen PE students took part. Resting lung function was assessed by whole-body plethysmography and nitrogen-washout techniques. Blood volume was measured at rest by radio-isotope dilution. Red cell volume, haemoglobin, cardiac enzymes (AST, ALT, CK), lactate and 2-3 di-phosphoglycerate were assessed at rest and during four, 5 minute steady-state incremental workloads on the cycle ergometer. Blood samples were obtained via a long-dwell brachial vein catheter. Training consisted of 30 minutes interval running 5 times a week for eight weeks. Measures were taken before and after four and eight weeks training.

Lung function was largely unaffected by the training.