($n=13$) trained for 6 weeks at work loads eliciting more than 83% VO_2 max. After training the initial performance test was replicated: concentrations of metabolites (mM) are compared before and after training in Table I.

VO_2 max increased by $16 \pm 2\%$ and endurance by $251 \pm 28\%$ (both $p < 0.01$). Submaximum VO_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 prominent 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 Blood samples were withdrawn every one minute for blood lactate and every three minutes for the determination of blood glucose, NEFA, pyruvate, nor-adrenaline and cortisol.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 VO_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 VO_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.

Functional residual capacity, inspiratory capacity, vital capacity, forced vital capacity, airways resistance, residual volume and gas mixing efficiency were within normal limits and did not change. Only peak expiratory flow showed significant improvement after four weeks (7.79-8.28 l.sec).

Blood volumes, red-cell volumes and haemoglobin were unaffected by this relatively short training programme. Two cardiac enzymes, AST and ALT were within normal limits before training and did not change. The third, CK, was 168% higher than the normal range of 5-40 u.l. before training (107.1 u.l. $\pm$ 72.3), fell significantly after eight weeks (64.7 u.l. $\pm$ 36.9) but was still 62% above normal limits. Blood lactate at standard work was also lower following training (5.37 m.mol.l. $\pm$ 2.29-4.14 m.mol.l. $\pm$ 1.70) but 2-3 d-PG remained unchanged.

Raised levels of CK reflect skeletal muscle injury. The high levels noted before training may be the result of a sharp increase in physical activity experienced by the students as they continued their physical education programme after the long summer vacation. The importance of above normal levels of CK is not yet clear and further work is needed to support the findings reported here and test the hypothesis that CK may be a simple index of straining rather than training.

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THE EFFECT OF GRADED AND EXHAUSTIVE PHYSICAL EXERCISE ON VASOPRESSIN RESPONSE IN NORMAL, HEALTHY VOLUNTEERS

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The vasopressin response to steady-state and exhaustive exercise was investigated in 16 normal, healthy volunteers. The maximum functional capacity test comprised the basis for calculation of the relative intensities corresponding to heart rates equivalent to 40% and 70% VO_2 max. The steady-state exercise tests (i.e. 40%, 70% and 70% + heat for 15 minutes) were assigned to the subjects using a latin square design, with seven days intervening between tests. Following 30 minutes of supine rest, 25 ml of venous blood was removed using a two-syringe technique. Immediately after the cessation of exercise, a second blood sample was removed (25 ml) for subsequent analysis of vasopressin using RIA.

Results

Non-significant ($p > 0.05$) inter- or intra-individual variations in the resting level of vasopressin were estab-

lished over the four testing occasions, the mean values being 0.97, 1.28, 0.99 and 1.04 ng/L respectively. A significant difference ($p < 0.05$) was found in the mean vasopressin responses to graded and exhaustive exercise at 70% ($\times 3.22$), 70% + heat ($\times 3.79$) and 100% ($\times 11.65$), with a non-significant vasopressin response at 40% ($\times 1.93$). When the vasopressin was measured following three repeated exercise tests at 70% VO_2 max, the reproducibility was within $\pm 10\%$. Accordingly, it is concluded that physical exercise induces a significant increase in the level of vasopressin, probably as a contributing factor in the regulation of plasma volume.

A TECHNIQUE FOR MONITORING THE EFFECTS OF TRAINING ON SWIMMING EFFICIENCY

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Most of the studies of swimming efficiency in man have involved the use of expensive specialised equipment (Di Prampero et al, 1974; Kemper et al, 1976). These studies have provided considerable information concerning the physiology and biomechanics of swimming but there does not seem to have been much spin-off for the club coach in terms of methods of assessing swimming efficiency and, therefore, methods of evaluating the effects of different training programmes (Costill et al, 1980). The present paper outlines the development of a technique for monitoring the effects of training on swimming efficiency for use with well-trained swimmers. The technique is based on the relationship between heart rate and swimming speed which has been shown to be linear for well-trained swimmers (Treffene, 1978). Each swimmer is required to swim three trials of 200 m at speeds which correspond approximately to moderate, fast and all-out efforts. During each trial the elapsed time between push-off and touch is recorded to the nearest tenth of a second and the heart rate of the swimmer is assessed at the end of each trial by taking a pulse count during the period 0-15 seconds of recovery. A least squares regression line is calculated from the speed:heart rate data. The gradient of the line and the predicted speed at a heart rate of 190 beats per minute (S190) are used as measures of swimming efficiency. With a group of fifteen well-trained swimmers, including five current internationalists, the effects of endurance swimming training (rather than sprint training or land conditioning) is to increase both the gradient and the S190 which are reflected in performance times in competitive events.

References

Costill, D., Sharp, R. and Troup, J., 1980 "Muscle strength: contributions to speed swimming". *Swimming World* 21 (2): 29-34.