Prolonged Exercise in Prepubertal Boys
II. Changes in Plasma Volume and in Some Blood Constituents

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Summary. A group of 10 prepubertal boys was studied during prolonged exercise (60 min) on bicycle ergometer and on treadmill at two levels of work load (appr. 40% and 60% \( V_\text{O}_2 \text{ max} \)). The hematocrit, serum proteins, Cl\(^-\) and K\(^+\) were followed, and from the blood hematocrit changes the plasma volume changes were calculated. At the exercises of lower intensity of both types a slight hemodilution was found (appr. +5% increase in plasma volume), at higher intensity practically no changes could be demonstrated. These findings are supported by the values of serum protein concentration, where no increase was found, and by the fact that at the lower work loads a rather decreasing trend was found for this blood constituent. These findings are at variance with those in adults under similar conditions. The authors suggest that different changes of plasma volume during exercise in boys than in adults could be related to the disparate lactate production and fate in these age groups.

Key words: Prolonged exercise in boys — Hematocrit — Plasma volume — Plasma proteins.

Introduction

Physical exercise is accompanied with the shifts of body fluids, changes in plasma volume, and blood constituents, thus reestablishing a homeostasis of the milieu intérieur. Most earlier studies in this field have been concentrated on adults, but little attention has been paid to children. From the clinical experience a more delicate water and ion balance can be suggested in young organisms, and therefore, the aims of this study was to investigate the influence of prolonged exercise on plasma volume and some plasma constituents in prepubertal boys.

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Procedures and Methods

The subjects were 10 boys with mean age 12 y. 9 m. submitted to an extended exercise of 60 min duration on both treadmill and bicycle, at two relative work loads of 35--39% $\dot{V}O_2$ max and 60% $\dot{V}O_2$ max. The characteristics of the boys group and the details of the methods were described in a previous paper (Máček et al., 1976) The blood samples were drawn without stasis through an indwelling catheter from the cubital vein at rest, after 10, 20, 40, and 60 min of exercise. Immediately after collection of each blood sample quadruplicate microhematocrit determinations were made. The serum samples were analyzed for $K^+$ with flame photometer, for $Cl^-$ with the titration method (Trtilek, 1937), and for total protein concentration with the biuret method.

Microhematocrit readings were corrected for trapped plasma and converted to whole body hematocrit by the factor $(0.96 \times 0.91)$. Proportional changes in plasma volume were calculated by application of the proportionality factor $[100/(100 - \text{Hct})]$ proposed by Beaumont et al. (1972). The equations by Beaumont et al. (1973) were used to calculate the proportional changes in total content of proteins from the plasma volume changes and the protein concentrations at the various time intervals.

Results

The changes in hematocrit (Hct) before and during prolonged exercise are shown in Table 1. At lower work loads of both types a slight decrease ($P < 0.05$) was found after 10 min of exercise without any significant changes throughout the extended work time. At higher work loads the hematocrit values changed only unsignificantly.

On the basis of the hematocrit changes, the calculated plasma volume (Table 1) increased by about 4--5% at the onset of exercise of lower intensity (36--39% of $\dot{V}O_2$ max), without any further changes. At the higher work loads (60% of $\dot{V}O_2$ max), only a negligible decrease, if any, of the plasma volume can be noted at the onset of the exercise, while it remains essentially unchanged at prolonged bicycle exercise. This fact suggests a transition to a slight hemodilution during extended exercise on treadmill.

The changes in serum protein concentration during exercise (Table 1) are not statistically significant, with a high interindividual variability in all types of exercise, except for the exercise of lower intensity on treadmill where a decreasing trend was found during extended exercise.

The changes in plasma volume and serum protein concentration are reflected in the calculated protein content (Table 1). The changes of protein content due to exercise are not statistically significant in any of the types used, suggesting a slight increase at lower loads (+2 to +3%), and a questionable decrease at higher work loads (−1 to −2%). Further changes during extended exercise are rather inconsistent, without any statistical significance.

The serum $Cl^-$ concentration (Table 1) increases slightly during exercise as compared to the control values, but not significantly.

The serum $K^+$ concentration (Table 1) increases after the onset of exercise ($P < 0.05$) in all types of exercise used, but it does not vary essentially in the later course of exercises. No difference can be found between the types of exercises used.