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Electrolyte changes in human serum during and after exercise

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ABSTRACT

The objective of this investigation was to assess the effect of exercise on serum electrolytes after a short term and a prolonged exercise in non-endurance untrained males aged between 18 – 30 yrs. Blood samples for Na^+, K^+, Cl^- and $HC0_3^-$ analysis were taken before and after two exercise bouts. The study showed significant decreases in plasma Na^+, Cl^- and $HC0_3^-$ levels after the short intense and prolonged exercises (P< 0.05). Serum K^+ showed a significant increase after the short-term exercise (P<0.05), which significantly lowered after the prolonged exercise. Low K^+ values have been observed to cause excitatory changes in muscle irritability and myocardial dysfunction. Also fatigue, hypertension and congestive heart failure have been associated with low K^+ and high Na^+ and Cl^- levels. Thus the observed decrease in K^+, decrease in Na^+ and Cl^- levels after prolonged exercise is physiologically advantageous in the maintenance of proper body function.

INTRODUCTION

Over the years, exercise has been recommended in health conscious societies as an essential element in normal life style both to maintain good health and to ameliorate disease, disability and depression (Macleod *et al*, 1987). The greatest demands ever placed on cardiovascular, respiratory and metabolic control systems occur during exercise. This may disrupt the body's dynamic equilibrium, altering some biochemical processes by either increasing or decreasing the amount of molecules involved in such processes.

Hence the homeostatic process is normally mobilized to ensure the maintenance of these body parameters or molecules within a tolerable range. A typical example of this is observed in the body's maintenance of electrolyte and fluid balance and the acid-base status during exercise (Wilmore and Costil, 1994). Electrolytes, which are minerals dissolved in body fluids that carry an electrical charge are involved in the maintenance of osmotic pressure, water distribution and transmission of messages across nerve cells. They are also involved in the regulation of heart and muscle functions, electron transfer reactions and pH regulation (Burtis and Ashwood, 2001).

An investigation of the changes which occur in plasma electrolytes during a moderately intense exercise in young active but non-endurance untrained men is the main focus of this research work.

MATERIALS AND METHODS

Subject

Twenty two young adult male volunteers between the ages of 18 – 30 yrs served as subjects for this study. They were recruited on the basis of their fitness and are apparently healthy with no history of electrolytes disorder, diabetes and were not on drugs containing steroids.

The purpose and detailed procedure were well explained to all the subjects and their written consent were obtained prior to the study as recommended by WHO (TDR, 2001 and TDR, 2002). Ethical clearance was obtained from Research, Ethics Committee of the College of Medicine and Health Sciences, Imo State University, Owerri, before the commencement of work.

Study design

The exercise was carried out in the early hours of the morning when heat interference is not much. Venous blood was collected from the subjects before embarking on the exercise. The subjects were made to run vigorously, a distance of about 400m, they were allowed to rest for about 5 minutes before another blood sample was collected from them. The subjects then engaged in a football game, which lasted for about 90 minutes. After which they rested for 5 minutes prior to the collection of the last blood sample. The subjects are students who normally consume carbohydrate and protein diets.

Analytical methods

About 5ml of blood was collected into a dry test tube. This was allowed to clot and then centrifuged for 10 minutes at 2500g (Wisterfuge Centrifuge, England). The serum was collected and either used immediately or stored in a refrigerator at -20^{o}C until when used. Na^+ and K^+ levels were estimated using Teco diagnostic kit. Chloride levels were estimated by the mercuric nitrate titrimetric method (Schales and Schales, 1994). while bicarbonate, was estimated using titrimetric method (Natelson, 1951).

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Statistical methods

All values were expressed as mean ± standard deviation. The statistical analysis was carried out using ANOVA. Values with levels of significance ($P<0.05$) were statistically significant.

RESULTS

The mean serum sodium level of the subjects before engaging in the exercise was found to be 147.9±3.57 mmol/L (table 1). This was significantly reduced after the short-term exercise to 138.9 ± 3.02 mmol/L ($P< 0.05$). After prolonged exercise, it was further reduced to 132.25 ± 2.24 mmol/L ($P< 0.05$). The mean serum potassium concentration of the subjects significantly increased from 3.66 ± 0.29 mmol/L before exercise to 5.42 ± 0.26 mmol/L after the short intense exercise ($P< 0.05$), but was reduced to 4.21 ± 0.25 mmol/L ($P< 0.05$), at the end of the prolonged exercise. The mean serum chloride levels decreased significantly from 108.65 ± 1.98 mmol/L to 97.93 ± 1.92 mmol/L after the short-term exercise ($P< 0.05$). This was further reduced to 90.5 ± 1.47 after the prolonged exercise ($P< 0.05$). Mean serum bicarbonate levels decreased significantly from 29.35 ± 1.53 mmol/L to 25.36 ± 1.27 mmol/L after the short term exercise ($P< 0.05$), and was further reduced to 20.2 ± 1.29 mmol/L at the end of the prolonged exercise.

DISCUSSION

The mean serum sodium ion concentration of the subjects before engaging in the exercise significantly reduced after the short intense exercise ($P< 0.05$) and was reduced further after the prolonged exercise ($P< 0.05$). This is in agreement with similar work in which it was estimated that about 15 – 30 mmol/L of sodium was lost in men following two hours of intense exercise in the heat (Sjogaard, 1986). Hence the decrease observed may be attributed mainly to loss in sweat (Wilmore and Costil, 1994). It has been observed that high sodium levels enhance the incidence of hypertension and oedema (Saladin, 1998). Thus the reduction observed after the exercise programme supports the recommendation of exercise for proper healthy living.

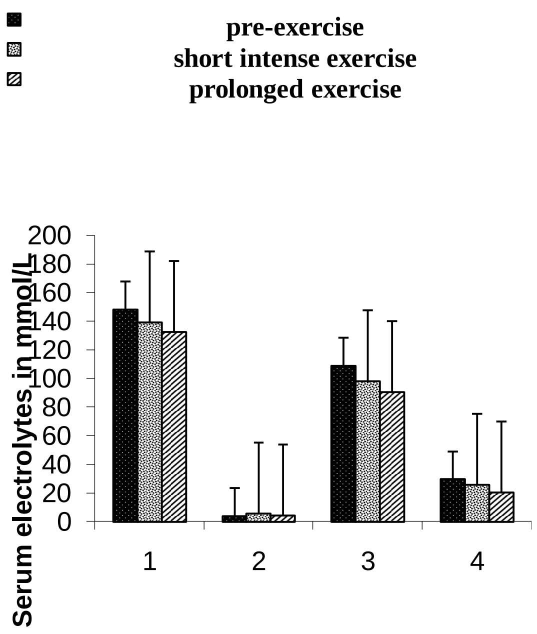
There was an increase in the mean serum value of potassium ion concentration after the short intense exercise when compared with the mean value before exercise ($P< 0.05$). After the prolonged exercise, mean value of potassium ion concentration was observed to reduce significantly from the initial higher value. The sharp increase observed after short intense exercise was in keeping with the findings of Lindinger *et al,* (1995), who observed that during highly intense exercise, plasma potassium concentrations increase due to the efflux of K^+ from contracting muscles into the blood, raising plasma level (Hodgkin and Horowiez, 1959). The significant reduction after prolonged exercise could be explained by the fact that the non-contracting muscles takes up K^+ during circulation at such site leading to reduced levels and with low intense activities experienced during the prolonged exercise the rate of release also was reduced (Clausen, 1986). Low potassium values have been observed to cause excitatory changes in muscle irritability and myocardial dysfunction. Also fatigue, hypertension and congestive heart failure have been associated with low potassium ion – levels (Elson and Haas, 1999).

There were decreases in mean serum chloride levels obtained from the short term and prolonged exercise when compared with the mean chloride levels before exercise ($P< 0.05$). This may be explained by the fact that chloride excretion especially in sweat increases during exercise. About 15 – 30 mmol/L of chloride has been estimated as amounts lost after a two-hour intense exercise by male subjects (Sejersted, 1992).

Results obtained from this study also showed statistically significant decreases in mean serum bicarbonate concentration after both short term and prolonged exercise. This can be explained by the fact that the draining of lactate from contracting muscles into the blood increases plasma H^+ concentration, pCO_2 and osmolality, hence lowering the plasma pH (Lindinger *et al,* 1995). Bicarbonates being the major physiological buffer in the control of plasma pH is used up to maintain the pH at tolerable ranges. This leads to the reduced levels observed in the $HC0_3^-$ concentration. High levels of chloride and bicarbonate may trigger disturbances in the acid - base balance. Hence exercise programmes with its observed effects are a good control to the incidence of such anomalies.

CONCLUSION

This study shows that exercise causes a reduction in the concentration of sodium, chloride and bicarbonate ions and an increase in concentration of potassium ion (Fig. 1). High sodium levels predispose one to obesity and hypertension. Similarly, high chloride levels usually trigger disturbances in the acid - base balance, hence the reduced levels observed after exercise is physiological for maintaining a healthy life. Increased level of potassium is also advantageous as very low levels may cause excitatory changes in muscle irritability and myocardial dysfunction. Hypertension and congestive heart failure is also associated with low potassium levels. Hence it is not surprising that people who exercise enjoy good health and are usually physically fit. There is therefore need for exercise no matter how little; but in suggesting such exercise, the physiological state of the individual and a regulated exercise programme must be considered.



1 = Sodium. 2= potassium. 3=chloride ion. 4= bicarbonate ion

Fig. 1. Relationship between serum electrolytes and exercise

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