Correlation of Serum Electrolytes (Na^+, K^+, Ca^{++}, Mg^{++}) and ECG Changes Before and After Exercise

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Abstract

Exercise is known to cause changes in electrolytes in different compartments of the body and homeostasis keeps in check these changes. This study was planned to access and evaluate changes biochemical parameters like Na^+, K^+, Ca^{++} and Mg^{++} along with changes in E.C.G. in healthy young Indian adults. Fifty two healthy students (26 each, male and female) with an age range of 18–30 years were subjects in this study. The participants performed an exercise test of moderate to vigorous intensity on bicycle ergometer. Pre and post exercise biochemical parameters (serum electrolytes Na^+ K^+ Mg^{++} Ca^{++}) along with ECG was done. The serum sodium levels in both pre & post exercise group were within normal range but serum sodium is highly significant in post exercise group. The serum potassium levels in both pre & post exercise group were within normal range but serum potassium is highly significant in post exercise group. The serum magnesium levels in both pre & post exercise group were within normal range but serum magnesium is highly significant in post exercise group. The serum calcium levels in both pre & post exercise group were within normal range but serum calcium is highly significant in post exercise group. In the ECG the voltage of p wave QRS complex and ST segment shows highly significant/significant changes in pre and post exercise group. The duration of ST segment, RR interval, QT interval and QTc interval change highly significantly in the pre and post exercising group. PR interval is no change in either group.

Keywords: *Exercise, Serum electrolytes Na^+ K^+ Mg^{++} Ca^{++}, E.C.G.*

Introduction

Apart from the role of regular exercise in disease prevention there may be sometimes Sports paradox where exercise can also trigger sudden cardiac death particularly in case of underlying cardiac disease. This warranting an adequate cardiac screening (E.C.G.) and individual specific recommendation for sports participation and use of biochemical parameters like Na^+, K^+, Ca^{++}, Mg^{++} can be done to predict metabolic elimination as besides homeostasis alterations.

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Similarly electrolytes which make a very important composition of body homeostasis system (buffer). Magnesium is vital for muscle electrolyte homeostasis, oxygen uptake and energy production.

Sodium has been falsely blamed for hypertension when the true cause is the chlorine component of sodium chloride. Excessive consumption of sodium is associated with increased risk of gastric ulcers. Increasing sodium consumption by 1 gram per day cause 500 mg calcium taken from bone can attribute to bone loss of 1 percent per annum unless calcium loss is compensated for by supplementation or increased dietary calcium intake Shorttet al 1990[1].

Physical exercise had been shown to induce bone mass gain, especially in load bearing bone sites Maimoumet al 2005[2]. Parathyroid hormone (PTH) which is the major regulator of bone metabolism,

functions to maintain the calcium ion concentration of the extra cellular fluids within physiological limit. The activity of PTH and readily influenced by both exercise duration and intensity. Renal reabsorption of calcium or a combination of the two are factor that lead to increase in urinary excretion of calcium but serum levels of calcium are under strict homeostatic control and remain within narrow limits .

Potassium the main electrolytes found inside the body's intracellular fluid and stored in muscle fibres along with glycogen plays a key role by helping transport glucose into the muscle cells, interacts with both sodium and chloride to control fluid and electrolyte balances and assists in the conduction of nereve impulse Armstrong and Epstein 1999 [3].

Gerth J et al 2002[4] studied that the serum concentrations of potassium, protein and albumin after strenuous exercise decreased significantly but remained within physiological ranges. The serum sodium concentration decreased immediately after the race.

Meludu, Yoshitakeet al (2002) [5] Studied the homeostasis of each of minerals on sedentary and exercise days. Subjects were restricted within the premises of the research institute and relaxed as much as possible. Apart from the 3-minute anaerobic exercise on exercise day, the activities of the subjects were not different from that on sedentary day.

Exercise induced a significant increase in urinary excretion of Zn and Mg, a decrease of K and no significant effect on urinary excretion Ca. Interestingly, the excretion of the minerals normalized except Mg, which remained high 12 hours after exercise. On a 24 hr bases, Mg and Zn excretion were increased, while Ca and K did not change significantly on exercised day compared with sedentary day.

John Onimisi Ogedengbe et al 2012 [6] in their study, QTC durations fell within the normal range, higher in the females both pre and post-exercise. An increase was recorded post-exercise in both sexes the increase in males was statistically significant (p-value <0.05).

Exercise-induced gastrointestinal symptoms are caused by shifts in blood flow and electrolyte balances in response to changing metabolic demands. During physical activity, body magnesium stores shift transiently from the plasma into skeletal muscle and adipose tissue to increase energy production and counteract oxidative stress Nielsen and Lukaski 2006[7].

Materials and Method

This cross sectional study would include 52 students both male and female of 18 to 30 years old enrolled in 1st year MBBS in GSVM Medical College Kanpur, Informed consent was taken from each subject. The study group consisted of young healthy individuals (males and females).who were selected randomly from the whole MBBS 1st year batch.

Pre and post exercise biochemical parameters (serum electrolytes Na^+ K^+ Mg^{++} Ca^{++}) along with ECG was done.

Detailed information was collected through careful history and physical examination.

After measurements the subjects were instructed to warm-up on the cycle ergometer for 5 minutes at a very light workload. At this time, the seat height was adjusted to the optimal height and comfort. The light warms up was followed up by 5 minutes of stretching, primarily emphasizing the torso and the lower extremities. The workload increased at the end of the 3 minute intervals (stages) until volitional fatigue. The target of the exercise was to achieve a heart rate 125-130 beats/ minute (severe exercise) and it was achieved in 10 to 15 minutes by doing the cycling without any extra load. The brink of exhaustion after 10 minutes of exercise was taken as end point of the exercise for that subject. 5ml of blood sample was drawn from anticubital vein of each subject before and after exercise, Simultaneously ECG was done, Serum was subjected to biochemical assay for estimation of serum electrolytes (Sodium, Potassium Magnesium, calcium). All these biochemical estimation would be done in department of pathology GSVM Medical College Kanpur.

The Electrocardiogram (ECG) records the changes in magnitude and direction of the electrical activity of the heart. The electrodes placed in standard positions on the body detect the electric current generated by depolarisation and repolarisation of the atria and ventricles. The voltages generated are amplified and recorded on ECG paper as waves and complexes. Statistical analysis of groups was compared by independent Student's t test. A two-tailed (α=2) p value less than 0.05 ($p<0.05$) was considered statistically significant. Analyses were performed on SPSS software (windows version 17.0).

Observations and Results

A total of 61.53% participants perform physical exercise as a routine. In which 34.61% were male participants and 26.92% were female.

Table 1: Various Parameters in Pre and Post Exercise Group

Exercise group		Mean±SD	p-Value
Sodium	Pre	141±3.10	<0.001
	Post	142±3.51	
Potassium	Pre	4.1±0.32	<0.001
	Post	4.15±0.29	
Magnesium	Pre	1.84±0.09	<0.001
	Post	1.87±0.10	
Calcium	Pre	4.58±0.23	<0.001
	Post	4.60±0.24	

A highly significant (p<0.001) difference was observed between pre and post exercise level of serum sodium, serum potassium, serum magnesium, serum calcium.

Table 2: Various Parameters in Pre and Post Exercise Group

Parameters			Mean±SD	p-Value
Heart Rate (beat per minute)		Pre	80.10±10.80	<0.001
		Post	104.10±12.54	
P wave	Voltage (mv)	Pre	0.14±0.04	<0.001
		Post	0.16±0.04	
	Duration (ms)	Pre	0.08±0.02	>0.05
		Post	0.11±0.13	
PR interval	Duration (ms)	Pre	0.14±0.02	NC
		Post	0.14±0.01	
QRS (complex)	Voltage (mv)	Pre	1.09±0.29	<0.05
		Post	1.14±0.32	
	Duration (ms)	Pre	0.10±0.13	>0.05
		Post	0.073±0.01	
ST segment	Voltage (mv)	Pre	0.01±0.04	<0.001
		Post	0.04±0.04	
	Duration (ms)	Pre	0.09±0.02	<0.001
		Post	0.09±0.02	
RR Intrerval	Duration (ms)	Pre	0.14±0.02	<0.001
		Post	0.10±0.07	
QR Interval	Duration (ms)	Pre	0.35±0.01	<0.001
		Post	0.32±0.01	
QTc Interval	Duration (ms)	Pre	0.41±0.01	<0.001
		Post	0.42±0.01	

The study which was conducted by us consisted of participants in the age group of 17-30 years of which maximum no of participants were the age group of less than 20 years where 28 male and 24 are females. The study is primarily enrolled young adults.

As per their habits majority of the participants (73.07%) were non vegetarian. The ratio of non vegetarians to vegetarians was 3:1 and dietry habits of both genders were in the ratio of 1:1. On distributing the participants on the basis of those involved in physical exercise, total of 61.53% performed physical exercise as a routine daily in which 36.61% were male and 26.92% were female.

Approximately 73.03% of participants who are having B.M.I. (Body Mass Index) in the optimal range while 9.6% were below and about 17.30% participants were having above normal value of B.M.I.

In our study highly significant (p<0.001) difference was observed between pre and post exercise levels of serum sodium, serum potassium, serum magnesium, serum calcium.

Evans J 1951[8] found in his study that p wave becomes taller after exercise this results is more significant in lead II and III the same result is observed in our study.

Holzman D et al 1952[9] studied about PR interval and said usually unaltered after exercise or slightly shortening of of PR intervals occurs which is supported our study also. The same author observed slight prolongation of the interval may occur where beginning of the p wave is indistinct at the rest.

The QTc interval in our study increases in both sexes which is similar to John Onimisi Ogedeube et al 2012 [6] where the QTc duration was higher in female than males.

Effects of exercise on PR intervals, QRS durations and QTC intervals in male and female students of University of Abuja John Onimisi Ogedengbe et al 2012[6] studied that QTc durations fell within the normal range, higher in the females both pre and post-exercise. An increase was recorded post-exercise in both sexes the increase in males was statistically significant (p-value <0.05). This result also supported our study.

Ted D. Adams et al [10] 2007 electrographic changes in athletes have been well described. Common findings

include sinus bradycardia, atrioventricular conduction disturbances, ST-T-wave changes, and voltage changes of ventricular hypertrophy. These ECG changes are believed to be the result of physiologic changes of the cardiovascular system caused by prolonged physical activity. Fewer studies that describe the serial changes in normal individuals undergoing exercise training have been reported.

Rautaharajuet et al 1999[11] found change in both magnitude and duration of P wave along with ST segment during submaximal exercise. The results of this study also correspond with our observations.

The biochemistry of runners in 1600 km ultra marathon study done by Fallon KE et al 1999[12] suggests prolonged exercise and increase in serum calcium. In our study highly significant increase in calcium and sodium levels are seen.

Nielson and Lukaski 2006 [7] update on relationship between magnesium and exercise states that during physical activity body magnesium stores shift transiently from the plasma into skeletal muscle and adipose tissue to increase energy production and adipose tissue to increase energy production and counteract oxidative stress. In our study significant changes in serum magnesium are seen.

Koc et al 2010 [13] determined in their study they conducted in order to make a comparison between blood electrolyte levels of athletes and sedentary university students that sodium and potassium levels were higher in athletes and this difference was significant, which does support our finding.

Conclusion

The serum sodium levels in both pre & post exercise group were within normal range but serum sodium is highly significant in post exercise group. The serum potassium levels in both pre & post exercise group were within normal range but serum potassium is highly significant in post exercise group. The serum magnesium levels in both pre & post exercise group were within normal range but serum magnesium is highly significant in post exercise group. The serum calcium levels in both pre & post exercise group were within normal range but serum calcium is highly significant in post exercise group. In the ECG the voltage of p wave QRS complex and ST segment shows highly significant/significant changes in pre and post exercise group. The duration of ST segment, RR interval, QT interval and QTc interval change highly significantly in the pre and post exercising group. PR interval is no change in either group.

Thus the findings of our study as above would be highly helpful in evaluating & estimating the serum electrolyte level the biochemical parameter and ECG changes in exercising young adults, but further study are still needed.

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