Analysis of Serum Electrolyte Concentration by Exercising on Treadmill Ergometer at different MET Levels

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Abstract

Objective: Physical exercise could lead to change in electrolyte concentrations and this could lead to adverse effect in the body. The effect of physical activity on serum electrolytes was investigated in the current study using treadmill workouts for the analysis sodium, potassium, and calcium electrolytes. To determine the effect of treadmill ergometer exercise on Serum Electrolytes Sodium, Potassium, and Calcium in undergraduate students in Peshawar KP.

Method: 20 students aged between 20-25 years were selected for the study. 5ml blood samples taken from the forearm antecubital vein into Gel barrier tubes and were analyzed by the autoanalyzer in the central laboratory for blood electrolyte levels. The samples for analysis were collected at pre-exercise and post-exercise stage for 5 MET and 10 MET from 10 participants in each group respectively. Post-Exercise blood Samples were collected within 10 minutes after the exercise. Results & Findings: Pre and Post exercise values of 5 MET protocol for Na⁺ mmol/L (Pre = 141.2560 ± 2.15497 & Post = 139.0550 ± 2.93401), K⁺ mmol/L (Pre = 4.3480 ± 0.27892 & Post = 4.1660 ± 2.93401) and Ca²⁺ mmol/L (Pre = 2.1160 ± 0.13023 & Post = 2.5110 ± 0.19439). Pre and Post exercise values of 10 MET protocol for Na⁺ mmol/L (Pre = 141.2560 ± 2.15497 & Post = 139.0550 ± 2.93401), K⁺ mmol/L (Pre = 4.3480 ± 0.27892 & Post = 3.9300 ± 0.19212) and Ca²⁺ mmol/L (Pre = 2.2620 ± 0.14062 & Post = 2.7340 ± 0.10426) were found. Conclusion & Recommendation: A very small increase in mean concentrations of serum electrolytes (Na⁺, and K⁺) and a significant increase in serum Ca²⁺ level was observed for 10 MET Protocol when compared with exercising condition of 5 MET Protocol. The findings of this work suggest that exercises of low intensity and speed are altering very slowly the serum electrolytes concentration while high intensity exercise can show significant changes in serum electrolytes level.

Keywords: Treadmill exercise, Serum Electrolytes, Non-Athlete Students.

Introduction

A metabolic equivalent (MET) is the ratio of active metabolic rate to resting metabolic rate. The metabolic rate is defined as the amount of energy expended per unit of time. It's one way to describe a workout's or activity's level of difficulty. The amount of energy you expend while sitting at rest is measured in METs, which is also known as your resting or basal metabolic rate. So, if you have a MET score of 4, you are consuming four times the amount of energy you would if you were sitting idle (Jette et al., 1990; Jette et al., 2005).
Exercises are defined as structured, planned, and repetitive physical activities that are performed with the purpose of conditioning the body. Exercises can help you enhance your physical fitness as well as your general health and well-being (Kylasov and Gavrov, 2011). Correct nutrition, exercise, hygiene, and rest are all important components of physical fitness. Exercising has a long list of health benefits. Stroke, hypertension, diabetes mellitus, colon and breast cancer, and obesity are all known to be reduced by regular exercise (Lakka, 2003). Physical activity improves the quality of life by enhancing respiratory and cardiovascular functions, increasing feelings of well-being, improving work performance, lowering anxiety, stress, and depression, and reducing total body fat (Chaudhery et al., 2010). It is unavoidable that we exercise in order to maintain a healthy lifestyle. It boosts self-esteem, improves mental wellness, and reduces depression. Physical activity is critical to optimal health, which must be understood by people who aspire to achieve and maintain a high quality of life. Numerous studies have discovered a link between physical activity, health, and a higher quality of life in a variety of ways (Ogihara et al., 2009). According to the recommended physical activity standards, all healthy adults between the ages of 18 to 65 should engage in moderate intensity aerobic exercise for 5 days a week at least 30 minutes daily (Riebe et al., 2018). Walking, jogging, running, cycling, swimming, and skating are examples of aerobic workouts. Treadmills, bicycle ergometers, elliptical trainers, stair climbing, and other types of indoor aerobic training are available (Wilmore and Knuttgen, 2003). The bicycle ergometer and treadmill activities are the most typical indoor aerobic exercises in today's hectic lifestyle. Treadmill exercise is comparable to walking and running, whereas an ergometer cycle is comparable to cycling. These gadgets are utilized not only for physical fitness maintenance, but also for exercise testing (Thompson and Fernandez, 2018). Exercise is the most frequent physiologic stress, and it places significant demands on the cardiovascular system (Thendral, 2016). Tough and strenuous physical workouts have a significant impact on human metabolism. Physical exertion causes reversible, and occasionally irreversible, changes in many homeostatic systems (Lippi, 2004). The positively and negatively charged chemicals termed ions found inside the cells and extracellular fluid compartment of blood are known as electrolytes. They convey nerve signals, contract muscles, keep the body hydrated, and maintain the body's pH levels. Electrolyte
disturbances can be damaging to one's health and can even be fatal in rare situations. As a result, prolonged exercise or exertion, especially in hot weather, can result in considerable electrolyte loss. The most frequently requested electrolytes for laboratory analysis are potassium, sodium, chloride, bicarbonate, calcium, and phosphate (Heisig et al., 2001; Gullotta and Bloom, 2003; Feng et al., 2005).

Physical activity has been shown to enhance bone mass, especially in load-bearing bone areas. This will almost always alter the blood calcium ion concentration, causing the blood electrolyte balance to be thrown off. PTH, the primary regulator of bone metabolism, works to keep the calcium ion concentration in extracellular fluids within physiological limits. PTH activity can be easily affected by both time and intensity. Blood calcium concentrations were also found to move in different ways (Linda et al., 2005).

Sodium is a key extracellular cation that plays a crucial function in bodily fluid transport. The usual sodium levels in the blood are 136-145 mmol, 10-40 mml in male sweat, and 40-220 mmol/day in urine. Sodium is required for fluid equilibrium, muscular contraction, and nerve reactions in the body. Sodium is also necessary for the proper functioning of bodily fluids and tissue electric potential (Crawford, 1951).

According to study, exercise causes a rise in blood sodium levels in hot and humid environments. This shows that water replenishment may be more important than sodium replacement under acute heat stress. Many long-distance endurance athletes have low sodium levels (hypernatremia), and they were recommended to drink as much water as possible while exercising to avoid dehydration. Maintaining plasma sodium levels during prolonged exercise may help to promote plasma volume stabilisation and reduce exercise-induced cardiovascular strain (Senay, 1968; Speedy et al., 1997; Noakes et al., 1990; Snyder et al., 1991; Convertino et al., 1996; Anastasiou et al., 2009; Winger, 2010).

Potassium, one of the major electrolytes found in the body's intracellular fluid and stored in muscle fibres alongside glycogen, is essential for glucose transport into muscle cells. Potassium is the most abundant cation (positively charged ion) found inside cells. Potassium's primary purpose is to maintain body fluid levels. Potassium aids in the growth and health of nerve cells through improving muscle control. This mineral also aids in the excretion of waste by the kidneys and has a crucial role in mental and physical activities (Maria, 2001). Normal potassium levels in serum are 1.5-3.5 mmol, 4-9.7 mmol in male sweat, 7.6-15.6 mmol in
female perspiration, and 25-125 mmol/day in urine (Kaplan et al., 1995). Potassium also helps nerve impulse conduction by interacting with salt and chloride to maintain fluid and electrolyte balances. Muscle cells lose potassium as glycogen is broken down to produce energy for activity. Potassium replacement after exercise is crucial since hyperkalemia can cause electrical impulse abnormalities and even death (Armstrong and Epstein, 1990; Rehrer et al., 1992; Armstrong et al., 1985). During cell activity, the regular equilibrium of electrolytes inside and outside the cell changes, allowing sodium ions to enter and potassium ions to escape. To restore to the initial condition of such imbalance, ingested energy and sodium ions are expelled from the cell, while potassium ions are reintroduced. In the presence of fluids, ions entering and leaving cells give cellular energy and eliminate waste (Maria, 2001).

A normal serum calcium level is 2-2.5 mmol/L. Exercise can lower serum ionized calcium (Ca$^{2+}$), raise parathyroid hormone (PTH), and trigger bone resorption (Kohrt et al., 2018). The hormone calcitonin is produced and released by the C-cells in the thyroid gland. It aids in calcium and phosphate regulation in the bloodstream. The release of calcitonin (CT hormone into the bloodstream is sensitive to changes in free ionized calcium (Ca$^{2+}$) levels in blood serum. (Brown, 1982; Kohrt et al., 2018). Some studies reported that Ca$^{2+}$ concentrations fell immediately after exercise in both nonathletic and athletic groups, but others found that Ca$^{2+}$ concentrations increased following various types of exercise. In theory, higher levels of calcitonin could reduce osteoclast-mediated bone resorption and lead to a more positive bone balance. PTH activates bone osteoblasts. Physical activity has been demonstrated to modify calcitonin and PTH serum and plasma concentrations. According to several researches, calcitonin levels remained unaltered after acute exercise, but PTH levels increased (Rong et al., 1997; Brown, 1982; Torring et al., 1985; Henderson et al., 1989; O'Neill et al., 1990; Cunningham et al., 1985; Salvesen et al., 1980; Lin and Hsieh, 2003).

The goal of this study is to see how different sets of treadmill activities affect particular serum electrolytes. This study also aims to quantify [Na$^{+}$], [K$^{+}$], and [Ca$^{2+}$] at room temperature for both the 5 MET and 10 MET procedures and compare them using statistical techniques. Because there has been little research on changes in blood sodium, potassium, and calcium concentrations as a result of varied treadmill protocols, the current study examines the changes in blood sodium, potassium, and calcium levels during interval and continuous aerobic workouts.
Aims and Objectives
To determine the effect of different set of treadmill exercises on serum electrolyte

Materials and Methods
Treadmill Ergometer: CYBEX® 770T BIOSIG INSTRUMENTS. INC. EMG/ECG Treadmill from Heart Rate Technology was used for the activity. For 5 MET and 10 MET Protocols Speeds of 5.3mph and 8.7mph with inclination of 2 respectively were planned.

Sample
This study was conducted during 5 days of the week done by the non-athletic students of Sarhad University of Science & Information Technology, Peshawar Pakistan. Twenty (20) students were selected randomly from BS degree program.

Inclusion Criteria
1. Only male students between the ages of 20 and 25 were enrolled.
2. Students must not have engaged in any physical activity in the previous three months.
3. There must be no history of medical sickness among the students.

Students must not have a history of long-term or recent prescription drug usage.

Ethical Approval: Permission for blood sample of the students was confirmed from their Parents/Guardian and students itself orally.

Estimation of Serum Sodium, Serum Potassium and Serum Calcium:
Microlab 300 Semi-automated Biochemistry Analyzer, Model of ELITECH from Netherlands and New Medica Easylyte Xpand Analyzer from Medica Corporation of USA were used for analysis of Electrolytes.
The serum concentrations of sodium, potassium and calcium were estimated using ion selective electrodes.

Samples of Pre-Exercise Blood
Pre-exercise blood samples were taken from anticubital veins in the sitting posture from all students 15 minutes before the workout. For further examination, all blood samples were carefully labelled and stored in well-sealed tubes.

Samples of Post-Exercise Blood
Within 10 minutes of the end of the exercise session, blood samples were taken.

Procedure
Each group consisting of 10 students were allowed to exercise for at least 45minutes with a 10
minutes break after each 15 minutes activity. They were allowed to use just normal routine food for eating and to take only 250mls of water during this exercising period. The samples were processed within 45 minutes of being collected. For serum separation, the blood samples were centrifuged at 3,000 revolutions per minute (RPM) for 10 minutes.

**Results & Discussion**

Results of analysis of serum electrolytes Na\(^+\), K\(^+\) and Ca\(^{2+}\) after performing treadmill activities of 5 MET and 10 MET protocol are shown in the following tables

### Table 1: Comparison of Pre & 5 MET Post-Exercise Sample regarding Na\(^+\) Values

<table>
<thead>
<tr>
<th>Electrolytes</th>
<th>Group</th>
<th>Mean</th>
<th>N</th>
<th>Std.</th>
<th>df</th>
<th>t</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na(^+)</td>
<td>Pre</td>
<td>141.260</td>
<td>10</td>
<td>2.15497</td>
<td>9</td>
<td>1.092</td>
<td>0.303</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>139.055</td>
<td>10</td>
<td>2.93401</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 shows the comparison of Pre & 5 MET Post-Exercise Sample regarding Na\(^+\) values. According to the analyzed data, the mean and standard deviation were recorded of pre and post group of Na\(^+\) mmol/L (Pre = 141.2560 ± 2.15497 & Post = 139.0550 ± 2.93401). Similarly, the P = values of Na\(^+\) = 0.303 which is greater than the standard value of 0.05 which confirm that no significant difference was found in 5 MET Post-Exercise Na\(^+\) values in comparison to Pre-Exercise values.

### Table 2: Comparison of Pre & 5 MET Post-Exercise Sample regarding K\(^+\) Values

<table>
<thead>
<tr>
<th>Electrolytes</th>
<th>Group</th>
<th>Mean</th>
<th>N</th>
<th>Std.</th>
<th>df</th>
<th>t</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>K(^+)</td>
<td>Pre</td>
<td>4.3480</td>
<td>10</td>
<td>.27892</td>
<td></td>
<td>1.57</td>
<td>.149</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>4.1660</td>
<td>10</td>
<td>.41506</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The above table illustrates the comparison of Pre & 5 MET Post-Exercise Sample regarding K\(^+\) values. According to the table, the mean and standard deviation were recorded of pre and post group of K\(^+\) mmol/L (Pre = 4.3480 ± 0.27892 & Post = 4.1660 ± 2.93401). Similarly, the P = values of K\(^+\) 0.149, greater than the standard value of 0.05 and confirm no significant difference for 5 MET Post-Exercise activity in serum K\(^+\) values.

### Table 3: Comparison of Pre & 5 MET Post-Exercise Sample regarding Ca\(^{2+}\) Values

<table>
<thead>
<tr>
<th>Electrolytes</th>
<th>Group</th>
<th>Mean</th>
<th>N</th>
<th>Std.</th>
<th>df</th>
<th>t</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca(^{2+})</td>
<td>Pre</td>
<td>2.1160</td>
<td>10</td>
<td>.13023</td>
<td></td>
<td>7.734</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>2.5110</td>
<td>10</td>
<td>.19439</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Paired sample t-Test shows the comparison of Pre & 5 MET Post-Exercise Sample regarding Ca\(^{2+}\) values. According to the table, the mean and standard deviation were recorded of pre and post group of Ca\(^{2+}\) mmol/L (Pre = 2.1160 ± 0.13023 & Post = 2.5110 ± 0.19439). Similarly, the P = values of Ca\(^{2+}\) 0.001 which is lesser than the standard value of 0.05, confirm a significant difference for 5 MET Post-Exercise regarding Ca\(^{2+}\) values showing an increase in the serum calcium concentration.

**Table 4: Comparison of Pre & 10 MET Post-Exercise Sample regarding Na\(^{+}\) Values**

<table>
<thead>
<tr>
<th>Electrolytes</th>
<th>Group</th>
<th>Mean</th>
<th>N</th>
<th>Std.</th>
<th>df</th>
<th>t</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na(^{+})</td>
<td>Pre</td>
<td>141.2560</td>
<td>10</td>
<td>2.15497</td>
<td>9</td>
<td>10.690</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>138.2570</td>
<td>10</td>
<td>2.09261</td>
<td>9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4 shows the comparison of Pre & 10 MET Post-Exercise Sample regarding Na\(^{+}\) Values. According to the analyzed data, the mean and standard deviation were recorded of pre and post group of Na\(^{+}\) mmol/L (Pre = 141.2560 ± 2.15497 & Post = 139.0550 ± 2.93401). Similarly, the P = values of Na\(^{+}\) 0.000 which is lesser than the standard value of 0.05. There is significant difference was found in 10 MET Post-Exercise regarding Na\(^{+}\) Values. It means that there was decreasing in the sodium concentration which was recorded.

**Table 5: Comparison of Pre & 10 MET Post-Exercise Sample regarding K\(^{+}\) values**

<table>
<thead>
<tr>
<th>Electrolytes</th>
<th>Group</th>
<th>Mean</th>
<th>N</th>
<th>Std.</th>
<th>df</th>
<th>t</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>K(^{+})</td>
<td>Pre</td>
<td>4.3480</td>
<td>10</td>
<td>0.27892</td>
<td>9</td>
<td>7.543</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>3.9300</td>
<td>10</td>
<td>0.19212</td>
<td>9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The above table 5 illustrates the comparison of Pre & 10 MET Post-Exercise Sample regarding K\(^{+}\) Values. The results show the mean and standard deviation were recorded of pre and post group of K\(^{+}\) mmol/L (Pre = 4.3480 ± 0.27892 & Post = 3.9300 ± 0.19212). Likewise, the P = values of Na\(^{+}\) 0.000 which is lesser than the standard value of 0.05. There is significant difference was found in 10 MET Post-Exercise regarding K\(^{+}\) Values. It means that there was decreasing in the Potassium concentration which was receded.

**Table 6: Comparison of Pre & 10 MET Post-Exercise Sample regarding Ca\(^{2+}\) values**

<table>
<thead>
<tr>
<th>Electrolytes</th>
<th>Group</th>
<th>Mean</th>
<th>N</th>
<th>Std.</th>
<th>df</th>
<th>t</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca(^{2+})</td>
<td>Pre</td>
<td>2.2620</td>
<td>10</td>
<td>0.14062</td>
<td>9</td>
<td>25.699</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>2.7340</td>
<td>10</td>
<td>0.10426</td>
<td>9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table 6 demonstrates the comparison of Pre & 10 MET Post-Exercise Sample regarding
Ca\(^+\) Values. According to the table, the mean and standard deviation were recorded of pre and post group of Ca\(^{2+}\) mmol/L (Pre = 2.2620 ± 0.14062 & Post = 2.7340 ± 0.10426). Similarly, the P = values of Ca\(^{2+}\) .000 which is lesser than the standard value of 0.05. There is significant difference was found in 10 MET Post-Exercise regarding Ca\(^{2+}\) values.

As sweat is generated to promote heat escape, 10 MET (Speed = 8.7mph at inclination = 2) protocol exercise causes a progressive loss of water and electrolytes from the body. The loss of sodium in sweat during exercise can be ascribed to the decrease in serum sodium level during exercise. The small decrease in serum potassium could be related to the fact that the length of the exercise was linked to perspiration. Similar findings were also observed by other authors (Senay, 1968; Speedy et al., 1997; Noakes et al., 1990; Snyder et al., 1991; Convertino et al., 1996; Anastasiou et al., 2009; Winger, 2010; Olisah and Nicholate, 2021; Sanders et al., 2001; Emenike et al., 2014; Speedy et al., 1997; Noakes, 2002; Pala, 2013; Erdemir, 2013).

Ninety percent of the potassium in the body is intercellular, with 70-75 percent of this quantity found in skeletal muscle cells, and the sodium potassium pump maintains the concentration gradient. During a workout, potassium quickly departs muscle cells and can potentially create hyperkalemia depending on the intensity of the exercise, resulting in increased urine potassium after completing continuous/interval exercise (Mottaghi et al., 2016; Maughan and Shirreffs, 2008).

Calcium level in serum increased significantly during present study using 10 MET protocols may be attributed to high intensity of exercise. Similar results were also confirmed by other authors (Townsend et al., 2016; Mathis et al., 2020; Kohrt et al., 2018; Brown, 1982; Torring et al., 1985).

**Conclusion**

It is consequently critical that persons engaging in intense physical exercise, particularly extended exercise, consume as much fluid as possible, particularly water and electrolyte replacement. Changes in serum electrolyte concentration are always a major problem whether they are either too high or too low, and can result in abrupt death. When the 10 MET Protocols was compared to the 5 MET Protocol exercising condition, there was a very minor rise in mean blood electrolyte concentrations (Na\(^+\) and K\(^+\)) and a considerable increase in serum Ca\(^{2+}\)
level. The findings of this study imply that low-intensity and fast-paced activities modify serum electrolytes concentrations very slowly, but high-intensity exercise causes large changes in serum electrolytes levels. Some key recommendations are as under:

✓ With the help of a treadmill one can burn your extra calories easily, but only if the treadmill is used in the manner prescribed by a professional trainer.

✓ Treadmill may be used only after warming up the body to get maximum benefits and to not disturb biochemistry of blood.

✓ For Cardio workout at the treadmill may be used in a way that there should be no stress on the joints, bones and muscles.

✓ By using treadmill without guidance of a professional trainer can cause pressure or stress on the joints and bones and can leads to injuries

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