**ISSN** 1750-9823 (print)
**International Journal of Sports Science and Engineering**
Vol. 03 (2009) No. 02, pp. 073-076

# Plasma Biochemical Changes During Moderate and Vigorous Exercises

K.S.Adedapo[1], O.M.Akinosun[1], G.O.Arinola[1, +], Bola Odekunle Odegbemi[2], O.I.Adedeji[2]

[1]Department of Chemical Pathology, University Teaching Hospital, Ibadan, Nigeria

[2]Department of Biomedical Sciences, Faculty of Basic Medical Sciences, Ladoke Akintola University of Technology, Ogbomoso, Nigeria

(*Received February 12, 2009, accepted April 5, 2009*)

**Abstract.** Physical exercise is beneficial at all ages but the biochemical basis of this is not completely known. Liver function tests, renal function tests, plasma lipid profiles and plasma glucose concentration were determined in 50 sedentary Nigerians, 50 Nigerians on moderate-exercise and 50 Nigerians on vigorous-exercise. The levels of aspartate transaminase (AST), total protein (TP), albumin, urea and high density lipoprotein-cholesterol (HDL-C) were significantly elevated while the levels of $Na^+$, $K^+$, cholesterol (TC), triglycerides (TG), low density lipoprotein-cholesterol (LDL-C) and glucose were significantly reduced in vigorous exercising subjects compared with the controls. The level of AST was significantly increased while the levels of plasma TC, LDL-C and glucose were significantly reduced in moderate exercising subjects compared with the controls. This study shows that the influence of exercise on blood biochemistry is related to the duration of the activity; and that vigorous exercise should be performed with caution.

**Keywords:** Electrolytes, physical activity, organ functions, lipids

## 1. Introduction:

Physical exercise is bodily activity that develops or maintains physical fitness and overall health (1). It is often practiced to strengthen muscles and to optimize athletic skills. Exercise has multiple beneficial effects on human body such as increasing threshold for pain, reducing high blood pressure, preventing obesity, heart disease, and type 2 diabetes mellitus (2, 3, 4). Regular exercise decreases the risk for certain cancers (prostate, lung, colon cancers), and improves cognitive functioning (3). It has been shown to be neuro-protective in many neurodegenerative and neuromuscular diseases (4, 5, 6). Exercise boosts the immune system by increasing the levels of interleukin 1 and interferons (7, 8). Exercise also decreases stress, anxiety, and depression by increasing oxygen supply to brain tissue and by increasing dopamine, serotonin, nor-epinephrine and acetylcholine (3).

Excessive exercise damages the muscle (rhabdomyolysis) and regular exercise without proper rest increases the chance of stroke or circulatory problems (7, 8, 9). Some studies have shown that vigorous exercise executed by healthy individuals can effectively increase opioid peptides and positively influence the production of testosterone and growth hormone (8). Reasons given by previous authors to explain the observed effects of exercises were mainly based on chemical messengers such as hormones and cytokines (7, 8). The present study is designed to provide additional information on biochemical indices during moderate and vigorous exercise.

## 2. Materials and Methods:

A total of 150 male Nigerian subjects were considered for this study. They were divided into three groups of physical activity based on the definition of Kern (10); viz: sedentary (engaging in very little exercise), moderate exercise (playing football for 15 minutes) and vigorous exercise (15 minutes of vigorous and continuous jogging). They aged between 25- 48 years (35.4±9.5 yrs). Inform consents were obtained from each subject before sample collection and ethical approval was obtained from Institution Ethical Review Committee before the commencement of the study. Ten (10ml) of blood were obtained by

[+] Corresponding author. G O Arinola. *E-mail address*: drarinolaog64@yahoo.com.

venepuncture and put into bottles containing appropriate anticoagulant. The plasma obtained was used for the analysis of blood biochemistry using chemistry auto-analyser. The results were presented in mean ± standard deviation. The differences between the means were determined using Student's t-test. P-value less than 0.05 was considered significant.

## 3. Results

The levels of AST, total protein, albumin (Table 1), creatinine and urea (Table 2) were significantly elevated while $Na^+$ and $K^+$ (Table 2) were significantly reduced in vigorous exercising subjects when compared with the controls. Only AST was significantly increased in moderate exercising subjects when compared with controls (Table 1). Also in Table 1, the levels of AST, ALT, ALP, albumin, total proteins, conjugated bilirubin and total bilirubin were not significantly different in moderate exercising subjects compared with the vigorous exercising subjects. Urea and creatinine were significantly increased while $Na^+$ and $K^+$ were significantly reduced in subjects on vigorous exercise compared with those on moderate exercise (Table 2).

In Table 3, the levels of TC, LDL-C and glucose were significantly reduced in subjects that engaged in moderate or vigorous exercise compared with the controls. Moreso, the levels of TC and LDL-C were significantly reduced in subjects on vigorous exercise compared with those on moderate exercises. HDL-C was significantly increased in subjects on vigorous exercise compared with controls or subjects with moderate exercise. TG was significantly reduced in subjects with vigorous exercise compared with controls.

Table 1 Liver function tests in sedentary Nigerians and those that engaged in moderate or vigorous exercise.

| | ALT (U/L) | AST (U/L) | ALP (U/L) | TP (g/L) | Alb (g/L) | Tot. Bil (umol/L) | Conj. Bil (umol/L) |
|---|---|---|---|---|---|---|---|
| Control | 9.8±1.2 | 9.1±2.22 | 85.4±4.4 | 61±4.5 | 41±2.9 | 15.0±1.9 | 3.2±1.1 |
| Moderate | 9.2±2.9 | 12.1±2.0 | 85.5±6.0 | 62±5.6 | 42±2.8 | 14.7±1.9 | 3.0±1.1 |
| Vigorous | 9.4±2.0 | 14.2±2.3 | 86±7.2 | 69±5.6 | 45±3.2 | 14.4±2.0 | 2.9±1.1 |
| T, p[a] | 0.74,0.46 | 4.4,0.00 | 0.22,0.52 | 0.71,0.5 | 0.34,0.84 | 0.05,0.62 | 0.74,0.46 |
| T, p[b] | 0.61,0.55 | 7.2,0.00 | 0.34,0.53 | 4.6,0.00 | 4.4,0.00 | 1.69,1.24 | 0.84,0.37 |
| T, p[c] | 2.55,0.80 | 0.3,0.60 | 0.62,0.54 | 1.9,1.30 | 0.34,0.25 | 0.58,0.59 | 0.15,0.77 |

[a]Control compared with moderate exercise

[b]Control compared vigorous exercise

[c]Moderate compared with vigorous exercise

Table 2 Kidney function tests in sedentary Nigerians and those that engaged in moderate or vigorous exercise.

| | Urea (mMol/L) | Creatinine (umol/L) | Sodium (mMol/L) | Potassium (mMol/L) |
|---|---|---|---|---|
| Control | 4.5±0.4 | 73.5±6.17 | 136±4.17 | 3.0±0.39 |
| Moderate | 4.6±1.1 | 73.9±7.36 | 130±6.43 | 2.9±0.50 |
| Vigorous | 5.9±1.0 | 87.6±14.1 | 127±5.48 | 2.4±0.3 |
| T, p[a] | 0.44, 0.71 | 0.19, 0.61 | 1.75, 0.84 | 1.07, 0.88 |
| T, p[b] | 8.76, 0.00 | 6.48, 0.00 | 5.81, 0.00 | 5.45, 0.00 |
| T, p[c] | 4.16, 0.00 | 3.95, 0.00 | 3.51, 0.00 | 3.52, 0.00 |

[a]Control compared with moderate exercise

[b]Control compared vigorous exercise

[c]Moderate compared with vigorous exercise

Table 3 Lipid profiles and plasma glucose in sedentary Nigerians and those that engaged in moderate or vigorous exercise.

| | TC (mMol/L) | TG (mMol/L) | HDL-C (mMol/L) | LDL-C (mMol/L) | Glucose (mMol/L) |
|---|---|---|---|---|---|
| Control | 4.7±0.9 | 1.9±0.4 | 1.1±0.2 | 2.6±0.5 | 2.8±0.5 |
| Moderate | 3.5±0.5 | 1.7±0.3 | 1.2±0.2 | 1.6±0.4 | 2.2±0.3 |
| Vigorous | 2.9±0.3 | 1.6±0.2 | 1.6±0.2 | 0.7±0.4 | 2.4±0.3 |
| T, p[a] | 4.62, 0.00 | 1.80, 0.17 | 1.63, 0.11 | 6.97, 0.00 | 4.77, 0.00 |
| T, p[b] | 8.77, 0.00 | 3.00, 0.00 | 3.23, 0.00 | 14.00, 0.00 | 4.00, 0.00 |
| T, p[c] | 3.76, 0.00 | 1.24, 0.08 | 4.75, 0.00 | 7.99, 0.00 | 2.20, 0.08 |

[a]Control compared with moderate exercise

[b]Control compared vigorous exercise

[c]Moderate compared with vigorous exercise

## 4. Discussion:

The benefit of exercise in preventing disease and decreasing the worsening symptoms of certain diseases has been a concern. Regular exercise increases energy level, decreases stress on the liver and delays the onset of certain complications associated with liver disease (11, 12). During moderate exercise, glucose uptake by the working muscle rises 7 to 20 times over the basal levels (1). This exercise induced glucose utilization without appropriate increase in endogenous glucose production coupled with delayed hepatic glucose production might explain significantly reduced levels of glucose in our exercising subjects. However, intense exercise provokes the release of insulin-counter regulatory hormones such as glucagon and catecholamines which ultimately cause a reduction in insulin action (1). Thus, explaining the observed increase in plasma glucose of our vigorous exercising subjects compared with moderate exercising subjects.

The findings of decreased TC, TG and LDL-C in our test groups (especially during vigorous exercises) might be due to increased mitochondrial activity. The decreases in the plasma levels of TC, TG, and LDL-C might indicate that cholesterol was transported from peripheral tissues to the liver for degradation during exercises. The implication of decreased LDL-C and increased HDL-C in our test subjects stress the protective effect of exercises against cardiovascular disease and other related ailments.

The present study shows that AST was significantly reduced in controls compared with test subjects. This observation might be related to the fact that during exercise skeletal muscle cells are not producing ATP in proportion to the rate of consumption. Reduction in ATP increased cellular permeability which leads to slight increase in plasma AST activity originating from skeletal muscle cells. Increased plasma creatinine in our exercising subjects might be a result of increased phosphorylation of creatine in muscles under the influence of creatine kinase to phosphocreatine which was subsequently and spontaneously converted to creatinine. Dehydration is higher during vigorous exercise compared with mild exercise or resting state (15, 16). This explained raised level of albumin, and total protein during prolonged exercise as compared to the controls could be related to dehydration. Albumin, the most abundant plasma protein, is an important extra cellular antioxidant regulating glutathione levels in lungs epithelial cells. Albumin is a metal-binding protein shown to possess free radical scavenging properties, and may thus be selective antioxidants. Therefore, significantly raised albumin in prolonged exercising subject is important as it may scavenge reactive oxygen species which are raised during exercises (4, 13, 14).

Furthermore, the level of urea in vigorous exercising subjects was significantly higher than in moderate exercising subjects or control subjects. This is however in consonance with the fact that the rate of urea reabsorption is dependent on a person's state of hydration. Dehydration during vigorous exercise causes renal vasoconstriction and redistribution of blood such that there is a decrease in glomerular filtration rate with resultant decrease in urine flow and thereby, causing increased passive tubular reabsorption of urea.

The significantly low levels of $Na^+$ and $K^+$ in vigorous exercising subjects when compared with moderate exercising subjects and control subjects were observed in this study. This observation might have arisen from profuse sweating which is typical of prolonged exercise. $Na^+$ and $K^+$ are lost during sweating and as such the levels of these electrolytes are reduced. In this condition, plasma osmolality is also reduced due to loss of $Na^+$ through sweat. Electrolyte imbalance might be aggravated by vigorous exercise, because fall in ATP production that follows strenuous exercise affects $Na^+$-$K^+$ ATP dependent pump that moves $Na^+$ out of cells and $K^+$ into cells (13, 15). Thus, the claim by some health experts (16) that too much exercise without adequate rest increases the chance of stroke and other circulatory problems might be due to derangement of electrolyte homeostasis.

In summary, it was evident from this study that:

(i) Both moderate and vigorous exercises significantly reduced plasma glucose, LDL-C and TC but significantly increased AST. While vigorous exercise significantly reduced $Na^+$ and $K^+$ but significantly increased urea and creatinine.

(ii) During exercise (especially vigorous exercise), there was evidence of skeletal muscle breakdown (as shown by increases in creatinine, AST and ALT) and of dehydration (as shown by elevation of total protein, urea and cholesterol). It may therefore be concluded that vigorous exercise should be performed with caution.

## 5. References:

[1] Zdrenghea D, Poantă L, Pop D, Zdrenghea V, Zdrenghea M. Physical training--beyond increasing exercise capacity. *Rom J. Intern. Med.*. 2008, **46**(1):17-27.

[2] Kawano M, Shono N, Yoshimura T, Yamaguchi M, Hirano T, Hisatomi A. Improved cardio-respiratory fitness correlates with changes in the number and size of small dense LDL: randomized controlled trial with exercise training and dietary instruction. *Intern Med*.. 2009, **48**(1): 25-32. .

[3] De Matos MG, Calmeiro L, Da Fonseca D. *Effect of physical activity on anxiety and depression.* Presse Med. 2009. **8**: 8-12.

[4] Malatesta D, Werlen C, Bulfaro S, Chenevière X, Borrani F. Effect of high-intensity interval exercise on lipid oxidation during postexercise recovery. *Med Sci Sports Exerc.* 2009, **41**(2): 364-374.

[5] Jacobs DR Jr, Sluik D, Rokling-Andersen MH, Anderssen SA, Drevon CA. Association of 1-y changes in diet pattern with cardiovascular disease risk factors and adipokines: results from the 1-y randomized Oslo Diet and Exercise Study. *Am. J. Clin Nutr.*. 2009, **89**(2): 509-517.

[6] Weinberger M, Abu-Hasan M. Perceptions and pathophysiology of dyspnea and exercise intolerance. Pediatr Clin North Am.. 2009, **56**(1): 33-48.

[7] Lewis SJ. Prevention and treatment of atherosclerosis: a practitioner's guide for 2008. *Am. J. Med.*. 2009, **122**(1 Suppl): S38-50.

[8] Ueda SY, Yoshikawa T, Katsura Y, Usui T, Nakao H, Fujimoto S.J. Changes in gut hormone levels and negative energy balance during aerobic exercise in obese young males. *Endocrinol*. 2009, 21.

[9] Manson, J.E, Hu FB, Rich-Edwards JW. A prospective study of walking as compared with vigorous exercise in the prevention of coronary heart disease in women. *New England Journal of Medicine*. 1999, **341**: 650-658.

[10] Kern L. The influence of vigorous versus mild exercise on autistic stereotyped behaviors. *Journal of Autism and Developmental Disorders.* 1984, **14**(1): 57-67.

[11] Rafiq N, Younossi ZM. Effects of weight loss on nonalcoholic fatty liver disease. *Seminar Liver Dis.* 2008, **28**(4): 427-433.

[12] Zelber-Sagi S, Nitzan-Kaluski D, Goldsmith R, Webb M, Zvibel I, Goldiner I, Blendis L, Halpern Z, Oren R. Role of leisure-time physical activity in nonalcoholic fatty liver disease: a population-based study. *Hepatology*. 2008, **48**(6): 1791-1798.

[13] Brzeszczynska J, Pieniazek A, Gwozdzinski L, Gwozdzinski K, Jegier A. Structural alterations of erythrocyte membrane components induced by exhaustive exercise. *Appl. Physiol Nutr. Metab*. 2008, **33**(6): 1223-1231.

[14] Malatesta D, Werlen C, Bulfaro S, Chenevière X, Borrani F. Effect of high-intensity interval exercise on lipid oxidation during postexercise recovery. *Med. Sci. Sports Exerc.*. 2009, **41**(2): 364-374.

[15] Bai Y, Sigala W, Adams GR, Vaziri ND.Effect of Exercise on Cardiac Tissue Oxidative and Inflammatory Mediators in Chronic Kidney Disease. *Am J. Nephrol*. 2008, 17, **29**(3):213-221.

[16] Mayo Clin Women's Healthsource. Weight-loss programs. What to know about popular diets, eating plans. *Mayo Clin Women's Healthsource*. 2008, Suppl:1-8.