Section: Physiology

Original Research Article

EFFECTS OF AEROBIC TRAINING ON SKELETAL MUSCLE BIOMARKERS- A PROSPECTIVE OBSERVATIONAL STUDY IN SOUTH INDIA

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Abstract

Background: Exercise induced metabolic changes can alter the serum concentrations of numerous laboratory parameters. Increases in serum enzymes such as creatinine kinase and lactate dehydrogenase serve as markers of acute or chronic muscle damage and cell necrosis. In this study the various metabolic markers like lactate dehydrogenase (LDH), creatine kinase (CK) were measured to assess the changes in these parameters following aerobic exercise for a period of 8 weeks. **Objectives:** The objectives were to study the effects of 8 weeks aerobic training on metabolic markers Lactate dehydrogenase (LDH) and Creatine kinase (CK) and to compare the effects of aerobic exercise (treadmill running and ergometer cycling) on metabolic markers between the study group and the control group between pre- test (baseline) and post- test for each group. **Material & Methods:** A prospective observational study was performed on 80 normal healthy subjects during a period of 1 year after obtaining ethical clearance and informed consent. Among the eighty participants forty were control group and forty were study group. Subjects were divided into three groups, Group A - Control Group, Group B - Treadmill group and Group C - Ergometer Cycle group. Blood samples were collected for analysis of the metabolic markers LDH and CK, both before and after 8 weeks of the training program for all the groups. Data was entered in MS Excel and analyzed using SPSS version 25. Descriptive statistics and inferential statistics such as independent t test, paired t test and ANOVA were used. **Results:** Among the control group, the mean LDH levels in pretest was 333.95 ± 40.34 and in post test was 336.88 ± 37.79. which was not statistically significant. Among the treadmill group, the mean LDH levels in pretest was 317.56 ± 38.27 and in post test was 458.24 ± 53.03 which was statistically significant ($p < 0.05$). Among the cycle group, the mean LDH levels in pretest was 328.79 ± 47.74 and in post test was 404.79 ± 51.26 which was statistically significant ($p < 0.05$). Among the control group, the mean CK levels in pretest was 51.54 ± 7.42 and in post test was 53.32 ± 7.91 which was not statistically significant. Among the treadmill group, the mean CK levels in pretest was 50.55 ± 8.70 and in post test was 69.53 ± 11.39 which was statistically significant ($p < 0.05$). Among the cycle group, the mean CK levels in pretest was 54.03 ± 11.04 and in post test was 60.32 ± 11.89 which was statistically significant ($p < 0.05$). **Conclusion:** There is an increase in metabolic markers like LDH and CK following eight weeks of moderate intensity aerobic exercise training which was statistically significant. An increase in these parameters in a normal healthy individual must be interpreted with his routine exercise pattern before making any pathological diagnosis like myopathy, myocardial infarction, acute hepatic or renal failure.

INTRODUCTION

Exercise is a bodily activity in which energy stored as chemical compound is transformed into mechanical and heat energy.[1] Frequent and regular physical exercise boosts the immune system and helps to prevent the disease of affluence such as heart disease, cardiovascular disease, type 2 diabetes and obesity.[2] Endurance exercise induces cellular changes within the body, bringing about changes in the muscle, cartilage, heart, liver and kidneys.

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Physical exercise may affect the blood-based biomarkers.[3]

Regular physical activity enhances body's fuel utilization by adapting its metabolism to increased energy expenditure.4 Exercise induced metabolic changes can alter the serum concentrations of numerous laboratory parameters. Exercise causes micro injuries in the skeletal muscle.[5] Changes in serum levels of muscular enzymes are found in normal subjects after strenuous exercise. The amount of enzyme release from muscle tissue into blood is influenced by physical exercise.[6]

Increases in serum enzymes such as creatinine kinase and lactate dehydrogenase serve as markers of acute or chronic muscle damage and cell necrosis.[7] Alanine transaminase and Aspartate transaminase are markers of liver disease and increases in AST, ALT and LDH after long distance running like marathon induces chronic liver injury. Temporary elevations of liver enzymes are seen during and immediately after a routine exercise program.[8]

In this study the various metabolic markers like lactate dehydrogenase (LDH), creatine kinase (CK) were measured to assess the changes in these parameters following aerobic exercise for a period of 8 weeks as it is important that clinicians and sports physicians must know the changes in muscle metabolism following exercise as disclosed through common laboratory parameters measured in clinical laboratory. The measurement of serum enzymes in active healthy population helps to identify subclinical myopathies which may predispose to the development of acute renal failure or heat stroke during prolonged exercise.

Very few studies are available in India to study the effects of 8 weeks aerobic training on metabolic markers. Hence, this study was carried out to study the effects of 8 weeks aerobic training on metabolic markers like LDH and CK.

Objectives

The aim of the study was to investigate the effects of 8 weeks aerobic training (tread mill running and ergometer cycling) on metabolic markers. The primary objectives were to study the effects of 8 weeks aerobic training on metabolic markers Lactate dehydrogenase (LDH) and Creatine kinase (CK) and to compare the effects of aerobic exercise (treadmill running and ergometer cycling) on metabolic markers between the study group and the control group between pre- test (baseline) and post-test for each group. Secondary objective was to compare the treadmill and the ergometer cycle, to identify the influence of these instruments in causing changes in metabolic markers.

MATERIALS AND METHODS

A prospective observational study was conducted in a tertiary care hospital in South India. The study period was for a period of one year. Healthy Participants of age 20–40 years of both sexes who are untrained in any exercise program were included. Participants with Diabetes mellitus, hypertension, hyperlipidemia, bony deformities, neurological disorders and pulmonary illness were excluded. Those who did not give consent were also excluded from the study.

80 normal healthy subjects of both sexes were selected. The age group of the individuals were between 20 – 40 years. Among the eighty participants forty were control group and forty were study group. Subjects were divided into three groups, Group A - Control Group, Group B - Treadmill group and Group C - Ergometer Cycle group. The control group – Group A which included 40 participants (20 were males, 20 were females). The study group (Aerobic training group) included 40 participants and was divided into two groups. Group B – Treadmill group which included 20 participants (10 were males, 10 were females) who underwent treadmill running. Group C – Ergometer bicycle group which included 20 participants (10 were males, 10 were females) who underwent cycling. Pre-test and Post-test metabolic markers of control group (n=40) and aerobic training group (Group B - Treadmill group and Group C - Ergometer Cycle group) (n=40) were compared. Similarly, Pre-test and Post-test metabolic markers of Treadmill group (n=20) and Ergometer cycle group (n=20) were also compared. The mean difference between Pre and Post- tests of Treadmill, Ergometer bicycle and control groups respectively were compared.

Ethical clearance was obtained from the Institutional Ethical Committee. An informed written consent was obtained from all the participants. The details were collected in a pretested semi structured interviewer administered questionnaire.

For treadmill group participants, walking one hour per day, three days in a week on alternate days for eight weeks. For cycle group subjects, 60 to 70 revolutions per minute (RPM), forth resistance in tension adjuster, for 15 minutes, three days in a week on alternate days for eight weeks. These two protocols were qualified for the moderate exercise intensity as per WHO guidelines and AHA guidelines.

All the participants were asked to follow their routine diet regimen and there were no restrictions of diet. All of them were given a brief knowledge about the exercise program and assured them that there is nothing harm in doing treadmill running and cycling. In order to avoid anxiety and to get accustomed to the environment and the training the program with treadmill and bicycle the participants were given preliminary training. The participants were asked to attend the department from 10 am to 12 noon for the aerobic training and also to come without taking any food items one hour prior to the training program. The subjects after arriving at the department were asked to relax for about 10–15 minutes. Blood pressure was recorded in the sitting

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posture in the left arm using mercury sphygmomanometer. Resting heart rate was counted by palpating the left radial artery in mid-prone position of forearm for one minute.

Aerobic training using treadmill was given for 3 days in a week on alternate days for 8 consecutive weeks. In our study initial warm-up was done on treadmill itself for 10 minutes followed by which walking was done for one hour with the speed gradually increased from1.1km/hr to 3.2 to 3.5 km/hr. This is followed by 10 minutes cool down with light stretching exercises. During exercise, heart rate and oxygen saturation was monitored using pulse-oximeter.

Aerobic training using ergometer bicycle was given for 3 days in a week on alternate days for 8 consecutive weeks. In our study initial warm-up was done for 5 minutes with pedalling speed of 30-40 revolutions per minute (RPM) with grade 1 resistance. After that the pedalling was gradually increased to 60 to 70 RPM with resistance also increased from 1 to 4 in the tension adjuster.

Blood samples were collected for analysis of the metabolic markers LDH and CK, both before and after 8 weeks of the training program for the study participants. Blood samples were also collected before and after 8 weeks for control group.

The data was entered in MS Excel and was analysed using SPSS version 24. Descriptive statistics such as frequencies and proportions were used and inferential statistics such as independent t test and paired t test were used. P value < 0.05 was considered significant. Data were expressed in tables and charts wherever necessary.

RESULTS

Among the study participants, the mean LDH levels in pretest among control group was 333.95 ± 40.34 and in study group was 323.17 ± 43.08. This difference was not statistically significant. The mean CK levels in pretest among control group was 51.54 ± 7.42 and in study group was 52.29 ± 9.97. This difference was not statistically significant. [Table 1]

Among the study participants, the mean LDH levels in post test among control group was 336.88 ± 37.79 and in study group was 431.51 ± 58.16. This difference was statistically significant by independent t test ($p < 0.05$). The mean CK levels in post test among control group was 53.32± 7.91 and in study group was 64.93 ± 12.40. This difference was statistically significant by independent t test ($p < 0.05$). [Tables 2]

Among the study group, the mean LDH levels in pretest was 323.17.95 ± 43.08 and in post test was 431.51 ± 58.16. This difference was statistically significant by paired t test ($p < 0.05$). Among the study group, the mean CK levels in pretest was 52.29 ± 9.97 and in post test was 64.93 ± 12.4. This difference was statistically significant by paired t test ($p < 0.05$). [Table 3]

Among the control group, the mean LDH levels in pretest was 333.95 ± 40.34 and in post test was 336.88 ± 37.79. This difference was not statistically significant by paired t test. Among the treadmill group, the mean LDH levels in pretest was 317.56 ± 38.27 and in post test was 458.24 ± 53.03. This difference was statistically significant by paired t test ($p < 0.05$). Among the cycle group, the mean LDH levels in pretest was 328.79 ± 47.74 and in post test was 404.79 ± 51.26. This difference was statistically significant by paired t test ($p < 0.05$). [Table 4] [Figure 1]

Among the control group, the mean CK levels in pretest was 51.54 ± 7.42 and in post test was 53.32 ± 7.91. This difference was not statistically significant by paired t test. Among the treadmill group, the mean CK levels in pretest was 50.55 ± 8.70 and in post test was69.53 ± 11.39. This difference was statistically significant by paired t test ($p < 0.05$). Among the cycle group, the mean CK levels in pretest was 54.03 ± 11.04 and in post test was 60.32 ± 11.89. This difference was statistically significant by paired t test ($p < 0.05$). [Table 4] [Figure 2]

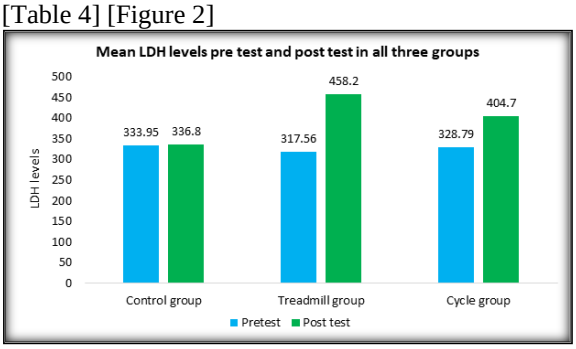

Figure 1: Mean LDL levels pre test and post test in all three groups

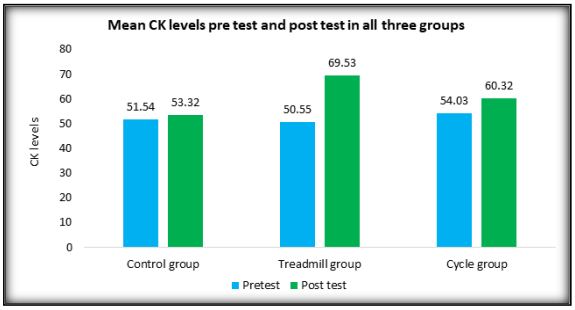

Figure 2: Mean CK levels pre test and post test in all three groups

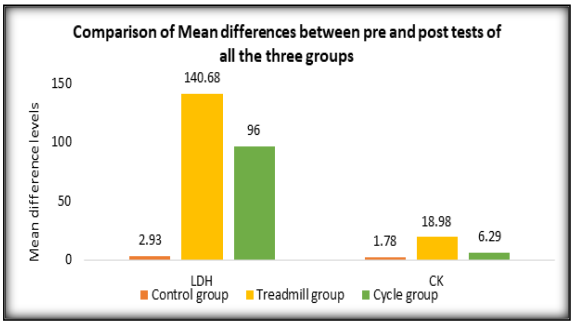

Figure 3: Comparison of Mean differences between pre and post tests of all the three groups

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For LDH, the mean difference between pre and post tests among control group was 2.93 ± 2.55, among treadmill group was 140.68 ± 14.76 and among cycle group was 96.00 ± 3.52. This difference was statistically significant by ANOVA test. ($p < 0.05$). [Table 5] [Figure 3]

For CK, the mean difference between pre and post tests among control group was 1.78 ± 0.49, among treadmill group was 18.98 ± 2.69 and among cycle group was 6.29 ± 0.85. This difference was statistically significant by ANOVA test. ($p < 0.05$). [Table 5] [Figure 3]

Table 1: Comparison of pre-tests of control (A) and study group (B & C)

Variable	Control group (A)	Study group (B & C)	P value
	Pretest	Pre test	
LDH	333.95 ± 40.34	323.17 ± 43.08	0.252
CK	51.54 ± 7.42	52.29 ± 9.97	0.703

Table 2: Comparison of post-tests of control (A) and study group (B & C)

Variable	Control group (A)	Study group (B & C)	P value
	Post test	Post test	
LDH	336.88 ± 37.79	431.51 ± 58.16	< 0.001*
CK	53.32± 7.91	64.93 ± 12.40	< 0.001*

*- statistically significant by independent t test

Table 3: Comparison of pre and post tests of study group (B & C)

Variable	Study group (B & C)		P value
	Pretest	Post test	
LDH	323.17.95 ± 43.08	431.51 ± 58.16	**< 0.001***
CK	52.29 ± 9.97	64.93 ± 12.4	**< 0.001***

*- statistically significant by paired t test

Table 4: Comparison of pre and post tests of all the three groups

Variables	Control group (A)			Treadmill group (B)			Cycle group (C)		
	Pretest	Post test	P value	Pretest	Post test	P value	Pretest	Post test	P value
LDH	333.95 ± 40.34	336.88 ± 37.79	0.727	317.56 ± 38.27	458.24 ± 53.03	**< 0.001***	328.79 ± 47.74	404.79 ± 51.26	**< 0.001***
CK	51.54 ± 7.42	53.32 ± 7.91	0.239	50.55 ± 8.70	69.53 ± 11.39	**< 0.001***	54.03 ± 11.04	60.32 ± 11.89	**0.001***

Table 5: Comparison of Mean differences between pre and post tests of all the three groups

Variable	Control group (A)	Treadmill group (B)	Cycle group (C)	P value
LDH	2.93 ± 2.55	140.68 ± 14.76	96.00 ± 3.52	< 0.001*
CK	1.78 ± 0.49	18.98 ± 2.69	6.29 ± 0.85	< 0.001*

*- statistically significant by ANOVA test

DISCUSSION

In our study among the control group, the mean LDH levels in pretest was 333.95 ± 40.34 and in post test was 336.88 ± 37.79. This difference was not statistically significant by paired t test. Among the treadmill group, the mean LDH levels in pretest was 317.56 ± 38.27 and in post test was 458.24 ± 53.03. This difference was statistically significant by paired t test ($p < 0.05$). Among the cycle group, the mean LDH levels in pretest was 328.79 ± 47.74 and in post test was 404.79 ± 51.26. This difference was statistically significant by paired t test ($p < 0.05$). In our study among the control group, the mean CK levels in pretest was 51.54 ± 7.42 and in post test was 53.32 ± 7.91. This difference was not statistically significant by paired t test. Among the treadmill group, the mean CK levels in pretest was 50.55 ± 8.70 and in post test was69.53 ± 11.39. This difference was statistically significant by paired t test ($p < 0.05$). Among the cycle group, the mean CK levels in pretest was 54.03 ± 11.04 and in post test was 60.32 ± 11.89. This difference was statistically significant by paired t test ($p < 0.05$).

Similar to our study, Foran et al1 reported the effects of exercise on laboratory test results following marathon race and after 60 minutes of ergometer test. They showed elevation in BUN, Creatinine, Uric acid, ALT, AST and Direct Bilirubin 24 hours after marathon race. LDH and CK were elevated in 15 untrained healthy adults after 60 minutes of ergometer test.

Brancaccio et al2 reported that CK levels depend on age, gender, race, muscle mass, physical activity and climatic conditions. He concluded that highest serum enzyme activities are found after prolonged exercise like marathon running which causes eccentric muscular contractions. After prolonged exercise CK levels remain elevated for 24 hours after exercise. Highest peak of CK reached after 5 minutes of ergometer cycling. This is consistent with our present study provided CK was elevated after 8 weeks following 15 minutes of ergometer bicycling but less when compared to 1-hour treadmill running.

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Similar to our results, Chamera et al,[3] studied the enzymatic markers in football players of both sex after the training session of running outdoors for 60 minutes and showed elevation in LDH and CK after exercise and these changes are related to distance covered by the individuals. Mashiko et al,[4] studied the effects of exercise in 25 rugby players during summer training camp, which showed elevated AST, ALT, CK and LDH.

Klapcinska et al,[5] reported the effect of high intensity exercise on muscle damage in untrained men and showed a significant increase in LDH and CK 20 hours after 300m sprint running and concluded in similar lines to our results. Callegari et al,[6] concluded CK and LDH levels in different resistance and aerobic exercises among 12 trained men and showed a significant elevation in CK and LDH immediately and 24 hours after exercise.

Studies done by Siegel et al,[7] reported the CK elevation in 15 male marathon runners and showed that CK levels were elevated 24 hours after the race. Rumley et al,[8] concluded the serum LDH and CK during marathon training and showed that CK activities increased during first 15 weeks and LDH increased after 30 weeks.

Similar to our results, Shin et al,[9] reported that CK and LDH were elevated following marathon running. Lippi et al,[10] measured CK and LDH following a half marathon run in male atheletes and showed significant elevation of these enzymes 24 hours after the race.

In our study, for LDH, the mean difference between pre and post tests among control group was 2.93 ± 2.55, among treadmill group was 140.68 ± 14.76 and among cycle group was 96.00 ± 3.52. This difference was statistically significant by ANOVA test. ($p < 0.05$)

In our study, for CK, the mean difference between pre and post tests among control group was 1.78 ± 0.49, among treadmill group was 18.98 ± 2.69 and among cycle group was 6.29 ± 0.85. This difference was statistically significant by ANOVA test. ($p < 0.05$).

Both the treadmill and cycle training showed significant increase in LDH and CK. Aerobic training produces metabolic changes in the muscle, liver and renal parameters which are physiological changes as a result of exercise and not pathological. Also, rather than intensity, duration of exercise has a greater impact on these parameters which was revealed by comparing the mean difference of these parameters among the treadmill group and cycle group. The metabolic markers were elevated in treadmill group than the cycle group.

The limitations of our study include longer duration of aerobic training is needed to evaluate metabolic adaptations due to aerobic exercise and also to compare between treadmill and bicycle ergometer. Blood samples need to be taken at timely intervals after exercise to assess the exact elevation and recovery of the metabolic parameters.

CONCLUSION

The results of our present study showed that there is an increase in metabolic markers like LDH and CK following eight weeks of moderate intensity aerobic exercise training which was statistically significant. An increase in these parameters in a normal healthy individual must be interpreted with his routine exercise pattern before making any pathological diagnosis like myopathy, myocardial infarction, acute hepatic or renal failure. It is also safe to counsel individuals with suspected myopathy to continue physical activity at a lower intensity to prevent muscle damage.

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