Effect of Training on the serum creatine Kinase (CK) levels of Athletes

Anugweje KC[1] and Okonko IO[2]

[1]Department of Health Services, Lulu Briggs Health Centre, University of Port Harcourt, East-West Road, P.M.B. 5323, Uniport Post Office, Choba, East-West Road, Port Harcourt, Rivers State, Nigeria;
[2]Virology Unit of Medical Microbiology Division, Department of Microbiology, University of Port Harcourt, P.M.B. 5323 Uniport Post Office, Choba, East-West Road, Port Harcourt, Rivers State, Nigeria;
Iheanyi.okonko@uniport.edu.ng; Tel: +234 803 538 0891

ABSTRACT: The effect of training on the serum creatine kinase levels of athletes was evaluated clinically. Study was conducted in 46 highly-trained athletes. The collective results indicate that training has effect on the serum creatine kinase. The study showed that there was significant difference (P=0.002) between the serum creatine kinase (CK) values of pre-training and post-training values for the study groups and their controls. The study showed that serum CK is a marker for skeletal and myocardial muscle damage. Muscle damage reduces performance in endurance activities.
[Anugweje KC and Okonko IO. **Effect of Training on the serum creatine Kinase (CK) levels of Athletes.** .*Nat Sci* 2012;10(9):180-185]. (ISSN: 1545-0740). http://www.sciencepub.net/nature. 26

Key words: serum creatine kinase, endurance, performamce, muscle damage

1. Introduction

Prolonged endurance exercise, such as long-distance running, induces marked changes in enzymes of energy metabolism in muscle (Holloszy and Booth, 1976; Chi *et al*., 1983). The most consistent effect is a large increase in mitochondrial enzymes with concomitant increase in capacity to oxidize carbohydrate and fat (Holloszy and Booth, 1976; Chi *et al*., 1983). This adaptation, first shown in rats (Chi *et al*., 1983), also occurs in human skeletal muscle (Chi *et al*., 1983). Useful and purposeful training is a process in which a person's abilities on a regular basis, gradually and progressively increased to reach peak performance (Zafari, 2012). Therefore, exercise programmes and make adjustments in power to have the properties to reach peak performance (Glowacki *et al*., 2004). Endurance training increased maximum oxygen consumption (Izquierdo *et al*., 2005), the number of mitochondrial and specific enzymes (Zafari, 2012) and the yield stress in the muscle fibers (Izquierdo *et al*., 2005; Zafari, 2012).

In the last two decades, there has been significant accumulation of scientific data regarding athletes' physiology and medicine. Previous investigations have evaluated ideal physiological and anthropometric profile of successful karate and cycling players mostly from Western Europe and America, although there is a lack of descriptive data concerning characteristics of elite karate athletes from Eastern Europe (Giampietrom *et al*., 2003; Nezhad and Farhadi, 2012). Aspects such as experience, body composition, endurance, balance between anaerobic power and aerobic power, among other factors, are of primary importance in evaluation of elite athletes (Markovic *et al*., 2005; Nezhad and Farhadi, 2012).

Thus, knowing and identifying factors such as energy requirements, mechanical efficiency and oxygen intake, is essential to performance (Bircher *et al*., 2006; Nezhad and Farhadi, 2012).

In this paper, we report the effect of training on the serum creatine kinase levels of University of Port Harcourt athletes.

2. Materials and Methods

2.1. Population and sample

A total 46 student-athletes and 14 non-athletes (control group) of the University of Port Harcourt, Nigeria were used for this study. Samples of blood were collected from the antecubital veins of each athlete and control. The training programmes of the participants during the 30-day period were similar and properly designed. The participants were all treated for malaria prior to the commencement of the study. Written informed consent was obtained from participants after detailed explanations of the risks involved in the study. Detailed physical examination was carried out on all the participants to exclude any heart disease.

2.2. Endurance clinical trial

Forty-six volunteers (22 males and 24 females), who were training for the Nigerian Universities Games (NUGA) were enrolled in the study with the 14 control group (7 males and 7 females). The volunteers and the controls were divided into 2 groups of 30 males and 30 females, ages 18 – 28 years. The endurance of all participants was measured by a treadmill run with increasing workload (stepwise every min), until muscle fatigue (time-to-fatigue). The time-to-fatigue was measured pre-study and at day 30. Serum creatine kinase measurements were also made at the same intervals using lactate analyizer.

2.3. Data Analysis

The data generated were analyzed by multivariate statistical methods. For statistical analysis SPSS software (version 20.0, Chicago, USA) was used, the paired *t* test and independent samples-test were used to compare values of the experimental treatment and control group. A comparison was considered statistically significant if the *P* value was < 0.05.

3. RESULTS ANALYSIS

Table 1 shows the serum creatine kinase (IU/L) levels of participants before training (pre-training) and after training (post-training). The study showed that there was significant difference (P=0.001) between the serum creatine kinase (CK) values for pre-training and post-training among the study group. The study also showed a significant difference (P=0.001) between the serum CK values for pre-training and post-training among the controls (Table 1).

The study showed a significant difference (P=0.001, P=0.002 and P=0.05) between the serum CK values of females before and after training among the study groups and controls. It also showed a significant difference (P=0.001, P=0.006 and P=0.05) between the serum CK values of male subjects before and after training among the study groups and their controls. Other details are shown in Table 1.

Table 1: Serum Creatine kinase (IU/L) levels of participants before training and after training

S/N	SEX	Pre-Training	Post-Training	S/N	SEX	Pre-Training	Post-Training
Study Group 1				**Study Group 2**			
1	M	62±2.6	240±5.4	1	M	40±1.9	195±6.6
2	F	51±2.6	215±5.4	2	F	29±1.9	185±6.6
3	M	56±2.6	221±5.4	3	F	56±1.9	200±6.6
4	M	50±2.6	200±5.4	4	M	54±1.9	199±6.6
5	F	54±2.6	225±5.4	5	M	46±1.9	190±6.6
6	M	62±2.6	245±5.4	6	M	48±1.9	200±6.6
7	M	68±2.6	274±5.4	7	M	46±1.9	198±6.6
8	M	56±2.6	219±5.4	8	M	51±1.9	190±6.6
9	M	66±2.6	250±5.4	9	F	_	_
10	F	68±2.6	241±5.4	10	F	61±1.9	209±6.6
11	F	36±2.6	190±5.4	11	F	56±1.9	218±6.6
12	M	48±2.6	210±5.4	12	F	62±1.9	222±6.6
13	F	38±2.6	199±5.4	13	M	56±1.9	198±6.6
14	F	34±2.6	198±5.4	14	M	62±1.9	195±6.6
15	F	28±2.6	195±5.4	15	F	68±1.9	225±6.6
16	M	46±2.6	200±5.4	16	M	54±1.9	217±6.6
17	M	38±2.6	190±5.4	17	F	58±1.9	216±6.6
18	M	29±2.6	187±5.4	18	M	48±1.9	201±6.6
19	F	36±2.6	190±5.4	19	F	44±1.9	192±6.6
20	F	42±2.6	186±5.4	20	F	38±1.9	138±6.6
21	F	44±2.6	198±5.4	21	M	42±1.9	148±6.6
22	F	40±2.6	190±5.4	22	F	56±1.9	125±6.6
23	M	36±2.6	163±5.4	23	F	47±1.9	113±6.6
Control Group							
24	M	24±1.1	102±4.0	24	M	42±1.3	160±7.4
25	F	28±1.1	116±4.0	25	F	37±1.3	108±7.4
26	F	32±1.1	109±4.0	26	M	40±1.3	137±7.4
27	M	24±1.1	86±4.0	27	M	32±1.3	113±7.4
28	M	26±1.1	89±4.0	28	F	38±1.3	133±7.4
29	F	25±1.1	98±4.0	29	F	38±1.3	116±7.4
30	F	28±1.1	104±4.0	30	M	42±1.3	106±7.4

Key: _ = Haemolysis

Table 2 shows the serum creatine kinase (IU/L) values of participants group before training and after training in relation to their demographic characteristics. The study showed that there was no significant difference (P=0.265) between the serum creatine kinase (CK) values of pre-training values for Group I and Group II study groups. There was a significant difference (P=0.023) between the serum CK values of post-training values for Group I and Group II study groups. Other details are shown in Table 2.

Table 2: Comparative analysis of serum creatine kinase (IU/L) values of participants before training and after training in relation to their demographic characteristics.

Study Group	Pre-training	Post-training
Group 1		
Males (n=**11**)	**51.4**±3.6	**216.6**±9.1
Females (n=**12**)	**42.8**±3.4	**202.5**±5.2

Total (n=23)	**47.3**+2.6	**209.8**+5.4
Control		
Males (n=3)	**24.7**+0.7	**92.3**+4.9
Females (n=4)	**28.3**+1.4	**106.7**+3.8
Total (n=7)		
Group 2		
Males (n=11)	**49.7**+1.9	**193.7**+5.1
Females (n=12)	**52.3**+3.5	**185.7**+12.4
Total (n=23)	**51.0**+1.9	**189.7**+6.6
Control		
Males (n=4)	**39.0**+2.4	**129.0**+12.3
Females (n=3)	**37.7**+0.3	**119.0**+7.37
Total (n=7)		

DISCUSSION

The purpose of the present study was to evaluate the effect of training and 30-day endurance training on the performance of university athletes. The serum levels of skeletal muscle enzymes is a marker of the functional status of muscle tissue and varies widely in both pathological and physiological conditions (Brancaccio et al., 2007). An increase in these enzymes may represent an index of cellular necrosis and tissue damage following acute and chronic muscle injuries (Mokuno et al., 1987; Szumilak et al., 1998; Brancaccio et al., 2007). Changes in serum levels of muscular enzymes and isoenzymes are also found in normal subjects and in athletes after strenuous exercise (Priest et al., 1982; Munjal et al., 1983; Wolf et al., 1987; Ide et al., 1999; Brancaccio et al., 2007): the amount of enzyme from muscle tissue to blood can be influenced by physical exercise (Boros-Hatfaludy et al., 1986; Brancaccio et al., 2007). Muscle creatine kinase (CK) activity measured from needle muscle biopsies shows different behaviour before and after training (Linossier et al., 1997; MacDougall et al., 1998), and the serum level of CK changes according to different protocols and to the intensity and level of training (Ohkuwa et al., 1984; Klapcinska et al., 2001; Szabo et al., 2003; Brancaccio et al., 2007).

The study of serum CK in sports medicine allows to obtain information on the state of the muscle (Brancaccio et al., 2007). High levels of serum CK in apparently healthy subjects may be correlated with physical training status. However, if these levels persist at rest, it may be a sign of subclinical muscle disease, which training loads may evidence through the onset of symptoms such as profound fatigue (Angelini, 2004; Brancaccio et al., 2007).

In normal serum, total CK is provided mainly by the skeletal muscle and is almost only of the MM fraction. Total CK levels depend on age, gender, race, muscle mass, physical activity and climatic condition. The 2.5 and 97.5 percentile reference limits have recently been revisited (Stomme et al., 2004; Brancaccio et al., 2007).

Young adult males have high serum levels of CK (Borges and Essen-Gustavsson, 1989), which decline slightly with age during the geriatric period (Tietz et al., 1992). There are marked sex differences in CK serum levels at rest (Fu et al., 2002), with lower values in females than in males. After muscular exercise, sex-linked differences are still present (Amelink et al., 1988), and oestrogen may be an important factor in maintaining post-exercise membrane stability, thus limiting CK leakage from the damaged muscle (Amelink et al., 1990; Tiidus, 2000; Brancaccio et al., 2007).

Many factors determine the degree to which serum enzyme activities increase during and after exercise (Brancaccio et al., 2007). The highest post-exercise serum enzyme activities are found after very prolonged competitive exercise such as ultradistance marathon running (Nuviala et al., 1992) or triathlon events (Denvir et al., 1999). Weight-bearing exercises, which include eccentric muscular contractions such as downhill running, induce the greatest increases in serum enzyme activities (Malm et al., 2004). There is a breakpoint at 300–500 IU/l of CK serum release after exercise, and the levels of enzyme are associated with distinctive individual musclar properties (Brancaccio et al., 2007). Subjects can be classified into high and low responders. In high responders, the cross-sectional area and volume of the quadriceps femoris muscle were significantly lower than those in low responders (Totsuka et al., 2002; Brancaccio et al., 2007).

Daily training may result in persistent serum elevation of CK (Kratz et al., 2002), and resting CK levels are higher in athletes (Hortobagyi and Denhan, 1989; Fallon et al., 1999), but the significant increases of CK occurred after exercise are usually lower in trained subjects when compared with untrained subjects (Vincent and Vincent, 1997; Fehrenbach et al., 2000; Garry and McShane, 2000). In fact, if athletes and sedentary subjects undertake the same physical exercise test, the CK levels of athletes are lower than those recorded in matched healthy control subjects (Karamizrak et al., 1994; Garry and McShane, 2000).

Total creatine kinase (CK) levels depend on age, gender, race, muscle mass, physical activity and climatic condition (Brancaccio et al., 2007). High levels of serum CK in apparently healthy subjects may be correlated with physical training status, as they depend on sarcomeric damage: strenuous exercise that damages skeletal muscle cells results in increased total serum CK (Brancaccio et al., 2007). The highest post-exercise serum enzyme activities are found after prolonged exercise such as ultradistance marathon running or weight-bearing exercises and downhill running, which include eccentric muscular contractions (Brancaccio et al., 2007). Total serum CK activity is markedly elevated for 24 h after the exercise bout and, when patients rest, it gradually returns to basal levels. Persistently increased serum CK levels are occasionally encountered in healthy individuals and are also markedly increased in the pre-clinical stages of muscle diseases (Brancaccio et al., 2007).

Some authors, studying subjects with high levels of CK at rest, observed that, years later, subjects developed muscle weakness and suggested that early myopathy may be asymptomatic. Others demonstrated that, in most of these patients, hyperCKemia probably does not imply disease (Brancaccio et al., 2007).

In many instances, the diagnosis is not formulated following routine examination with the patients at rest, as symptoms become manifest only after exercise (Brancaccio et al., 2007). Some authors think that strength training seems to be safe for patients with myopathy, even though the evidence for routine exercise prescription is still insufficient. Others believe that, in these conditions, intense prolonged exercise may produce negative effects, as it does not induce the physiological muscle adaptations to physical training given the continuous loss of muscle proteins (Brancaccio et al., 2007).

High CK serum levels in athletes following absolute rest and without any further predisposing factors should prompt a full diagnostic workup with special regards to signs of muscle weakness or other simple signs that, in both athletes and sedentary subjects, are not always promptly evident (Brancaccio et al., 2007).

These signs may indicate subclinical muscle disease, which training loads may evidence through the onset of profound fatigue. It is probably safe to counsel athletes with suspected myopathy to continue to undertake physical activity at a lower intensity, so as to prevent muscle damage from high intensity exercise and allow ample recovery to favour adequate recovery (Brancaccio et al., 2007).

In this study, results showed expected increases in the serum creatine kinase levels of participants following training, signifying exercise-generated muscle damage (Brancaccio et al., 2007).

CONCLUSION

The finding of this study has further confirmed the effect of training on athletes. Habitual activity seems to be the most important factor in the differences observed among athletes (Paton and Hopkins, 2005; Nezhad and Farhadi, 2012). Physical activity is supported by both aerobic and anaerobic systems of energy production. Each system contributes to the total energy and the percentage of total energy contributed by each system depends on the type (karate, cycling, running, jumping and dancing), and the duration of the sport (wrestling-a few minutes, football-90 mins). The sources of fuel for the production of the energy are the glycogen stores in the liver and muscles and the fat stores in the muscles and adipose tissues.

Correspondence to:
Iheanyi O. Okonko
Department of Microbiology,
University of Port Harcourt, Choba,
PMB 5323 Port Harcourt, Rivers State, Nigeria;
E-mail:mac2finney@yahoo.com;
iheanyi.okonko@uniport.edu.ng
Tel.: +234 803 538 0891

References

1. Amelink GJ, Kamp HH, Bar PR (1988) Creatine kinase isoenzyme profiles after exercise in the rat: sex-linked differences in leakage of CKMM. Pflugers Arch, 412, 417–421.
2. Amelink GJ, Koot RW, Erich WB, Van Gijn J, Bar PR (1990). Sex-linked variation in creatine kinase release, and its dependence on oestradiol, can be demonstrated in an in-vitro rat skeletal muscle preparation. Acta Physiol Scand, 138, 115–124.
3. Angelini C (2004) Limb-girdle muscular dystrophies: heterogeneity of clinical phenotypes and pathogenetic mechanisms. Acta Myol, 23, 130–136.
4. Bircher S, Enggist A, Jehle T and Knechtle B. Effects Of An Extreme Endurance Race On Energy Balance And Body Composition - A Case Study. *Journal of Sports Science and Medicine*, 2006, 5(1): 154-162.
5. Borges O, Essen-Gustavsson B (1989) Enzyme activities in type I and II muscle fibres of human skeletal muscle in relation to age and torque development. Acta Physiol Scand, 136, 29–36.
6. Boros-Hatfaludy S, Fekete G, Apor P (1986) Metabolic enzyme activity patterns in muscle biopsy samples in different athletes.

Eur J Appl Physiol Occup Physiol, 55, 334–338.
7. Brancaccio P, N. Maffulli and FM Limongelli. (2007). Creatine kinase monitoring in sport medicine. British Medical Bulletin; 81 and 82: 209–230
8. Chi, M.M-Y., C.S. Hintz, E.F. Coyle, W.H. Martin III, J.L. Ivy, P.M. Nemeth, J.O. Holloszy, and Oliver H. Lowry. 1983. *Effects of detraining on enzymes of energy metabolism in individual human muscle fibers.* Am. J. Physiol. 244 (Cell Physiol. 13): C276-C287
9. Denvir MA, Galloway PJ, Meighan AS et al. (1999) Changes in skeletal and cardiac muscle enzymes during the Scottish Coast to Coast Triathlon. Scott Med J, 44, 49–51.
10. Fallon KE, Sivyer G, Sivyer K, Dare A (1999) The biochemistry of runners in a 1600 km ultramarathon. Br J Sports Med, 33, 264–269.
11. Fehrenbach E, Niess AM, Schlotz E, Passek F, Dickhuth HH, Northoff H (2000) Transcriptional and translational regulation of heat shock proteins in leukocytes of endurance runners. J Appl Physiol, 89, 704–710.
12. Fu FH, You CY, Kong ZW (2002) Acute changes in selected serum enzyme and metabolite concentrations in 12-yr to 14 yr old athletes after an all-out 100 m swimming sprint. Percept Motor Skills, 95, 1171–1178.
13. Garry JP, McShane JM (2000) Postcompetition elevation of muscle enzyme levels in professional football players. Med Gen Med, 2, E4.
14. Giampietro M, Pujia A, Bertini I. Anthropometric features and body composition of young athletes practicing karate at a high and medium competitive level. Acta Diabetol. 2003; 40 Suppl 1:S145-148.
15. Glowacki, S.P., Martin, S.E., Maurer, A., Baek, W., Green, J.S., Crouse, S.F. 2004. Effects of resistance, endurance, and concurrent exercise on training outcomes in men. *Med Sci Sports Exerc.*; 36 (12): 2119 – 27.
16. Holioszy JO and FW Booth. Biochemical adaptations to endurance exercise in muscle. *Annu. Rev. Physiol.* 38: 273-291, 1976.
17. Hortobagyi T, Denhan T (1989) Variability in creatine kinase: methodological, exercise and clinically related factors. Int J Sports Med, 10, 69–80.
18. Ide M, Tajima F, Forusawa K et al. (1999) Weelchair marathon racin causes striated muscle distress in individuals with spinal cord injury. Arch Phys Med Rehabil, 80, 324–327.
19. Izquierdo, M., Hakkinen, K., Kraemer, W.J., Esteban, M. 2005. Effects of combined resistance and cardiovascular training on strength, power, muscle cross-sectional area, and endurance markers in middle-aged men. Eur J Appl Physiol 1007/s00421-004-1280-5
20. Karamizrak SO, Ergen E, Tore IR, Akgun N (1994) Changes in serum creatine kinase, lactate dehydrogenase and aldolase activities following supramaximal exercise in athletes. J Sports Med Phys Fitness, 34, 141–146.
21. Klapcinska B, Iskra J, Poprzecki S et al. (2001) The effects of sprint (300 m) running on plasma lactate, uric acid, creatine kinase and lactate dehydrogenase in competitive hurdlers and untrained men. J Sports Med Phys Fitness, 41, 306–311.
22. Kratz A, Lewandrowski KB, Siegel AJ et al. (2002) Effect of marathon running on hematologic and biochemical laboratory parameters, including cardiac markers. Am J Clin Pathol, 118, 856–863.
23. Linossier MT, Dormois D, Perier C et al. (1997) Enzyme adaptation of human skeletal muscle during bicycle short-sprint training and detraining. Acta Physiol Scand, 161, 439–445.
24. MacDougall JD, Hicks AL, Mac Donald JR et al. (1998) Muscle performance and enzymatic adaptations to sprint interval training. J Appl Physiol, 84, 2138–2142.
25. Malm C, Sjodin TL, Sjoberg B et al. (2004) Leukocytes, cytokines, growth factors and hormones in human skeletal muscle and blood after uphill or downhill running. J Physiol, 556, 983–1000.
26. Markowitz JS, Donovan JL, DeVane CL, Chavin KD (2004). Common herbal supplements did not produce false-positive results on urine drug screens analyzed by enzyme immunoassay. J. Anal. Toxicol. 28: 272-273.
27. Mokuno K, Riku S, Sugimura K, Takahashi A, Kato K, Osugi S (1987) Serum creatine kinase isoenzymes in Duchenne muscular dystrophy determined by sensitive enzyme immunoassay methods. Muscle Nerve, 10, 459–463.
28. Munjal DD, McFadden JA, Matix PA et al. (1983) Changes in serum myoglobin, total creatine kinase, lactate dehydrogenase and creatine kinase MB levels in runners. Clin Biochem, 16, 195–199
29. Nezhad MHM and Farhadi H. (2012). A comparison of anthropometric and physiological characteristics of Elite cycling and karate athletes. Annals of Biological Research, 3 (1):628-631

30. Nuviala RJ, Roda L, Lapieza MG, Boned B, Giner A (1992) Serum enzymes activities at rest and after a marathon race. J Sports Med Phys Fitness, 32, 180–186.
31. Ohkuwa T, Saito M, Miyamura M (1984) Plasma LDH and CK activities after 400 mt sprinting by well-trained sprint runners. Eur J Appl Physiol, 52, 296–299.
32. Paton C.D., and Hopkins W.G. Seasonal changes in power of competitive cyclists: implications for monitoring performance. *International Journal of Science and Medical Sport*. 2005. 8: 4: 375-381.
33. Priest JB, Oei TO, Moorehead WR (1982) Exercise-induce changes in common laboratory test. Am J Clin Pathol, 77, 285–289.
34. Stomme JH, Rustad P, Steensland H, Theodorsen L, Urdal P (2004) Reference intervals for eight enzymes in blood of adult females and males measured in accordance with the international Federation of Clinical Chemistry reference system at 378C: part of the Nordic Reference Interval Project. Scand J Clin Lab Invest, 64, 371–384.
35. Szabo A, Romvari R, Bogner P et al. (2003) Metabolic changes induced by regular submaximal aerobic exercise in meat-type rabbits. Acta Vet Hung, 51, 503–512.
36. Szumilak D, Sulowicz W, Walatek B (1998) Rhabdomyolysis: clinical features, causes, complications and treatment. Przegl Lek, 55, 274–279.
37. Tietz NW, Shuey DF, Wekstein DR (1992) Laboratory values in fit aging individualssexagenarians though centenarians. Clin Chem, 38, 1167–1185.
38. Tiidus PM (2000) Estrogen and gender effects on muscle damage, inflammation and oxidative stress. Can J Appl Physiol, 25, 274–287.
39. Totsuka M, Nakaji S, Suzuki K, Sugawara K, Sato K (2002) Break point of serum creatine kinase release after endurance exercise. J Appl Physiol, 93, 1280–1286.
40. Vincent HK, Vincent KR (1997) The effect of training status on the serum creatine kinase response, soreness and muscle function following resistance exercise. Int J Sports Med, 18, 431–437.
41. Vincent HK, Vincent KR (1997) The effect of training status on the serum creatine kinase response, soreness and muscle function following resistance exercise. Int J Sports Med, 18, 431–437.
42. Wolf PL, Lott JA, Nitti GJ et al. (1987) Changes in serum enzymes, lactate and haptoglobin following acute physical stress in international-class athletes. Clin Biochem, 20, 73–77.
43. Zafari A. (2012). The Effects of Combined Training on Physical Fitness Factors in Academic Level Athletes. Annals of Biological Research, 3 (1):673-676

8/10/2012