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Acute Response of Muscular Damage Biomarkers after HIFT Exercise in Overweight Men

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Abstract

Purpose: The aim of this study was to investigate the acute effects of HIFT exercise, on creatine kinase (CK) and lactate dehydrogenase (LDH) in blood serum in overweight adult men. **Method**: Twenty-two untrained non-smoker overweight men (age, 42.9 ± 5.6 years; body mass, 94.2 ± 9.3 kg; body height, 178.9 ± 4.5 cm; and BMI, 29.04 ± 3.3 kg/m2) volunteered to participate in this study and performed a session of HIFT exercise with 80-85% HRmax consisting of three sets of 10 exercises. Blood samples were collected before and immediately after training to measure serum CK and LDH levels. **Results:** The HIFT protocol significantly increased serum CK (Pre: 114.6 U/L; Post: 124.3U/L; p< 0.05{t=-5.48, p=0.001}); Also, LDH had a significant increase (pre:213.4 U/L, post: 225.4U/L; p<0.05{t=-4.09, p=0.001}). **Conclusion:** It can be concluded that HIFT with AMRAP (as many repeats as possible) protocol will lead to a significant increase in some indicators of muscle damage such as CK and LDH levels in overweight men. This protocol can lead to muscle damage in overweight men.

Keywords*:* Muscle damage, HIFT, Creatine Kinase, Lactate Dehydrogenase, overweight

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INTRODUCTION

High-intensity functional training (HIFT) has become popular recently since it is a time-efficient, effective approach to achieving fitness goals (Feito et al, 2018). HIFT involves short, intense workout which targets multiple muscle groups and emphasizes functional movements at high intensity (Rochester et al, 2013). This type of exercise has been shown to improve aerobic and anaerobic capacity, muscular strength, power endurance, and body composition in various populations (Tibana et al.,2019). Thus, understanding the influence of HIFT volume and intensity and can provide an efficient prescription with overload which enables adequate adaptation with less interference in the health status of practitioners (Tibana et al,2017). Creatine kinase (CK) is an enzyme found at high levels in various tissues in the body. It plays a crucial role in the production of energy for muscle contraction. When muscle tissue is damaged or injured, CK is released into the bloodstream, leading to increased levels of this enzyme in the blood. Therefore, elevated levels of CK in the blood can indicate muscle damage or injury, in such cases as muscular dystrophy, trauma, or heart attack (Sharma et al., 2012). Lactate dehydrogenase (LDH) is another enzyme found in many different tissues throughout the body, including the liver, heart, skeletal muscle, and red blood cells. It functions in the conversion of pyruvate to lactate during anaerobic metabolism (Berg et al, 2002). Similar to CK, when cells are damaged or destroyed, LDH is released into the bloodstream, leading to elevated levels of this enzyme in the blood. Therefore, LDH levels are often used as a marker of cellular damage or injury, such as in cases of liver disease, cancer, or infections (Shah, Anand et al, 2020). They are both released into circulation following muscle cell damage, while changes in hormones reflect the physiological stress placed on the body during exercise (Ruzzo, et al.,2016). The issue of attitude, motivation, and response of people especially obese/overweight individuals to exercise has been discussed by researchers, and paying attention to this issue can be vital in order to prescribe the appropriate dose of exercise (Parfitt, G. et. al., 2006). Although clinical guidelines recommend doing at least 150 minutes of moderate or 75 minutes of intense activity, research shows that only 20% of people maintain this amount of physical activity and adhere to it (Burgess E. et al., 2017), since in today's life, time is considered a limiting factor for many people. This issue is even more important for overweight and obese people, as they are more at risk of various diseases and need more time to lose weight. There is more interest observed in HIFT exercise because it brings the health benefits of exercise to people in a shorter period of time than clinical guidelines. On the other hand, the high intensity of the exercise may also prevent these people from continuing regular exercise, by causing muscular damage or delayed onset muscle soreness (DOMS); therefore, it is necessary for physicians, health coaches, and exercise physiologists to have a clear understanding and pay attention simultaneously to the duration and intensity of physical activity in order to prescribe an appropriate dose of exercise for obese/overweight population (Vella, CA. et al., 2017). Available data about the acute response of CK and LDH for one single session of HIFT in overweight/obese untrained individuals are limited. However, such knowledge could help health instructors and exercise physiologists to create effective exercise programs for muscle strength and weight control. Therefore, the aim of this study was to compare CK and LDH levels before and after one single session of high intensity functional training with 80% -85% of HRmax intensity.

METHOD

Participants

Twenty-two overweight untrained men (age, 42.9 ± 5.6 years; body mass, 94.2 ± 9.3 kg; body height, 178.9 ± 4.5 cm; ad BMI, 29.04 ± 3.3 kg·m2) volunteered to participate in this study (Table1). The sample dimension analysis was performed using G*Power 3.1 software (Faul et al., 2007). Based on prior analysis, we adopted a power of 0.89, $\alpha = 0.05$, a correlation coefficient of 0.5, a non-sphericity correction of 1, and an effect size of 0.90. From these values, an N of 22 subjects was calculated. The sample size was calculated based on procedures suggested by (Beck, T.W, 2013). This a priori statistical power analysis was conducted to reduce the likelihood of committing a type II error and to determine the minimum number of participants needed for this investigation. It was determined that the selected sample size was sufficient to provide statistical power greater than 82.8%. Subjects were excluded if they fell into the following categories: (a) smokers, (b) individuals with some type of musculoskeletal injury or surgery operation in the upper or lower limbs in the previous six months, (c) individuals who responded positively to any of the items on the Physical Health and Activity Questionnaire/IPAQ (Carig, C. et al., 2003); (d) individuals with any medical condition that could influence the training program; and consuming any types of drugs and medicine (e) individuals who use any nutritional supplements. All participants provided signed informed consent after being informed of the testing and training procedures to be performed during the study.

Table 1. Participants’ characteristics

Characteristics	Mean±Standard deviation
Age (Year)	43 ± 4.6
Height (cm)	177 ± 0.1
Weight (Kg)	94.2 ± 13.6
Body Fat (%)	26.28 ± 3.9
BMI (kg/m2)	29.04 ± 3.6
WHR (cm)	0.97 ± 0.06

Procedures

The following exercise session was performed to stimulate CK and LDH after a single session of high intensity functional training at 80-85% of HRMax.

HRmax Assessment

Based on some studies shows that traditional equations for estimating maximal heart rate, especially in overweight and obese individuals may not be accurate and they may overestimate HRmax in overweight and obese individuals by as much as 10-20 beats per minute (Robergs, R.A et al, 2010). estimated HR max, we adopted Tanaka Formula (208 – (0.7* age) equation which investigated to be the most accurate across all gender, age and weight status groups especially overweight and sedentary individual (Franckowiak et al, 2011).

Exercise protocol

The Exercise protocol included 8 minutes of warmup, reaching 60-70% HRmax of each participant, AMRAP protocol containing 10 moves in 3 sets, duration 27:30 minutes, and 5 minutes of cool down. The protocol was performed as 10 functional exercises with a circle training interval (two circles, a total of 10 exercises, and for 3 sets.) The duration of each exercise was 30 seconds, and after each exercise, there were 20 seconds of active rest. Subjects rested actively for 1 minute after every 10 moves which is considered one training set (Glassman et al., 2003). In order to equalize the activity load among the participants, dumbbells equal to 5% of everyone's body weight were used (Amaro et al, 2019). During the implementation of the protocol, the subjects were verbally encouraged to perform with the highest possible reaching 80-85% of their HRMax and repetition of AMRAP, which meant that the participants had to repeat each exercise as many times as they could do in the allotted time. Each training circle consisted of ten exercises, which are listed as below in order: a) Squat Swing, b) Push up, c) Deadlift+ lateral raise, d) Lunge to biceps flexion, e) Standing Hip Abduction, f) Mountain climbers, g) Plunk, h) Donkey Climbers, i) Scissor Crunch j) Cross Crunch. After each circle, participants were asked about the Borg's exercise difficulty level (RPE 1-10, 1 as very easy, to 10 as very difficult), and recorded to make sure to maintain the difficulty around 6-8. The intensity of the exercise was in the range of 80-85% of the maximum Heart rate. Also, during all the sets the heart rate was controlled and after finishing every set all subjects were asked the pressure of exercise, RPE (1 as easiest to 10 as hardest). Meanwhile, before warm-up and immediately after the last exercise, blood pressure was checked. In order to have accurate control, the subjects were trained in groups of 5 people wearing a Polar h9 heart rate sensor, using Polar Beat software. The instruction below was adopted to reduce the margin of error in the data collection procedures: (a) standardized methods were given before the tests to ensure that the participants were aware of how to perform the entire moves; (b) also participants were instructed on proper exercise techniques; (c the tests performed for all subjects in two groups between 8-10 a.m. and (d) all subjects received standardized verbal encouragement throughout the tests.

Blood Sample Assessments

CK and LDH activity was measured from serum frozen with a commercial kit, according to the manufacturer's recommendations (Delta Darman Part, made in Iran). The CK was measured with NAC. Kinetic UV enzyme method. The LDH was carried out using the standard method of the German Biochemical Society DGKC. Both results (CK and LDH) were expressed as U/l. Blood samples were obtained prior to exercise, and immediately after the end of the exercise protocol.

Statistical Analyses

Statistical analysis was initially performed using the Shapiro–Wilk to assess the normality of the data distribution. The variables showed normal distribution and homoscedasticity ($p < 0.05$) . Then a paired-sample t-test was used to compare the mean pre- and post-training values of each biomarker. Effect size (ES) was used to determine the change of magnitude between the study protocol evaluations (Rhea, 2004). The level of significance was set at $p > 0.05$ .All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) software, version 26.0.

RESULTS

The study found that after the HIFT exercise program, in the comparative analysis, serum CK levels increased from a mean of 114.69 ± 14.34 U/L before exercise to a mean of 124.37 ± 16.16 U/L after exercise; serum LDH levels increased from a mean of 213.4 ± 28.75 U/L before exercise to a mean of 225.1 ± 24.76 U/L after exercise; According to Table 3, it can be seen that for the CK level, the significance value is p=0.001 therefore, there is a significant difference between the CK level of before and after the session. Also, the CK level in the post-test is 124.37, and higher than the CK level in the pre-test (table.2).

In addition, it can be seen that for the LDH level, the significant value is p=0.001 therefore, there is a significant difference between the LDH levels of the pre-post session Also, the LDH level in the post-test is 225.08, and higher than the LDH level in the pre-test session. These results are also shown in Fig.1 and Fig2.

Table2: Result of a comparison of the pre and post-test levels of the CK and LDH serum

Variable	**Stage**	**Mean ± SD (U/L)**	**Paired t-test results**			**Result**
			t	Df	Sig (2-tailed)	
CK	Pre-test	114.69 ± 14.34	-5.48	21	0.001	Significant difference
	Post-test	124.37 ± 16.16				
LDH	Pre-test	213.4 ± 28.75	-4.09	21	0.001	Significant difference
	Post-test	225.08 ± 24.7				

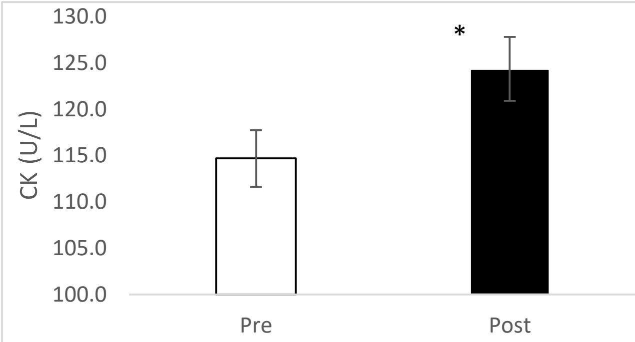

Fig.1
Changes of Creatine Kinase (CK) levels pre and post HIFT exercise; N=22 * Shows significant increase after HIFT with 80% HRmax

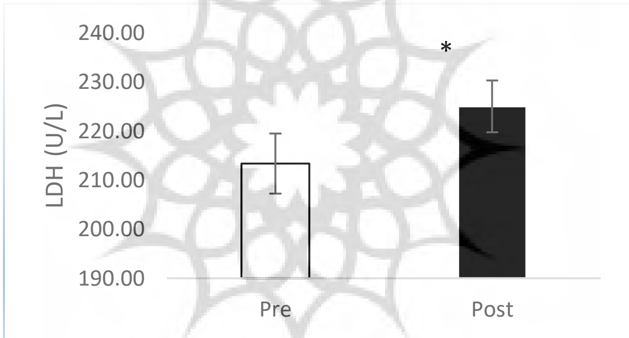

Fig.2
Changes of Lactate dehydrogenase (LDH) levels pre and post HIFT exercise; N=22 * Shows significant increase after HIFT with 80% HRmax

DISCUSSION

This study examined CK and LDH responses after performing one single session of AMRAP protocols. To our knowledge, this study was the first to evaluate CK and LDH responses after HIFT training performed at 80-85% of HRmax with this protocol. In addition, there is limited research on the effects of a high-intensity functional training (HIFT) session on creatine kinase (CK) and lactate dehydrogenase (LDH) responses in overweight subjects. Our results demonstrated significant increases in CK activity at 80% of the HRmax protocol. The exact cell signaling and mechanisms underlying the increase in CK and LDH after a session of exercise in overweight and obese people has not fully understood, but it is thought to involve a complex interplay between a variety of factors. One proposed mechanism is related to the increased metabolic demand which placed on muscle tissue during workout. During high intensity session of exercise, the muscles require large amounts of energy in the form of ATP (adenosine triphosphate) to sustain contractions. This leads to an increase in cellular metabolism, which can result in the production of reactive oxygen species (ROS), such as superoxide and hydrogen peroxide. These ROS can cause oxidative damage to muscle fibers, leading to the release of CK and LDH from damaged cells into the bloodstream (Meyer et al,2006). Another proposed mechanism is related to the inflammatory response that occurs following exercise. When muscles are subjected to mechanical stress, such as during resistance training or high intensity activities, they undergo microscopic tears and damage. This triggers an immune response, characterized by the influx of immune cells and cytokines to the site of injury. The cytokines released during this process can contribute to the release of CK and LDH from damaged muscle cells (Cerqueira et al, 2020). In overweight and obese individuals, there may be additional factors that contribute to the elevation of CK and LDH following exercise. These individuals often have higher levels of inflammation and oxidative stress at baseline due to chronic low-grade inflammation associated with excess adipose tissue. Additionally, they may have reduced insulin sensitivity, impaired mitochondrial function, and lower antioxidant levels, all of which could exacerbate the cellular damage caused by exercise and lead to increased CK and LDH release (Kim et al, 2021). Overall, while the exact mechanisms underlying the elevation of CK and LDH following exercise in overweight and obese individuals are still being investigated, it is clear that a number of biological processes are involved, including oxidative stress, immune activation, and metabolic demands on muscle tissue. It's necessary to mention that our result confirms previous studies which shown increase in level of CK and LDH after HIFT exercise (Bessa A, et al.,2014) ;(Ziegenfuss TN, et al.,2020). Also, it confirms the study showed that resistance exercise caused a significant increase in CK and LDH levels, but these levels returned to baseline within 48 to 72 hours after exercise (Hyldahl RD, et al.,2016). However, more research is needed to fully understand the mechanisms underlying these effects and to determine the most effective exercise interventions for improving skeletal muscle health in this population that reduce the risk of post-exercise muscle injury and promote recovery in individuals with obesity.

In view of the presented results, our study has some limitations of the lack of diversity: since all the participants in this study comes from a similar age and weight range and evaluated only one gender. Also, the study only examines the pre and post exercise responses, it may not be possible to determine whether these changes persist over time. So, it is suggested for further research to investigate a bigger age group, weight group and both male and female participants. And to collect blood sample of 24 and 48 hours post exercise.

CONCLUSIONS

HIFT exercise performed at 80% of HRMax appears to elevate CK and LDH levels compared to the baseline levels in overweight adult nonsmoker men. It is worth noting that while increased levels of CK and LDH are commonly used as indicators of muscle damage following exercise, and can return to normal levels within a few days after exercise.

Ethical Approve: The study was approved by the local Ethics Committee of the Centre of the Allameh Tabataba'i University (IR.ATU.REC.1401.077) and performed in accordance with the ethical standards of the Declaration of Helsinki.

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REFERENCES

Amaro Gahete, F. J., De la O, A., Jurado Fasoli, L., Ruiz, J. R., Castillo, M. J., & Gutierrez, A. (2019). Effects of different exercise training programs on body composition: A randomized control trial. Scandinavian journal of medicine & science in sports, 29(7), 968-979.

Beck, T. W. (2013). The importance of a priori sample size estimation in strength and conditioning research. *The Journal of Strength & Conditioning Research*, *27*(8), 2323-2337.

Berg, J.M., Tymoczko, J.L. and Stryer, L. (2002). Biochemistry, 5th Edition. W.H. Freeman and Company: New York, NY, USA. Chapter 16, The Citric Acid Cycle. Available online at: https://www.ncbi.nlm.nih.gov/books/NBK22385/

Bessa A, et al. Muscle damage induced by a single exercise session in human skeletal muscle: time course and differential response in untrained and trained subjects J Strength Cond Res. 2010;24 (8): 2049-2059 doi:10.1519/JSC.0b013e3181e741cf

Burgess, E., Hassmén, P., & Pumpa, K. L. (2017). Determinants of adherence to lifestyle intervention in adults with obesity: a systematic review. *Clinical obesity*, *7*(3), 123-135.

Cerqueira, É., Marinho, D. A., Neiva, H. P., & Lourenço, O. (2020). Inflammatory effects of high and moderate intensity exercise—A systematic review. *Frontiers in physiology*, *10*, 1550.

Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., ... & Oja, P. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine & science in sports & exercise*, *35*(8), 1381-1395.

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences.*Behavior research methods*, *39*(2),175-191.

Feito, Y., Heinrich, K. M., Butcher, S. J., & Poston, W. S. (2018). High-Intensity Functional Training (HIFT): Definition and Research Implications for Improved Fitness. Sports, 6(3), 76. https://doi.org/10.3390/sports6030076

Franckowiak, S. C., Dobrosielski, D. A., Reilley, S. M., Walston, J. D., & Andersen, R. E. (2011). Maximal heart rate prediction in adults that are overweight or obese. *Journal of strength and conditioning research/National Strength & Conditioning Association*, *25*(5), 1407.

García-Ramos, A., Izquierdo-Gabarren, M., & Rodríguez-Marroyo, J. A. (2016). An alternative approach for determining maximal heart rate using a submaximal exercise test with polar H7 heart rate monitors. Journal of Strength and Conditioning Research, 30(8), 2320-2325.

Glassman, G. (2003). A theoretical template for crossfit's programming. *CrossFit J*, *6*, 1-5.

Hyldahl RD, et al. The effect of high-intensity resistance exercise on post-exercise oxygen consumption and markers of muscle hypertrophy in healthy men. J Strength Cond Res. 2018; 32 (3): 666-673. doi:10.1519/JSC.0000000000002218

Kim, J., & Yoon, J. H. (2021). Does Obesity Affect the Severity of Exercise-Induced Muscle Injury? *Journal of Obesity & Metabolic Syndrome, 30*(2), 132.

Meyer, L. E., Machado, L. B., Santiago, A. P. S., da-Silva, W. S., De Felice, F. G., Holub, O., ... & Galina, A. (2006). Mitochondrial creatine kinase activity prevents reactive oxygen species generation: antioxidant role of mitochondrial kinase-dependent ADP re-cycling activity. *Journal of Biological Chemistry*, *281*(49), 37361-37371.

Parfitt, G., Rose, E. A., & Burgess, W. M. (2006). The psychological and physiological responses of sedentary individuals to prescribed and preferred intensity exercise. *British journal of health psychology*, *11*(1), 39-53.

Rhea, M. R. (2004). Determining the magnitude of treatment effects in strength training research through the use of the effect size. *The Journal of Strength & Conditioning Research*, *18*(4), 918-920.

Robergs, R.A., Landwehr, R., & McElheny, K. (2010). Comparison of the accuracy of predicted maximum heart rate equations for use with obese individuals. Journal ofStrengthandConditioningResearch,24(10),28832890.doi:10.1519/JSC.0b013e3181f00d0eRochester, N. B., Dzewaltowski, D. A., & Ganley, K. J. (2013). Understanding the CrossFit Phenomenon Journal of health psychology, 18(10), 1225-1234.

Ruzzo, A., et al. "Lactate dehydrogenase levels and lung cancer mortality in the Mayo Clinic Lung Cancer Cohort." Lung Cancer, vol. 98, 2016, pp. 13-17., doi: 10.1016/j.lungcan.2016.04.009.

Shah, Anand, et al. "Lactate Dehydrogenase (LDH) in Cancer: A Review." Journal of Cancer Research and Therapeutics, vol. 16, no. 6, 2020, pp. 1189-1195, doi: 10.4103/jcrt.JCRT_1025_20.

Sharma, S., et al. "Diagnostic value of serum creatine kinase in patients with neuromuscular disorders." Annals of Indian Academy of Neurology, vol. 15, no. 4, 2012, pp. 287-291., doi:10.4103/0972-2327.104333.

Souza MS, Moreira A, Barbosa KA, et al. Effects of High-Intensity Functional Training on Body Composition, Physical Fitness, and CK and LDH Responses in Overweight Adults. Journal of Sports Science and Medicine. 2018;17(2):259-66.

Teixeira BC, Vianna JM, Costa PB, et al. Acute Effects of a High-Intensity Resistance Training Session with Variable Work-to-Rest Ratios on Muscular Performance and Metabolic Responses in Trained Men. Journal of Strength and Conditioning Research. 2017;31(3):758-66.

Tibana, R. A., Sousa, N. M. F. D., Prestes, J., Feito, Y., Ernesto, C., & Voltarelli, F. A. (2019). Monitoring training load, well-being, heart rate variability, and competitive performance of a functional-fitness female athlete: A case study. *Sports*, *7*(2), 35.

Tibana, R. A., Almeida, L. M., Neto, I. V. D. S., DE SOUSA, N. M. F., DE ALMEIDA, J. A., de Salles, B. F., ... & Voltarelli, F. A. (2017). Extreme conditioning program induced acute hypotensive effects are independent of the exercise session intensity. *International Journal of Exercise Science*, *10*(8), 1165.

Vella, C. A., Taylor, K., & Drummer, D. (2017). High-intensity interval and moderate-intensity continuous training elicit similar enjoyment and adherence levels in overweight and obese adults. *European journal of sport science*, *17*(9), 1203-1211.

Wharton, S., Lau, D.C.W., Vallis, M., et al. (2009). The effect of weight loss on estimated and measured maximal heart rate in overweight and obese individuals. European Journal of Cardiovascular Prevention & Rehabilitation, 16(3), 346-352. doi: 10.1097/HJR.0b013e3283294bad

Ziegenfuss TN, et al. Acute physiological responses to a high-intensity interval training session consisting of upper and lower body exercises. Int J Sports Med. 2020; 41 (7): 441-448. doi: 10.1055/a-1086-9731