Original Research

Comparison of Acute Level of CK After Five Weeks Eccentric vs Concentric High Intensity Strength Exercise in Healthy Subject

Hasni[1], Hening Laswati[1], Nuniek Nugraheni[1]
[1]*Physical Medicine and Rehabilitation Department, Airlangga University, Surabaya, Indonesia.*

Abstract

Background: Musculoskeletal injuries both in sport and recreational activities, at each age level, can lead to immobilization. Injury and immobilization can lead to muscle strength decrease and deconditioning. These conditions can be addressed by provision of strength training therapy especially for people with low exercise tolerance such as the elderly and patients with chronic disease. Existing studies stated eccentric exercise can increase muscle strength with less energy expenditure compared to concentric exercise. However eccentric exercise can lead to muscle damage indicated with an acute CK level increase, and eccentric exercise has not been carried out regularly for post muscle injuries and deconditioned patients. The American College of Sport Medicine (ACSM) stated strength increase and muscle hypertrophy require high intensity load strengthening exercise with a minimum load of 70% 1 Maximum Repetition. The recommended load was given to the subjects in this research. Our pleriminary study intervention was well tolerated by healthy subjects.

Aim: Comparing acute CK level alteration in high intensity eccentric and concentric muscle strengthening exercise on untrained healthy subjects.

Methods: *Randomized pre test and post test group design*. Subjects of the study (n = 16) were untrained healthy males. CK level was evaluated by laboratory test.

Results: Our study showed decline of acute CK level in both groups with p value 0.65 and 0.76, respectively. No significant differences found on both groups.

Conclusion: The increase of acute CK level after five weeks of eccentric strengthening exercise is not higher than that in concentric strengthening exercise.

Keywords: *strengthening, eccentric, concentric, high intensity, creatin kinase.*

Introduction

Muscle strengthening exercise is an important part of a rehabilitation program that aims to improve muscle function in carrying out daily activities, to improve performance in the field of sports, to prevent injuries, to restore muscle strength and hypertrophy post-immobilization due to injury or surgery.[1,2]

The American College of Sport Medicine (ACSM) recommendation for increasing muscle strength and hypertrophy is to prescribe high intensity loads strengthening

exercises with a minimum load of 70% 1 RM (repetition maximum).[1]

It has been known recently that eccentric strengthening exercises present better neural adaptations which can further increase muscle strength, this property can be used in clinical management. For example, eccentric exercises are used in medical rehabilitation to restore patient's condition ssuffering tendinopathy, muscle and ligament injuries.[3]

Various existing literature in the research conducted by Panicker and Muthukumaran stated, among the advantages of the eccentric method is its use in elbow flexor strengthening exercises can be well tolerated by research subjects of healthy people and it can achieve higher absolute force compared to concentric method.[4] The improved force production also increases metabolic efficiency that will then stimulates greater muscle adaptation.[5]

However, the results of previous studies note that the acute effect of high intensity loads muscle strengthening exercises could lead to muscle damage and trigger an inflammatory response.[6] It is shown that eccentric strengthening exercises have a greater risk of muscle damage after exercise due to stretched sarcomeres. Muscle damage after exercise causes many negative consequences, such as decrease in the ability of the muscles to produce force (muscle strength) shortly after exercise, muscle aches that arise some time after physical exercise (Delayed Onset Muscle Soreness/DOMS), and stimulation of inflammatory response.[7]

The amount of muscle damage and inflammatory response after strengthening exercises is influenced by the type of muscle contraction, load intensity, and rest period during strengthening exercises. The greater the load intensity and the shorter the rest period between sets, the greater the muscle damage and the inflammatory response that will occur. This can be seen from the increase of CK levels after muscle strengthening exercises.[8]

In physical medicine and rehabilitation services, many of us find the provision of concentric muscle strengthening exercises in patients with chronic disease conditions. Whereas eccentric strengthening exercises, that are considered to have many advantages as mentioned in the previous paragraph, are not yet commonly found. [3,5]

In addition, there are currently not many studies reporting increase of CK level that occurs after strengthening exercises using eccentric method compared to concentric method with the same intensity, alhough CK level evaluation is important because high CK levels are often associated with muscle damage.[9]

Study conducted by Nosaka and Clarkson in 1992 provides a classic picture of the relationship between work and increase in serum CK.[10] In the experiment, two groups undergone eccentric movements of forearm flexor and isokinetic movements showed same CK levels increase.

In a review by Baird and Graham in 2011, there was a study of limb flexor muscles eccentric strengthening exercises on untrained subjects showing a significant increase in CK levels 24 hours after exercise.[8]

Based on the previously mentioned phenomenon, the purpose of this study was to compare changes in *Creatin Kinase* (CK) levels after the administration of high-intensity concentric muscle strengthening exercises and high-intensity eccentric muscle strengthening exercises on untrained healthy male subjects.

Material and Methods

Subjects were divided into two groups, eccentric and concentric group with *randomized pretest and posttest* research

design conducted for 16 healthy and untrained males in Medical Rehabilitation Department of Dr. Soetomo General Hospital, Surabaya.

Inclusion criterias were untrained and healthy male, 26-45 years old, Body Mass Index (BMI) 18.5-24.9 kg/m2, systole blood pressure 110-120 mmHg, diastole 70-80 mmHg, normal CK level for male (22-334 IU/L), able to understand and follow instructions, agree to be the subject of research and follow the entire series of research by signing informed consent form. Exclusion criterias were those who were undergoing or had undergone a regular upper arm muscle training program within the last 8 months, had history of previous injuries, fractures, or surgery on the non-dominant upper arm, ischemic heart disease (excluded through anamnesis, a history of angina, and ECG examination through the discovery of ST segment depression), not willing to continue the research by any cause, cannot complete the exercise in accordance with the established research protocol (not present in 3 consecutive exercise sessions), muscle pain (DOMS) on the non-dominant arm so that the subjects were not able to do the exercises for 3 consecutive times, chest pain during or after exercise.

All subjects got strengthening exercise on *Biceps Brachii* muscle. One group was tasked with eccentric exercise protocol and the other was tasked with concentric exercise protocol.

Eccentric exercise is one kind of isotonic strengthening exercises done in this study by using the EN-Tree pulley machine for biceps muscle elongation (extension of 0º elbow joints from 90º flexion position) with 70 load intensity % 1 RM, each training session consists of 3 sets, 12 repetitions for each set, with a 2 minute rest period between each set, 2 training sessions / week with a minimum of 1 day between training sessions, for 5 weeks.[4] Meanwhile, concentric exercise is one kind of isotonic strengthening exercises done in this study by using the EN-Tree pulley machine for biceps curl movements (135º flexion motion of the elbow joint from the 0º elbow joint extension position and then back to position 0º elbow joint extension) with 70 load intensity % 1 RM, each training session consists of 3 sets, 12 repetitions for each set, with a 2 minute rest period between each set, 2 training sessions / week with a minimum of 1 day between training sessions, for 5 weeks.[4] In this study, the exercise was done by using non-dominant *Biceps Brachii* muscles, moved with a velocity of twenty five beats per minute using a metronome and carried out in a standing position with the position of the foot against the pulley at a certain coordinated point.[11]

CK level was measured by laboratory testing in 30 minutes before exercise and 24 hours after exercise for 5 weeks.[11] All of the data were collected and analyzed using SPSS version 17 software. This study was ethically approved by Health Research Ethical Committee of dr. Soetomo General Hospital, Surabaya, East Java, Indonesia, with the ethical number: 0456/KEPK/VIII/2018.

Result

The study enrolled 16 untrained and healthy male subjects, age range of 26-45 years old. Characteristics of the research subjects studied included age, weight, height, body mass index and baseline CK level.

Table 1. The characteristics of participants

Characteristic	Eccentric group (n=8)	Concentric group (n=8)
Age (year)	32,12 ± 4,79	32,25 ± 4,80
Body weight (kg)	64,37 ± 10,21	63,62 ± 7,28
Body height (cm)	168,37 ± 6,47	166,37 ± 6,92
BMI (kg/m^2)	22,06 ± 2,26	22,96 ± 1,23
CK (IU/L)	110 (80-200)	140 (104-241)

Table 2.Changes in CK levels after exercise

Exercise group	Pre test (IU/L)	Post test (IU/L)	Δ CK (IU/L)	*p*
Eccentric	122,63 ± 39,19	113,88 ± 21,14	8,75 ± 52,16	0,650
Concentric	157,87 ± 56,17	146,25 ± 72,13	11,62 ± 76,26	0,726

Discussion

The research subjects were divided into 2 groups, namely groups trained with eccentric methods and groups trained with concentric methods. The number of subjects in each group was 8 people.

Baseline CK levels in the eccentric group were lower than concentric group. We suspect this phenomenon happened because eccentric training recruits fast type muscle fibers and motor units that were previously inactive. This will have an effect on the production of larger forces.[3] The ability of muscle to rapidly adapt following the damage from eccentric exercise raises the possibility for protecting a muscle against more major injuries marked by the CK level.[12]

During the study, there were 2 research subjects in the eccentric group who could not do the exercise on a predetermined schedule but they came the following day, complying with the research procedure that was twice a week session with a minimum training interval of 1 x 24 hours. This probably a factor that plays a role in the results.

In the eccentric group, there was no increase in the average CK level after five weeks of intervention. As mentioned in previous literature,[7] the effect of muscle contraction velocity on muscle damage is not a simple matter and most of the muscle damage is caused by the length of tension.[13]

Decrease of CK levels after the second or more exercise session may be influenced by the adaptation process causing the muscles to become more resistant to the risk of damage. Thus, an eccentric strengthening exercises only done once may cause muscle damage, but less muscle damage will be found when the exercise is repeated after a week or even six months (without training during that period). There can be less significant muscle soreness and faster recovery of muscle strength after the second exercise compared to the first exercise. The most dramatic response is a change in CK activity after the first exercise, which will provide a dramatic increase, but will not actually change after the second exercise.[6]

The CK level decrease was lower in the eccentric group compared to the concentric group. Muscle damage in sarcomere due to eccentric motion is first detected by the tendon as a sensory organ, especially in proprioception. The damage itself is brought by mechanical stress in the form of lengthening of the sarcomere. But the next period of exercise, as in the second week, will show less damage. This is the result of the adaptation process. One mechanism of adaptation is an increase in the number of sarcomeres in muscle fibers.[12]

In the concentric group, there was no increase in the average CK level after five weeks of intervention. A literature stated that a decrease in enzyme levels depends on the length of rest after training. Short term rest following physical activity can reduce CK lymphatic transport and release enzymes from muscle fibers.[14]

During the study, there were 4 research subjects in the concentric group who could not do the exercise on a predetermined schedule but changed the following day complying with the research procedure that was twice a week session with a minimum

training interval of 1 x 24 hours. According to researchers, this is probably a factor that plays a role in the results.

In this study, there was no increase in the average CK level after 5 weeks of training in both groups which showed that there was no microeleviation of muscle fibers, especially in the eccentric exercise group. This result is most likely caused by several factors. First, there is the role of AMPK which lowers ATP (*Adenosine Triphosphate*) consumption during physical exercise as a result of increased effectivity and efficiency. At the same time, AMPK will also stimulate biochemical and physiological processes and function and increase ATP production. The main activity of AMPK (*Adenosine Monophosphate-activated Protein Kinase*) is phosphorylating proteins, especially enzymes, and regulating the activity of these enzymes which play a role in important reactions.[1] The relationship between CK and ATP is that CK catalyzes the production of high energy ATP through *phosphate* transfer from *creatine phosphate* which is the main energy storage during rest.[14]

In some circumstances, both directly and indirectly, the control activities of AMPK will trigger a process that reaches its peak in CK elimination from cells as part of a mechanism to prevent muscle failure because of mechanical or metabolic disturbance in muscle cells.[8]

The second factor, rest intervals between sets in strengthening exercises, is a factor that is often overlooked. Some studies suggest that strengthening exercises with short intervals between sets (60 seconds) produce higher serum CK levels than the 180 second rest interval.[9] This is related to the serum CK response associated with physical exercise conditions and the ability to maintain higher muscle tension resulting in damage to sarcomeres.[15]

Third, the results of this study did not show a significant change in CK levels, these were probably caused by inadequate training intensity and frequency to cause a reduced number of sarcomeres. There were reduced CK level either in eccentric group (8,75 ± 52,16) IU/L or concentric group (11,62 ± 76,26) IU/L.

Overall, eccentric group CK levels are lower than concentric group because there are also several training factors that are related to changes in CK levels such as number of training volumes (work).[8] During muscle strengthening exercises, there are a number of work that are often associated with the term volume load, namely the load multiplied by repetitions multiplied by the number of training sets. In concentric training, the total number of exercises from subjects was less than the eccentric group.

Conclusion

After five weeks of training, the increase of acute level of CK in eccentric strengthening exercise is not higher than that in concentric strengthening exercise.

Acknowledgement

This research was partially supported by financial aid of health ministry. We thank our colleagues from Physical Medicine and Rehabilitation department, Airlangga University in Surabaya who provided insight that greatly assisted the research.

References

1. Evetovich T, Ebersole K. (2006). Adaptations to Resistance Training. In: *ACSM's Resource Manual for Guidelines for Exercise Testing and Prescription* 5thedn. Philadelphia: Lippincott Williams & Wilkins, pp. 325-335.
2. Yasuda. (2011). Combined effects of low-intensity blood flow restriction training and high-intensity resistance training on muscle strength and size. *Arbeitphysiologie*, pp.2525-33.

3. Hedayatpour N, Falla D. (2015). Physiological and Neural Adaptations to Eccentric Exercise: Mechanisms and Consideration for Training. *Biomed Research International.*
4. Panicker TJ, Muthukumaran J. (2017). Concentric versus eccentric strength training in elbow flexor strengthening. *Int j Pharm Bio Sci*, pp. 470-475.
5. Roig M, O'Brien K, Kirk G, Murray R. (2009). The effects of eccentric versus concentric resistance training on muscle strength and mass in healthy adults: a systematic review with meta-analysis. *Br J Sports Med*;43, pp. 556–568.
6. Izquierdo M, Ibanez J, Calbet JA, Amezqueta IN, Izal MG, Idoate F, Hakkinen K, Kraemer WJ, Sarrasqueta MP, Almar, Gorostiaga EM. (2009). Cytokine and Hormone Responses to Resistance Training. *Eur J Appl Physiol* 107(4), pp. 397-409.
7. Clarkson PM, Hubal MJ. (2002). Exercise Induced Muscle Damage in Humans. *Am. J. Phys. Med. Rehabil*, 81 (Suppl), pp.52-69.
8. Baird MF, Graham SM, Baker JS, Bickerstaff GF. (2012). Creatine Kinase and Exercise Related Muscle Damage Implications for Muscle Performance and Recovery. *Journal of Nutrition and Metabolic article* ID 960363.
9. Koch AJ. Pereira R, Machado M. (2014). The Creatine Kinase Response to Resistance Exercise. *J Musculoskelet Neurnal Interact* 144(1), pp. 68-77.
10. Nosaka K, Clarkson PM. (1992). Relationship between post exercise plasma CK elevation and muscle mass involved in the exercise. *Int J Sports Med*; 13 (6): 471-5.
11. Scalco RS,Snoeck M. (2018). Exertional rhabdomyolysis: physiological response or manifestation of an underlying myopathy?. *BMJ of Sport*. Vol2, p.4.
12. Proske U, Morgan DL. (2001). Muscle damage from eccentric exercise: mechanism, mechanical signs, adaptation and clinical applications. *Journal of Physiology*, 537.2, pp.333–345.
13. Thiebaud RS. (2012). Exercise Induced Muscle Damage : Is It Detrimental or Beneficial?. Journal of Trainology 1: 36-44.
14. Brancaccion P, Maffulli N, Limongelli FM. (2007). Creatine Kinase Monitoring in Sport Medicine. *British Medical Bulletin* 81 and 82, pp. 209-230.
15. Machado M, Williardson JM. (2010). Short recovery augments magnitude of muscle damage in high responders. *Medicine & science in sports & exercise*, pp. 1370-1373.