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EFFECT OF VITAMIN E ON CREATINE KINASE POST-EXERCISE IN ADULTS

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ABSTRACT

Exercise is well-known for its benefits to strengthen muscles and improve whole-body energy metabolism, but strenuous exercise can cause inflammation and oxidative stress. Increased creatine kinase (CK) level in the blood is an indicator of skeletal muscle damage induced by strenuous physical exercise. Vitamin E is known as a strong antioxidant which can be considered as the solution to attenuate exercise-induced muscle damage by reducing CK levels. There are few articles that discuss the effect of vitamin E specifically on CK. This literature review analyzes the effect of vitamin E on CK especially in adults. Seven articles were obtained and analyzed in this literature review which showed various results regarding the effect of vitamin E on CK level post-exercise especially in adults. Acute administration of vitamin E appears to be more beneficial in reducing CK serum than chronic administration. Vitamin E supplementation alone or in combination with vitamin C seems to provide greater benefits. However, the results still fail to show consistency regarding the effect of vitamin E supplementation in reducing CK serum. This inconsistency can occur due to the research have different sample population, variation of exercise, length of exercise and different doses, duration, and timing of supplementation. Further studies with a large number of participants, homogeneous samples and exercise should be carried out to answer the effect of vitamin E on reducing CK levels after exercise.

Keywords: vitamin E; exercise; muscle damage; creatine kinase

INTRODUCTION

Physical exercise has many health benefits for body, such as strengthening muscles and increasing energy metabolism throughout the body. Among the various molecules and signaling cascades involved in muscle health, reactive oxygen species (ROS) is a factor that plays a role in strengthening muscles during exercise as well as regulates the endogenous antioxidant enzymes. Regenerative response, mitochondrial biogenesis, and strengthened endogenous antioxidant defense are muscle adaptations that are induced by ROS in exercise.[1] On the other hand, strenuous exercise can cause metabolic and mechanical stress on the body resulting in inflammation and oxidative stress. Exercise that increases oxygen demand will increase the flow of electrons in the mitochondria and cause a leak of ROS. The high amount of ROS will increase tissue susceptibility to oxidative stress. ROS have a role in causing oxidative stress and damage to muscle fibers after exercise. High level of ROS during strenuous exercise can cause damage to skeletal muscles at the cellular level.[2] Exercise-induced muscle damage (EIMD) is a common response after intense exercise characterized by symptoms that show up immediately and last up to 14 days after exercise.[3] This condition can lead to a reduction of muscle function temporarily as well as cause muscle pain, swelling, and increased blood levels of intramuscular proteins such as CK.[4]

Several studies have shown that CK in muscle cells will leak out into the bloodstream 24-48 hours post-exercise when muscle damage occurs during or after exercise. The large amounts of CK levels post-exercise show the severity of muscle damage. Muscle damage is related to impaired muscle function and performance after exercise which will affect a recovery period. Therefore, observing post-exercise CK levels in the circulation as an indicator of muscle damage has clinical benefit for determining a useful method of promoting post-exercise recovery.[5]

High interest in post-exercise recovery has been increasing in recent years, and nutrition is a main strategy in this process. There are several supplementation and dietary strategies proposed to reduce muscle damage symptoms after exercise, one of which is antioxidant supplementation. The use of antioxidant supplements can be considered a potential agent to prevent muscle damage due to intense exercise.[4] Recommended antioxidant nutrient to prevent the harmful effects of exercise is Vitamin E.[1] Vitamin E has natural properties as a powerful antioxidant that works by providing electrons to free radicals thereby suppressing ROS and protecting cellular components against muscle damage due to exercise.[2] Vitamin E is fat-soluble and diffuses into biological membranes which allows it to maintain cell integrity and oxidation processes by inhibiting lipid peroxidation which can cause the release of CK. This mechanism allows vitamin E to lower CK concentration and protect muscle cells from damage.[6] Several previous studies have reported that provision of vitamin E showed significant decrease in CK concentration after exercise.[7] There is some evidence to suggest that vitamin E administration for 2-4 weeks before high-intensity exercise can attenuate muscle damage by lowering CK levels.[5] On the other hand, there is a meta-analysis study that states that vitamin E administration has no beneficial effect on CK concentration after exercise.[1]

It is known that vitamin E has strong antioxidant activity which can be considered as the solution to attenuate exercise-induced muscle tissue damage by reducing CK levels. However, provision of vitamin E has shown a controversial effect on CK levels post-exercise. Existing research is still limited regarding the effects of vitamin E supplementation which specifically only focuses on CK levels as an indicator of muscle damage. It is important to know the correlation between vitamin E, exercise, and CK concentration post-exercise in order to improve recovery and achieve a healthy life. This study provides a literature analysis to find the role of vitamin E administration to consider various factors on CK levels especially in adults.

METHODS

The literature search was performed using several databases: Research Gate, PubMed and Google Scholar. The following search terms were used: “exercise”, “vitamin E”, “creatine kinase”, “exercise-induced muscle damage” and “muscle soreness”. The inclusion criteria were original articles published in English or translated to English between 2013-2023 and examined the effects of vitamin E administration in humans especially adult participants. Exclusion criteria were research published before 2013 and conducted on animals. Seven articles out of 18 articles were eligible in this study. These articles obtained and analyzed in terms of topic relevance, research method, objectives, sample size, research findings, ethics, and limitations. Among the 7 articles collected, 1 article was excluded because the research was conducted on participants with an average age of 16 years old.

RESULTS

Table 1. Literature Review

No	Author	Sample	Method	Result

1	Santos SA, *et al* (2016)[8]	Nine healthy adult males with an average age of 24,2 years old	The sample was done in three sessions with intervals of 1 week for each session: • 1 hour exercise-induced hypoxia • 1 hour exercise normoxia • 1 hour exercise-induced hypoxia + vitamin E 1 hour before exercise Blood samples were taken before, immediately after, and 1 hour after exercise	In exercise session with vitamin E supplementation, the level of CK total (53,59 U/L) and CK-MB was decreased (21,14 U/L) compared with exercise without supplementation (CK total: 140,56 – 144,68 U/L; CK-MB: 56,38-68,43 U/L) after 1 hour exercise with p value < 0,05
2	Chou CC, *et al* (2018)[5]	Eighteen Taekwondo athletes average age of 21 years old, divided into two groups of supplementation : The vitamin C+E group and The placebo group	One group was given vitamin C 2000 mg per day + vitamin E 1400 U per day for 3 days before the match and the other group was given a placebo with blinded allocation Blood sample was taken in the morning, before every match and 24 hours after match	Plasma CK was lower in the vitamin C + E group (AUC -57,5% vs Placebo group with p value 0,017)
3	Taghiyar M, *et al* (2013)[2]	Sixty-four female aerobic athletes average age of 35 years old, were divided into four groups: Vitamin C group, Vitamin E group, Vitamin C+E group and placebo group	Group A was given vitamin C 250 mg per day; Group B was given Vitamin E 400 IU; Group C was given vitamin C+E; Group D was given a placebo Blood tests were taken baseline and at the end of four week	There was a significant decrease of CK in groups A, B, and C with p value < 0,05
4	Ferran MM, *et al* (2022)[4]	Eighteen recreational male runners aged between 39 to 58 years old, were	The first group was given supplementation of vitamin E 235 mg/DL alfa tocopherol acetate and vitamin C 1000 mg. Another group was given a placebo	There were no significant differences between CK before and after race in two groups.

		divided into two groups: supplementation vitamin C+E and placebo group	Blood tests were taken two hours before the race and 24 hours after the race	
5	Bataineh M, *et al* (2017)[9]	Fourteen male dead sea runners with an average age of 29,8 years old, were divided into two groups: with supplementation vitamin E and a control group	The supplementation group was given vitamin E 400 IU 3 days before the race until 1 day after the race. The other group did not receive any treatment. Blood samples were taken 24 hours after the event.	Supplementation with vitamin E did not attenuate post-event CK serum (± 5337,3 U/L) compared with the control group (± 5351,6 U/L) with p value 0,98
6	Kashef M (2018)[10]	Twenty healthy males with average age of 22,5 years old, were divided into two groups with single-blind: a group with supplementation vitamin E and a group with a placebo	The supplementation group was given 400 IU of vitamin E for 1 month and the placebo group was given maltodextrin empty capsules. Blood samples were taken pre-exercise, immediately after exercise, and 48 hours after exercise	There were no significant differences of CK serum between the supplemental and placebo groups during this study

DISCUSSION

Antioxidant Properties of Vitamin E

Vitamin E is a fat-soluble compound that has essential antioxidant properties for human health. Vegetables, oils and nuts are the main source of vitamin E.[11] Among the various forms of vitamin E, alpha-tocopherol is the most biologically active and is preferably absorbed and stored in the body. It has anti-inflammatory, antiplatelet, and vasodilator activities so vitamin E can boost the immune system presenting the capacity to promote health, and prevent and cure many diseases.[6] The natural properties of vitamin E as a fat-soluble antioxidant allows it to easily integrates with biological membranes so that it can regulate the oxidation processes in the body. It accumulates in the phospholipid bilayer of cell membranes as well as protects cell membranes, proteins, and DNA from damage by limiting lipid peroxidation and protein oxidation.[1] Vitamin E also plays a role in preventing hemolysis due to free radicals in red blood cells. This condition stabilizes coenzyme Q thereby enabling cellular circulation via the electron transport chain. In addition, this vitamin is also very important for many processes such as in the storage of creatine in skeletal muscles.[12] Exercise-induced oxidative stress on skeletal muscle can be delayed by antioxidant administration.[2] The antioxidant activities of vitamin E can be considered as a possible solution to prevent muscle damage due to intense exercise.[4] Vitamin E may be able to protect cell membranes and reduce cell damage from exercise.[2] Although some data point to the effect of vitamin E on muscle protection, so far not all studies have shown clear benefits. It is known that ROS can increase the susceptibility of tissues to oxidative stress, but on the other hand it is required by the body to act as signaling molecules that enhance protection against greater physical stress. Other evidence suggests that antioxidant supplementation may impair these adaptations by blocking anabolic signaling pathways, and thereby impairing adaptation to resistance training. The balance between ROS and antioxidant systems is important.[13] However, there is a previous systematic review that hypothesizes that vitamin E administration may provide a protective effect in exercise-induced muscle damage.[4]

Creatine Kinase as Muscle Damage Biomarker

Exercise-induced muscle damage is a condition where tears in muscle fibers and connective tissue are formed. Symptoms show up immediately and last up to 14 days after exercise.[3] This condition can lead to a reduction of muscle function temporarily as well as cause muscle pain, swelling, and increased blood levels of intramuscular proteins such as CK.[4] Raised concentration of CK is generally used as a muscle damage biomarker caused by strenuous physical exercise. CK is an enzyme that is responsible for cell energy production so it is commonly found in tissues that require a lot of energy supply, such as muscles and the brain.[14] This enzyme is composed of two subunits which are B (brain) and M (muscle). Each subunit has a molecule weighing 43,000 Daltons. The combination of these two subunits will form three CK isoenzymes, specifically CK-BB (CK-1), CK-MB (CK-2), and CK-MM (CK-3).[3] CK plays a role in catalyzing energy reactions by removing phosphate from creatine and adenosine diphosphate to produce adenosine triphosphate (ATP) and creatine so that the need for ATP for muscle contraction and other processes that require energy can be fulfilled. There have been many studies studying various aspects regarding the relationship between muscular activity and CK. A high amount of CK is usually found during both intense long-term exercise and eccentric muscular training.[15] CK will increase in the blood when there is damage to the structure of the sarcolemma and z-disk.[14] CK usually peaks in the bloodstream 24 to 48 hours after exercise.[9]

Effect of Vitamin E on Creatine Kinase

ROS plays a main role in the etiology of muscle damage through the oxidation of ion transport systems. The antioxidant action of vitamin E was considered a potential agent in reducing CK as a muscle damage biomarker.[4] It can protect cellular components by suppressing ROS and inhibiting lipid peroxidase.[2] Santos et al. in their study showed that the effect of vitamin E administration 1 hour before exercise is significant in reducing CK levels after moderate exercise in hypoxia. Acute vitamin E supplementation have more significant effect than chronic supplementation.[8] Chronic high intake of vitamin E may reduce the adaptive response to exercise so a short-term supplementation may be desirable to avoid the negative effects.[5] The increase in ROS during exercise results in the production of free radicals which cause muscle damage, fatigue and decreased performance. Despite their negative effect on performance, free radicals can act as molecular signalers enhancing protection against greater physical stress. Antioxidant supplementation tends to block anabolic signaling pathways thereby impairing adaptation to resistance training. Vitamin E supplementation may only provide benefits when given acutely. Especially when immediate improvement of performance is needed and adaptation is not the main focus such as in championships or achievement competitions. Chronic antioxidant supplementation is associated with impaired future exercise adaptation and performance.[13] Another study found similar findings that administration of high dose vitamins E (>1000mg) and vitamin C three days before match effectively reduce the increase of CK in taekwondo athletes. It is stated that this condition occurs due to vitamin C and vitamin E having been shown to provide a synergistic effect and have greater biological functions simultaneously.[5] Vitamin E is a strong antioxidant that provides electrons to free radicals thereby suppressing ROS and protecting cellular components against muscle damage due to exercise.[2] Vitamin E is fat-soluble and diffuses into biological membranes which allows it to maintain cell integrity and oxidation processes by inhibiting lipid peroxidation which can cause the release of CK. This mechanism allows vitamin E to lower CK concentration.[6] Vitamins E and C work closely with each other in a way that vitamin C helps to recycle vitamin E back to its reduced state and allows it to continue to oxidize free radicals.[13] A research examines the effect of vitamins E, C, and a combined model of these vitamins separately. The research was designed to be done on female athletes who had been doing aerobics for four weeks. It shows a significant decrease of CK in all groups.[2] Studies with trained participants showed a significant decrease in CK levels with the provision of vitamin E. Responses of CK might depend on the start point of muscle damage that occurred, type of exercise and training situation.[7]

On the contrary, another study revealed that there was no beneficial effect on CK levels after administration of 235 mg of vitamin E combined with 1000 mg of vitamin C two hours before exercise in runners over 30 years of age. Previous studies that detected a beneficial effect on CK from acute or chronic vitamin E supplementation is conducted in participants under 25 years of age. There are also studies that report the beneficial effects of vitamin E administration in response to exercise under hypoxic conditions compared to normoxia. It appears that short period of supplementation might only be effective under certain conditions, such as in younger adults or under hypoxia.[4] Another study also revealed that 400 mg vitamin E administration 5 days before exercise had no effect on CK levels in long distance downhill running. A lot of studies reveal that research participant must have a vitamin E deficiency to detect the effect of supplementation. The response of CK to vitamin E supplementation might depend on individual nutritional status.[9] The findings of existing studies in this literature show that both high and low dose supplementation of vitamin E has not been successful in providing consistent results. Acute or chronic administration of low-dose vitamin E did not significantly reduce CK levels. Meanwhile, high or low doses of acute vitamin E administration showed a decrease in CK levels. This shows that the effect of vitamin E supplementation on CK is more influenced by the period of administration compared to the dose of administration. Antioxidant supplements are beneficial to some extent, but it can be harmful if used in high doses for long periods of time. In addition, the period of supplementation can also affect the effect of antioxidants on exercise response and adaptation. These points may be considerations that make many researchers prefer to conduct research with acute compared to chronic supplementation.

There are still inconsistent findings regarding the effect of vitamin E on CK concentration due to various factors. Several factors may have contributed to the inconsistency in these studies. First, the types of exercise are very diverse. Second, doses of vitamin E administration vary greatly in concentration, duration, and timing of administration. Third, different numbers of samples and differences in gender. Researchers also do not report the same index of muscle damage.[10] Comprehensive interpretation of this study is more difficult because of the lack of homogeneity in the articles collected, the lack of complete baseline CK and vitamin E status analysis data and the lack of some information such as genetic history, lifestyle and exercise intensity and frequency.

CONCLUSION

There was still inconsistency results of vitamin E which can decrease CK serum after exercise. This inconsistency may occur due to each study has a different sample population, variation of exercise, length of exercise and different doses of vitamin E supplementation. From this literature review, it is known that vitamin E somehow reduces CK as a biomarker of post-exercise muscle damage, especially with short-term administration before exercise. Further studies with large participants, homogenous samples and exercise should be done to answer the effect of vitamin E to on CK levels after exercise.

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