EXERCISE-INDUCED MUSCLE DAMAGE (EIMD) AND NATURAL POLYPHENOLS

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Abstract

Although it is well known that physical activity contributes to a healthy lifestyle, unaccustomed exercise or high eccentric muscle contraction lead to exercise-induced muscle damage (EIMD) inducing pains and affecting exercise training in athletes. Several approaches, including nutrition based on a polyphenols-rich diet or supplementation, have been showed to prevent and/or reduce muscle damage in athletes after physical exercise. In this manuscript we addressed the effect of natural polyphenols as antioxidant and anti-inflammatory agent that are used on recovery of EIMD in athletes.

Key words: muscle soreness, polyphenols, recovery, sport supplements.

Introduction

Many sports and training exercises with high eccentric muscle contractions may cause "exercise-induced muscle damage" (EIMD), leading to muscle soreness, loss of functions and a reduced range of motion (Clarkson & Newham, 1995; Clarkson & al., 2002). These symptoms appear at the end and for up two weeks after the initial exercise training.

In the last years, many efforts have been devoted to a better understanding of the molecular and cellular mechanism involved in EIMD insurgence in order to identify strategies able to prevent or treat these symptoms. The nutritional approach is focused to the administration of supplement and functional foods that can contribute to the tissue muscle repair and functions.

Discussion

Exercise-induced muscle damage (EIMD)

Physical exercise, including high force or a large amount of eccentric muscle contractions such as prolonged running (Millet & al., 2011), resistance training (Burt & al., 2014), intermittent high intensity exercise (Leeder & al., 2014), more often produces EIMD. This phenomenon induces mainly a muscular disruption at Z-line streaming which is accomplished to fiber degradation. Mechanisms involved in EIMD are complex and still not well understood although it is known that eccentric contractions cause the initial damage which increases over 2-3 days. Physical damages occur at skeletal muscle structure such as the sarcomere and sarcolemma and these damages are attributed to an impaired coupling of eccentric lengthening and excitation during the contraction (Armstrong & al., 1991). Several theories to explain the molecular mechanism of muscle damage, have postulated that not only myosin and actin, contractile proteins involved in the cross-bridge theory, are implicated but also the interaction between titin and actin is involved in EIMD.

Up until today, the cross-bridge theory for muscle contraction (Huxley & Niedergerke, 1954) has been widely accepted as the molecular mechanism to explain isometric and concentric contractions. The eccentric contraction, with an active muscle lengthening under an external load, also include the activation of the structural protein titin, and the winding of titin on actin (Douglas & al., 2017).

Biomarkers of muscle damage

The initial mechanical fiber disruption causes a muscle damage that is followed by an inflammatory response. The muscle damage can be evaluated by the increase of inflammatory markers such as thromboxanes, prostaglandins, and leukotrienes (Kim & Lee, 2014). These events lead to a delayonset muscle soreness (DOMS), an increase in specific intramuscular proteins in circulation, swelling of the affected limb, a decrease in range of motion and an impairment of muscle force (Byrne & al., 2001).

Not only eccentric exercise but also high loads and unaccustomed exercise may lead to DOMS that can affect the training activity. DOMS represents the most common symptom of EIMD and it is characterized by muscular pains, stiffness, fiber swelling and strength loss (Gleeson & al., 1998). Therefore, DOMS negatively affects the athletes sport training and performance. DOMS can occur in acute, during the exercise and prolonged for about 4 -6 hours, or after the exercise, between 24-48 hours.

DOMS is associated to an alteration of biochemical markers including either specific muscle enzyme or enzyme for oxidant and anti-oxidant status (Nasso & al., 2019). Among serum blood markers of muscle damage, increased levels of specific muscle enzyme activities such as lactate dehydrogenase (LDH), and creatine kinase (CK) peaked at 24 hours after exercise.
Strenuous physical exercise increases ROS production causing an oxidative stress which can lead to cell damage and loss of physical function. However, in physiological conditions, ROS can improve the endogenous antioxidant defense system. The exercise-induced ROS production can lead to an increase of glutathione peroxidase (GPx) plasmatic levels (Nasso & al., 2019).

**Muscle repair**

Muscle damage is followed by an inflammatory response that eliminates the damaged tissue and triggers tissue repair to restore its functions (Chazaud, 2016). At the site of injury, the tissue repair process is characterized by the infiltration of numerous immune cell types, such as mast cells and neutrophils, mainly involved in the phagocytose of cellular debris, and macrophages which secrete growth factors. In addition, neutrophils and macrophages are also involved in ROS generation by production of reactive species (e.g. superoxide anion).

Since myofibers cannot regenerate, muscle repair occurs by satellite stem cells that are located proximity to the muscle fibers. Satellite cells, representing about 2-10% of total mononucleate muscle cells, are involved either in skeletal muscle growth or regeneration after a muscle trauma.

Muscle satellite cells represent myogenic precursors that undergo proliferation and differentiation after appropriate stimuli leading to repair of damaged fibers (Dumont & al., 2015). Molecular events following muscle injury and growth stimuli include activation of several coordinated transcription factors.

**Strategies for prevention and treatment DOMS and green tea polyphenols**

Multiple strategies can be adopted for DOMS prevention and treatments. These different approaches include massage, stretching, pharmacological therapy (e.g. non-steroidal anti-inflammatory medications) and nutritional supplements, such as branched-chain amino acid (BCAA), L-carnitine, used for the repair of muscle damage and recovery of muscle functions, and then anti-oxidant and vitamins (Meamarbashi, 2017). In addition, many studies have also analyzed the effects of nutritional supplements (Owens & al., 2019). As natural supplements, polyphenols from fruits and vegetables, known as major components of the health-promoting for their anti-oxidant properties and acting as anti-inflammatory and anti-cancer agents (Arcone & al., 2016; Romain & al., 2017).

In addition, since inflammation and reactive oxygen species (ROS) are also involved in EIMD, numerous dietary polyphenols have been tested for their effect on prevention and treatment of DOMS (Kim & Lee, 2014; Bowtell & Kelly, 2019).

Many studies have been performed to investigate the effect of these products such ascurcumin, omega-3 fatty acids and polyphenols (Meamarbashi, 2017, Cases & al., 2017).

Green tea polyphenols extract, rich in catechins, including epigallocatechin gallate (EGCG), epigallocatechin, epicatechin gallate and gallocatechin gal late, induces beneficial effects on metabolism, including fat oxidation at rest and during exercise (Hodgson & al., 2013) and also exhibits protective effects against environmental toxins such as polychlorinated biphenyls (PCBs) (Adornetto & al., 2013; Chen & al., 2017).

Studies performed in athletes on the effect of green tea extract on DOMS, muscle damage and oxidative stress, have demonstrated that the supplementation decreases CK activity, therefore suggesting that muscle damage was minimized during the exercise, vice versa, no effects were observed in LDH activity (da Silva & al., 2018; Machado & al., 2018).

Further, scientific literature also demonstrated that green tea extract supplementation increases fat oxidation and exercise-induced muscle GLUT4 protein content after endurance exercise (Tsai & al., 2017). Among dietary polyphenols, lemon verbena extract, identified as anti-inflammatory agent, has been shown to be a safe and well-tolerated natural supplement, by reducing muscle damage after exhaustive exercise (Buchwald-Werner & al., 2018).

**Conclusion**

Natural polyphenols, known for their anti-inflammatory and anti-oxidant properties, are also able to reduce muscle strength loss and accelerate muscle recovery after intense physical exercise.

Supplementation with green tea extract has shown to induce benefits on DOMS associated muscle damage. Therefore, these promising results of polyphenols supplementation represent useful approach to minimize exercise-induced muscle damage and acceleration of exercise recovery strategy. However, further studies will be required to elucidate the dosage and the time of supplementation.

**References**


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