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Review Article

Etiology, risk factors and complications of exercise induced muscle injury

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ABSTRACT

Healthy lifestyle includes physical activity as the basic component however, exercises with eccentricity have been associated to a higher risk of muscle injury and slower recovery. The development of exercise-induced muscle injury is a phenomenon that results from atypical or unaccustomed activity; the intensity of the pain and the extent of the damage steadily deteriorate over time, and when the exercise session contains an eccentric component, they may last for several days. Increasing levels of muscle-specific circulating protein are present, along with increased levels of muscular pain and decreased muscle strength. The extent of severity of the symptoms following eccentric exercise varies greatly. Exercise-induced muscle injury is influenced by a number of factors including intensity, duration, mode, muscle group, age, gender, genetics, and dietary state. Numerous scientific studies illustrate the circumstances under which exercise causes muscle injury. It is widely acknowledged that exercise that is unfamiliar, particularly exercise that involves eccentric contractions, causes damage. exercise-induced muscle injury is accompanied by an inflammatory response involving numerous mediators, including the production of muscle-specific creatine kinase and interleukins and interleukins receptor antagonist and acute phase proteins. Complications of exercise-induced muscle injury include temporary muscle inflammation, loss of strength, muscle discomfort, restricted range of motion, elevated passive tension, discomfort, and a momentary decline in insulin sensitivity and can also lead to rhabdomyolysis. The purpose of this research is to review the available information about an etiology, risk factors and complications of exercise-induced muscle injury.

Keywords: Muscle, Injury, Exercise, Eccentric

INTRODUCTION

The dedication to a physically active lifestyle, which may include exercise and sports, is essential for the improvement and maintenance of physical fitness and health. Defined guidelines are present for the ideal levels of physical activity to promote physical health and fitness in populations.[1] Humans frequently experience exercise-induced muscle injury after new or unusual exercise, especially if the exercise includes a lot of eccentrics which is muscle-lengthening contractions. Cellular and subcellular abnormalities, particularly Z-line streaming, are direct indicators of exercise-induced muscle injury. Increases in T2 signal intensity using magnetic resonance imaging techniques, prolonged drops in force production during electrically and voluntarily stimulated contractions especially at low stimulation frequencies, increases in inflammatory markers in the injured muscle and blood, an increase in the appearance of muscle proteins in the blood, and soreness in the muscles are a few indirectly assessed markers of muscle damage after exercise. The initial injury is attributed to mechanical disruption of the fiber, and further damage is linked to inflammatory processes and alterations in excitation-contraction coupling within the muscle, even if the precise mechanisms to explain these changes have not yet been defined.[2]

Exercise-induced muscle injury is a phenomena that develops as a result of unusual or unaccustomed activity; the degree of the pain and the severity of the damage progressively worsen with time, and when the exercise session includes an eccentric component, it may endure for several days.[3] Numerous scientific studies illustrate the circumstances under which exercise causes muscle injury. It is widely acknowledged that exercise that is unfamiliar, particularly exercise that involves eccentric contractions, causes damage. However, further bouts of eccentric exercise will not harm muscles that have undergone preconditioning with eccentric contractions. Few research has shown intrinsic causal variables or appropriate therapies for symptom management, despite the large number of publications describing muscle injury and its diverse clinical manifestations. In the clinical setting, it's critical to first identify those who are at a higher risk of experiencing more severe symptoms before devising interventions that could lessen those symptoms.[4]

Symptoms of exercise-induced muscle injury can appear right away or up to 14 days following the first exercise session. The effects of exercise-induced muscle injury on an individual's ability to function, muscle soreness, exercise tolerance, and feeling of force production and limb posture are all directly impacted. The intensity and length of the performance-harming exercise, as well as the person's vulnerability to the stimulus, all affect how severe and quickly these symptoms manifest and have an impact on performance.[5] Exercise performance is impaired as a result of exercise-induced muscle injury. Functionally, muscle strength is decreased by 20 to 50% right away, and full recovery after activity might take up to 7 days. Systemically, exercise-induced muscle injury is accompanied by an inflammatory response involving numerous mediators, including the production of muscle-specific creatine kinase and interleukins and interleukins receptor antagonist and acute phase proteins. Exercise-induced muscle injury causes temporary muscle inflammation, loss of strength, muscle discomfort, and may lead to a later avoidance of exercise.[6] The purpose of this research is to review the available information about an etiology, risk factors and complications of exercise-induced muscle injury.

METHODS

This study is based on a comprehensive literature search conducted on 18 November 2022, in the Medline and Cochrane databases, utilizing the medical topic headings (MeSH) and a combination of all available related terms, according to the database. To prevent missing any possible research, a manual search for publications was conducted through Google Scholar, using the reference lists of the previously listed papers as a starting point. We looked for valuable information in papers that discussed the information about etiology, risk factors and complications of exercise-induced muscle injury. There were no restrictions on date, language, participant age, or type of publication.

DISCUSSION

Injury to the skeletal muscles caused by exercise is most visible after unusual, eccentric muscular motions. Eccentric actions are characterized by a loading profile with a high force and low fiber recruitment, which puts a significant mechanical strain on the related structures. It is generally accepted that these mechanical elements cause exercise-induced muscle injury, and that the severity of the injury depends on the amount of strain and the muscle's length. Theoretically, disruption of the sarcomeres caused by mechanical stress and failure of the excitation-contraction coupling system are thought to be the main causes of injury. A variety of biochemical changes in the affected area, such as an increase in inflammatory cytokines and reactive oxygen species, may exacerbate the injury. Numerous studies have examined the effects of eccentric exercise at various intensities and how it contributes to muscle damage.[7]

Etiology and risk factors

Strenuous and unaccustomed physical activity, particularly exercise involving eccentric muscular contractions where muscles extend as they apply force can cause muscle injury. Both directly at the cellular level and indirectly through changes in several muscle function indices, damage can be seen. The genesis of the damage/repair process has been explained by a number of mechanisms, including mechanical variables like tension and strain, changes in calcium homeostasis, the inflammatory response, and the production of stress

proteins such as heat shock proteins. At the cellular level, changes in the amount and function of transport proteins for glucose and lactate/H+ have been seen after eccentric exercise. At the systematic level, changes in muscle function have been seen as an increase in stiffness and a sustained loss in the muscle's ability to generate force.[8] Diffuse muscle discomfort from misuse of the muscles is linked to structural damage to the contractile parts. Muscle injury is supposedly mostly caused by mechanical stress. After the first harm, there is an inflammatory reaction, and then there is regeneration. It is believed that calcium plays a significant part in initiating the inflammatory alterations. The delayed onset of muscle pain is unaccounted for because biopsy data on people show that the inflammatory alterations in humans do not correspond to the soreness assessments. One session of eccentric exercise has a long-lasting protective effect against damage brought on by a second bout of exercise, which is a well-known phenomenon.[9]

The likelihood of injury depends on a number of factors, including age, gender, injury history, body size, regional anatomy and biomechanics, aerobic fitness, muscle strength, imbalance, and tightness, ligamentous laxity, central motor control, psychological and psychosocial factors, as well as general mental ability. In numerous sports, juniors of age 15- to 16-year-old and senior competitors appear to be at a larger risk of injury. However, it appears that the type and level of exercise engaged in affect the association between age and injuries. In numerous studies, male athletes made up the majority of the injured athletes. It is unknown if men are generally more likely to sustain an injury when the exposure is taken into consideration, despite the fact that men are more likely to engage in sports and rigorous activity. Sprains, strains, and dislocations are examples of lesions that frequently repeat. If properly managed, prior injuries may not always result in a repetition of harm, but some people may be more vulnerable to injury because of biological traits that make them more prone to harm. It has been demonstrated that increased height and weight elevates the risk of stress injuries during physical activity. A local injury may result from idiopathic or acquired anomalies of the anatomy or biomechanics of any joint.[10] In accordance with a number of studies, having a high body mass index and percentage of body fat can have a considerable impact on the markers of muscle injury following exercise, such as myoglobin levels, delayed onset muscle soreness, maximum strength, and delayed onset muscular soreness. Potential mechanisms for these results include differences in muscle fiber distributions, sedentary habits, elevated inflammatory responses brought on by adipose tissues, reduced muscle satellite cell activation and myogenesis caused by lipid overload, and structural changes in the cell membrane brought on by high fat levels.[11]

Stiffness of the muscle and static flexibility, its clinical counterpart, are risk factors for more severe signs of exercise-induced muscle injury following eccentric activity.[12] Results of a retrospective cohort study showed that soldiers most frequently cited lifting and carrying, dismounted patrolling, and physical training as the reason for an injury. Age, higher enlisted rank, number of months deployed, lengthier strength training sessions, wearing the heaviest load, and more frequent or harder lifting jobs were all linked to injury. Tasks requiring physical exertion, such as carrying loads, lifting objects, or standing up, increased the risk of musculoskeletal injuries.[13] Ertel, Hallam and Hillman described in their study that exercise-induced muscle injury may be more likely to occur in people who exercise beyond their level of fitness, although it is unclear how training status affects the development of muscle damage. In comparison to low intensity exercise, high intensity exercise causes more muscle injury in both trained and untrained people. Untrained people should exercise caution when starting exercise regimens that call for repeated bouts of high intensity exercise since they experience pain more intensely and more quickly.[14]

Complications

An individual may experience exertional rhabdomyolysis after engaging in vigorous exercise. It can occasionally be accompanied with muscle aches and weakness as well as myoglobinuria, or cola-coloured urine. Striated muscle injury and the release of cellular components into extracellular fluid and the circulation are part of the pathophysiology of exertional rhabdomyolysis. Acute renal failure, aberrant electrolytes, arrhythmias, and maybe even death, might result from this. Exertional rhabdomyolysis is seen in highly trained or elite groups of military people as well as high-performance athletes who have engaged in extended, intense, repeated, and/or repetitious activity. Viral infection, drug and alcohol addiction, exercise in extremely hot and humid situations, genetic polymorphisms such as sickle cell trait and McArdle disease, and epigenetic alterations have all been documented to increase the chance of the condition in athletes.[15] Functionally, loss of strength results from disturbed calcium homeostasis, disruption of excitation-contraction coupling, disruption of force transmission, and metabolic alterations. It's significant to note that the trauma also triggers an inflammatory response, which manifests clinically as edema, restricted range of motion, elevated passive tension, discomfort, and a momentary decline in insulin sensitivity.[16]

It has been demonstrated that novel, unfamiliar activity causes transitory, repairable skeletal muscle injury. After prolonged endurance exercise, metabolic abnormalities brought on by ischaemia can cause muscle injury. After relatively brief eccentric exercise with strong mechanical stresses, extensive muscle fiber damage also takes place. Biopsies performed following repeated eccentric muscle contractions have shown Z-disc widening, streaming, and occasionally complete disruption. Additionally to becoming sore and losing their natural ability to produce force, muscles that develop active tension eccentrically also exhibit a noticeable release of muscle proteins into the bloodstream.[17] Exercise induced muscle injury decreases

agility and sprint performance, which is another proof that activities involving the quick generation of force are difficult to perform after muscle-damaging exercise.[18] Weaker sarcomeres take up the majority of the muscular stress during muscle contraction, which causes their disruption after several contractions. The surrounding structures, including as the sarcolemma, muscle spindles, and other sarcomeres, may also be affected by this injury. Such changes decrease muscle function over the long term, including proprioceptive functions like joint position perception and force output. Full recovery can take anywhere between 48 hours and more than seven days. Given the significance of proprioception for motor learning and the way that exercise-induced muscle injury disrupts proprioceptive information, it makes sense to assume that exercise-induced muscle injury impairs motor learning.[19]

Numerous significant metabolic effects of exercise-induced muscle injury exist. Reduced insulin sensitivity, extended glycogen depletion, and an increase in metabolic rate both at rest and during exercise are the most significant metabolic consequences of exercise-induced muscle injury.[20] Muscle has a limited ability to regenerate after injury, therefore scar tissue is formed as part of the healing process. The amount of muscle necrosis and the size of the haematoma are commonly correlated with each other. The vector of normal muscle contraction is changed by the presence of an intramuscular scar, decreasing strength and increasing fatigue. Therefore, a greater risk of re-injury results from increased muscle exhaustion and changed muscle biomechanics that occur with more severe injuries.[21] Further research elaborately studying the risk factors and complications of exercise-induced muscle injury is required for development of effective preventive strategies to reduce the risk of such injuries also will add to the literature since the available studies are quite limited.

CONCLUSION

Exercise-induced muscle injury poses a significant impact on individuals' physical ability and if not treated timely can lead to hazardous complications hence timely diagnosis and prompt management is essential also physical activity under the supervision of experts shall be encouraged to prevent exercise-induced muscle injuries.

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