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Delayed Onset Muscular Soreness: A look into post-exercise pain

Christopher Meltsakos

INTRODUCTION

Have you ever worked out hard one day and experienced that dreaded dull ache, stiffness, and tenderness in your muscles 24-72 hours later? Since you're actually reading this, you most likely have had the pleasure of experiencing this phenomenon at least once in your lifetime, and if you're like many other people, you've also probably wondered, "Why is this pain so delayed? Is this normal? Shouldn't this post-exercise pain peak shortly after a workout and not 1-2 days later?"

Delayed Onset Muscular Soreness:

To begin, one should get accustomed with the term delayed onset muscular soreness (DOMS). This term refers to the characteristic muscular pain that was described above as a dull ache, accompanied by stiffness and tenderness that is most commonly experienced 24-72 hours post-workout and intensified with stretching, contraction, and pressure of the affected muscles.[3] Some people actually refer to these symptoms as "muscle fever" because of the inflammatory process and pain felt in the muscles.

DOMS is most commonly and intensively experienced after an individual participates in an unaccustomed activity involving eccentric contractions, which for review, includes any activity in which the muscle undergoes lengthening as it contracts.[3] At first, the definition of eccentric contraction may seem a bit contradictory of what one normally perceives as a muscle contraction because we usually think of a muscle shortening in length to lift an object, as seen in an activity like bicep curls (concentric contraction). To further understand how DOMS affects a muscle, it helps to visualize an eccentric contraction by thinking of a situation analogous to lowering a weight/load slowly so as not to let it drop, or decelerating a body part after a movement. In these processes, we actually lengthen muscle fibers while they're actively contracting. It has been shown that this kind of mechanism is more damaging to muscle cells than the other types of contractions due to the mechanical shearing at the extracellular matrix and the high specific tension that is placed upon the connective tissue, myofilaments, sarcolemma, sarcomeres, and sarcoplasmic reticulum.[1,2]

Understanding now that eccentric contractions are most associated with the symptoms characterizing DOMS, one can begin to appreciate that the mechanism of pain is due to the mechanical stress applied to the ultrastructural components of the muscle cells during an eccentric contraction. As we stress a muscle cell in an exercise, the cell's membrane must withstand a great deal of mechanical stress. The cell must lengthen and shorten on command while maintaining its integrity upon physical contact in athletic situations such as a football hit, soccer slide tackle, hockey check, etc. Although the exact mechanism of DOMS is not clearly understood, the most commonly accepted proposal involves damage to the sarcolemma, which leads to disruption in the calcium homeostasis of the affected cell.[3] The damage by calcium can lead to cellular debris and immune cell infiltration, which would account for the sensation of pain and slight inflammation seen in DOMS. Such muscle damage can be measured by an increase in serum creatine kinase levels that peaks around 24 hours post-exercise. Furthermore, the broadening or disruption of ultrastructual components such as the z-disc and the myofilaments has been observed in DOMS. This transient disruption and dysfunction of the contractile elements in the damaged muscle contributes to the deficits in strength that are observed by individuals with DOMS and lends to the inflammatory process that results in localized edema. With increased tissue edema, the presence of prostaglandin E2 has been noted and postulated to increase the mechanical sensitivity of the group iv afferent nociceptors , resulting in the characteristic dull pain and tenderness upon stretching and palpation.[2,3,5]

Another theory proposes a slightly different mechanism for the onset of DOMS after atraumatic contrac-

tions involving long-duration exercise of moderate intensity.[3] This theory attempts to account for the symptoms of DOMS seen after long-distance running as opposed to weight lifting or sprinting and involves local muscle ischemia or hypoxia as the mechanism of cell injury.[3] This localized ischemia in the muscle tissue is hypothesized to result in hypoxic cell injury, which would decrease ATP synthesis and Na/K ATPase action due to the switch to anaerobic glycolysis, decrease intracellular pH due to lactate production, and impair protein synthesis due to detachment of ribosomes. This damage would result in the activation of the inflammatory cascade, which would stimulate nociceptors by direct prostaglandin action or by increased tissue pressure due to edema within the muscle. Additionally, there are also reperfusion type injuries that occur after the ischemia is relieved which may contribute to this process. As logical as this theory may sound, it is quite unlikely to be the causative mechanism for DOMS. It fails to acknowledge the fact that despite the more metabolically demanding nature of the concentric contractions, which require greater motor unit recruitment, they are not associated with the characteristic DOMS symptoms. Furthermore, a transient reduction in perfusion can be provoked by a localized increase in pressure within in the muscle that occurs in high-intensity weight training, or by a sweat-induced decrease in plasma volume. Given that neither of these modalities produces DOMS symptoms, the ischemia model certainly needs further investigation to examine specific instances in which hypoxic cell injury may result in DOMS.

So you're probably thinking, "Wait! What?! Is DOMS a warning sign that exercise is killing my muscles?!" Well, the answer to that is most certainly not. As we all know, with any acute pain, it is always best to double-check with one's physician, but in general DOMS is not indicative of severe magnitude muscular damage. In fact, the continued use of sore muscles typically has no adverse effect on muscle recovery as long as an individual allows an adequate recovery period after his/her workouts to prevent the manifestation of overtraining syndrome.[3] One must keep his or her scope in perspective and realize that this damage is occurring on a cellular level and is not of a larger-scale magnitude. Furthermore, there is a phenomenon known as the "repeated-bout effect" which simply suggests that once one has done a new and unaccustomed eccentric exercise that results in DOMS, one's muscles will rapidly adapt to the exercise so that subsequent participation in the same exercise will result in reduced damage to the muscle and decreased pain.[2]

TREATMENT

Delayed onset muscular soreness is not an inevitable hurdle that all exercisers must face. There are actually a number of things that one can do to try to prevent DOMS. The most effective way to limit this kind of post-exercise pain is to gradually work your way up to an intense exercise or longer-distance.[3] It is more traumatizing to the muscle if you exert an unaccustomed level of exertion upon the fibers than if you slowly work your way up to the desired intensity. In addition, one can attempt to limit the eccentric components of an exercise, which should theoretically reduce the symptoms of DOMS since there should be less structural damage. Unfortunately, stretching does not prevent DOMS because the etiology of DOMS symptoms comes from the damage to the muscle cells, which is not preventable by such measures.[3] In addition, cold water therapy, which has become increasingly popular in professional sports and involves the application of 13°C water for 20 minutes to affected muscles, has seemed to be effective in decreasing pain and more quickly increasing muscle activation amplitudes in competitive male distance runners.[5]

The proposed mechanism of the aforementioned pain relief surrounds the reflexive vasoconstriction that occurs in the local vessels of the muscle in which the ice treatment is applied to. Such vasoconstriction diminishes the inflammatory cascade and local edema, which theoretically reduces the pain perception. Conversely, there is also evidence contraindicating the use of cold water therapy in treating DOMS. A 2007 study published in the British Journal of Medicine examined 40 untrained volunteers and randomized them into two groups: one group that received cold water treatment (5+/- 1°C) and another that received tepid water treatment (24°C).[4] After subjecting the participants to seated leg extensions to elicit eccentric muscle damage, they measured a number of parameters including serum CK, muscle belly circumference, and perception of muscle tenderness.[4] Their results

indicated that there were no statistically significant decreases in any of the tested parameters amongst individuals in the cold water treatment group.[4] The researchers argue that many of the previous studies that substantiated the theoretical benefit of cold water treatment were not adequately controlled, which lead to conflicting data in regards to the efficacy of the treatment modality.[4] Lastly, although unsubstantiated, some anecdotally claim that exercising after the onset of DOMS will actually reduce or eliminate the soreness.[3]

Overall, the delayed pain that many experience 1-3 days after working out is not due to the popular misconception that "lactic acid is building up inside of the muscles."[3] Despite the claims of many gym teachers, coaches, and athletes, who at times cling to this lactic acid theory, we now know that this is most likely not the case because the type of activity which produces the greatest amount/intensity of DOMS symptoms (eccentric contractions) produces lower lactate levels than concentric and isometric contractions.3 Furthermore, lactate has a half-life of 15-25 minutes and is cleared from our muscles within an hour, so it is not present in the tissue to be causing soreness 48 or 72 hours later.[3]

CONCLUSION

Whether an individual is a high school student who's just finished "two-a-day" football or soccer practices, a runner trying to get in shape for an upcoming fall race/marathon, or simply a novice attempting to get back into a workout routine, it's important to remember some of the methods of preventing DOMS. In addition to fact that DOMS can limit one's performance and athletic participation, it's also never fun to experience that seemingly all-too-familiar ache after an intense bought of exercise, so try to make sure you're easing into your workouts. A pain-free athlete is generally a happier and more productive athlete.

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