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Treatment of delayed-onset muscle soreness: Is prevention the answer?

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KEY POINTS:
• Numerous strategies exist to ameliorate delayed-onset muscle soreness (DOMS) after strenuous activity, but a theoretically sound and consistent treatment has not been established.
• Treatments showing promise for the relief of DOMS after exercise-induced damage include use of some non-steroidal anti-inflammatory drugs, compression, yoga training, and increases in light muscle activity.
• For the athlete, preventing muscle damage through gradual adaptation to stressful exercise may be the best treatment strategy for DOMS.

INTRODUCTION

Delayed-onset muscle soreness (DOMS) is the perception of pain and discomfort in the muscles appearing in the days following strenuous, unaccustomed physical activity. While the mechanism of acute muscle soreness following exercise is known, the etiology of DOMS is not well understood. With DOMS, the intensity of muscle discomfort increases in the hours after strenuous activity, reaching a peak after 24-48 hours, and is generally resolved within a week (Connelly et al., 2003). The symptoms of DOMS include pain and tenderness either throughout the muscle belly or in the distal portion of the muscle at the myotendinous junction during palpation of the muscle or movement. Because DOMS can occur following strenuous everyday activities that are not associated with participation in sports or in formal exercise programs, it is likely that at one time or another everyone has experienced some form of DOMS. The recreational or trained athlete would likely benefit from a reliable treatment strategy for DOMS, which could remove a potential barrier to continued sport participation and optimal athletic performance. This article will briefly review the research on treatment strategies for DOMS after strenuous exercise and highlight the most promising of these treatments. The reader may wish to consult other more comprehensive reviews of the topic (Armstrong, 1984; Connolly et al., 2003).

RESEARCH REVIEW

Treatment strategies that purportedly alleviate the symptoms of DOMS are numerous and varied and include stretching, warm-up, massage, light muscle activity, use of anti-inflammatory medications and nutritional supplements, homeopathy, compression, cryotherapy, acupuncture, yoga, transcutaneous electrical nerve stimulation (TENS), ultrasound, laser therapy, hyperbaric oxygen therapy (HBOT), and combination therapies. This wide range of treatments is likely

due to a limited understanding of the exact mechanisms associated with DOMS. It is generally thought that inflammatory processes contribute to DOMS. Inflammation in the hours after strenuous exercise results in the proliferation of monocytes, which synthesize large amounts of prostaglandins. Prostaglandins, in turn, sensitize certain nerve fibers in the muscle to the effects of histamine, bradykinin, and other inflammatory mediators, resulting in the increased sensation of pain. A strong theoretical basis for many of the studies designed to ameliorate DOMS has been to target this inflammatory response.

Probably the most commonly investigated treatment for DOMS has been aspirin and other non-steroidal anti-inflammatory drugs (NSAIDs). A recent search of appropriate databases has revealed at least 25 published studies examining the effects of ibuprofen, flurbiprofen, naproxen, ketoprofen, indomethacin, diclofenac, and others on DOMS after strenuous exercise. Interestingly, for every study demonstrating the effectiveness of a particular NSAID, there is another report showing little or no effectiveness. Differences in the type of NSAID used, its mode of action, dosage and duration of treatment, and whether it was administered prophylactically or therapeutically are factors likely contributing to the inconsistency among the research findings. However, NSAIDs such as ketoprofen have been shown to reduce the perception of muscle soreness when administered either orally (Sayers et al., 2001) or transdermally (Cannavino et al., 2003) during peak muscle soreness. Diclofenac has demonstrated efficacy in reducing the symptoms of DOMS during both short-term (1.5 to 72 hours after exercise; Donnelly et al., 1988) as well as long-term administration (13 to 14 days after exercise; O'Grady et al., 2000). Because ketoprofen and dicolfenac are dual-action NSAIDs and block the two major pathways of prostaglandin production, these NSAIDs possibly provide a more robust anti-inflammatory or analgesic effect compared to single-action NSAIDs such as ibuprofen or aspirin. NSAID use, however, carries with it the risk of overuse and misuse, which could result in potential side effects such as stomach ulcers, liver damage, and kidney failure. In addition, inflammation itself is a necessary part of muscle remodeling and regeneration after muscle injury. Interfering with this natural healing process could conceivably be detrimental to long-term muscle health and recovery.

Surprisingly, other treatment strategies targeting the inflammatory response have generally been unsuccessful. Massage and cryotherapy, which target inflammation and edema by affecting arterial dilation and blood flow, have proven to be largely ineffective in numerous studies. Kraemer et al. (2001) recently introduced the application of compression, typically used in rehabilitation to reduce swelling and lymphedema, in the treatment of DOMS. A compression- sleeve garment worn for 5 days after eccentric exercise of the elbow flexors was found to be effective at reducing DOMS, but whether the efficacy of the treatment was due to a reduced inflammatory response was not examined.

Other strategies, such as increasing the activity level of muscle after injury, have emerged as potential treatments of DOMS. Light exercise of the sore and damaged muscle employing only concentric muscle actions (Saxton & Donnelly, 1995) or light dumbbell exercise (Sayers et al., 2000) can relieve DOMS. However, this relief lasts only briefly and has little effect on long-term recovery from DOMS. Recently, acute bouts of yoga training have been reported to reduce peak soreness levels from eccentric exercise (Boyle et al., 2004). More studies using exercise treatments are needed to determine the mechanisms associated with these findings. Currently, there is either no strong scientific rationale or only limited published evidence to support the use of other therapies such as homeopathy, warm-up, stretching, HBOT, TENS, laser therapy, ultrasound, nutritional supplements, or acupuncture.

Several problems exist within the DOMS literature that likely contribute to the inconsistency among research findings. First, different exercise models used to

induce muscle damage (e.g., downhill running, high-force eccentric exercise protocols, isokinetic dynamometry, upper vs. lower extremity exercise) cause variable levels of muscle injury; thus, two similar treatments applied to cohorts with different degrees of muscle injury may show very different outcomes. Second, in this author's experience one-third of participants undergoing eccentric exercise exhibit little or no DOMS. If these individuals are included in an active treatment group, they may appear to benefit greatly from the particular treatment. Conversely, if included in a placebo or control condition their presence could mask the efficacy of a particular treatment. This could prove problematic in studies that begin treatment prior to the appearance of muscle discomfort. With so many uncontrolled variables present when assessing DOMS, it is little wonder that there is such inconsistency among treatment regimens.

Preventing DOMS

The simple truth may be that once muscle damage has been initiated, there is little that can be done to halt the damage process and the accompanying muscle soreness. The solution to this problem might be to prevent the occurrence of muscle damage through gradual adaptation to stressful exercise instead of treating the outcome. A recent study by Boyle et al. (2004) reported that women with a history of yoga training (average of 53 months experience) demonstrated less peak muscle soreness at 24 and 48 hours after eccentric exercise compared to a control group similar in age, body mass index, and physical activity level. Although this was the first published study to explore chronic yoga training, it appears that this "pre-conditioning" of the muscle may help prevent soreness from a later stressful exercise bout.

Another approach to prevention of DOMS might be a gradual habituation to eccentric contractions. It is widely recognized that there is less muscle damage and soreness incurred after a second bout of eccentric exercise compared to the first bout. This adaptation is known as the repeated bout effect and can occur after as few as 6 eccentric muscle repetitions (Nosaka et al., 2001) and at intensities as low as 50% of maximal strength (Nosaka & Newton, 2002). Thus, it does not require significant amounts of muscle damage to induce this adaptation. For the athlete in particular, eccentric overload to the muscle could be an essential component of a pre-season training regimen to prevent DOMS occurring as a result of competitive sport performance. Future research is warranted to determine whether any currently practiced exercise training techniques could be utilized to provide an effective "conditioning" dose of eccentric exercise to prevent DOMS occurring as a result of athletic competition.

PRACTICAL APPLICATIONS

- Although certain NSAIDs have demonstrated efficacy in reducing the symptoms of DOMS, potential side effects and their inherent disruption of the natural healing process should caution the reader as to their beneficial value.
- Several treatment interventions such as compression, yoga training, and light muscle activity have emerged as potential strategies to reduce the symptoms of DOMS. However, more studies are warranted.
- There is either no strong scientific rationale or only limited published evidence to support the use of homeopathy, warm-up, cryotherapy, massage, stretching, HBOT, TENS, laser therapy, ultrasound, nutritional supplements, or acupuncture to treat DOMS.
- Instead of treating the outcome (DOMS), gradually adapting the muscle to stressful exercise and thereby preventing DOMS occurring as result of competition, may be the best treatment strategy.

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