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Review article

Literature review of Management of Delayed onset muscle soreness (DOMS)

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ABSTRACT

Introduction: Delayed onset muscle soreness (DOMS) is muscle pain and discomfort experienced approximately one to three days after exercise. DOMS is thought to be a result of microscopic muscle fiber tears and is more common after eccentric exercise (the muscle must lengthen or remain the same length against a weight) rather than concentric exercise (the muscle can shorten against a weight load). While DOMS is not a disease or disorder, it can be painful and is a because of the presence of pain and other possible debilitating performance factors, preventing or minimizing the effects of DOMS should be a concern for coaches, athletic trainers, physical therapists, and other sports medicine personnel concern for athletes because it can limit further exercise in the days following an initial training. **Management:** Amir H Bakhtiary through their work concluded that vibration therapy before eccentric exercise may prevent and control DOMS, whereas Lori A. Kuligowski, MS. et al concluded that cold whirlpool and contrast therapy are more effective than warm whirlpool or no treatment in alleviating delayed-onset muscle soreness in the elbow flexors However Zainal Zainuddin et al. concluded that massage was effective in alleviating DOMS approximately 30% and reducing swelling, but it had no effects on muscle function. **Conclusion:** In the aspect of treatment exercise works more effectively in reducing DOMS than heat, topical remedies containing methanols or camphors, or anti-inflammatory drugs

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1. Introduction

The first detailed description of delayed onset muscle soreness (DOMS) was first given in 1902 by Theodore Hough [1]. Delayed onset muscle soreness (DOMS) is muscle pain and discomfort experienced approximately one to three days after exercise. DOMS is thought to be a result of microscopic muscle fiber tears and is more common after eccentric exercise (the muscle must lengthen or remain the same length against a weight) rather than concentric exercise (the muscle can shorten against a weight load).

While DOMS is not a disease or disorder, it can be painful and is a concern for athletes because it can limit further exercise in the days following an initial training [2]. Exercise-induced muscle soreness can be classified as either acute onset or delayed onset. Acute onset muscle soreness occurs during exercise and may last up to 4 to 6 hours before subsiding. Delayed onset muscle soreness

(DOMS) has onset 8 to 24 hours post exercise, with soreness peaking 24 to 48 hours post exercise. The etiology of DOMS has been the topic of numerous studies, from which several theories have evolved. Despite differences in theories, the following factors have been documented:

Strenuous activity-especially eccentric exercise causes injury or trauma to the muscle, its musculotendinous junction, or both.

Injury and/or trauma initiate an inflammatory response resulting in muscles feeling painful and swollen.

Pain occurrence is delayed approximately 8 hours post activity and gradually increases, peaking 24 to 48 hours post exercise before gradually subsiding to pre exercise levels.

Trauma results in significantly increased levels of muscle proteins and other breakdown products of muscle and collagen in the blood and/or urine.

Pain is associated with decreased range of motion (ROM) and strength.

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Trauma or resulting pain may directly or indirectly result in muscle spasms and a pain-spasm feedback cycle.

Because of the presence of pain and other possible debilitating performance factors, preventing or minimizing the effects of DOMS should be a concern for coaches, athletic trainers, physical therapists, and other sports medicine personnel. Little research, however, exists on the prevention or treatment of DOMS [3].

After vigorous and unaccustomed resistance training or any form of muscular overexertion, delayed onset muscle soreness (DOMS), which is noticeable in the muscle belly or at the myotendinous junction, begins to develop approximately 12 to 24 hours after the cessation of exercise. The DOMS sensation usually intensifies and peaks 24 to 48 hours after exercise. Although the time course varies, the sign symptoms, which can last up to 10 to 14 days, gradually dissipate [4].

The severity and distribution of pain associated with DOMS are related to the intensity, duration, and type of exercise performed. Yet there is no standard treatment or prophylaxis for the condition. The effects of DOMS are alleviated when a soreness-producing exercise bout is preceded by a similar soreness-producing exercise bout. An adaptive response to one or more bouts of eccentric exercise has been termed the repeated bout effect and appears to be the best known prophylaxis for DOMS. Performance of a single eccentric exercise bout has been shown to reduce muscle soreness after a similar exercise bout up to 6 weeks but not beyond 9 weeks [5].

Exercise-induced DOMS has been extensively studied in several skeletal muscle groups, but there are few studies on low back DOMS. Early season sports activities and physical work have induced low back DOMS, resulting in painful symptoms and deficits in back strength and range of motion (ROM). Several modalities and medications have been used to prevent or to treat DOMS, but none has been shown to be clearly superior [6].

Numerous therapeutic interventions aimed at alleviating DOMS have been proposed. Standard physical therapy modalities such as cryotherapy, ultrasound, and electric stimulation have been used. In addition, massage, stretching, light exercise, immobilization, and simple rest have been examined. Alternative treatments include hyperbaric oxygen therapy (HBOT) and electromagnetic shielding [7].

Causes of DOMS

There are a number of suggested reasons explaining why DOMS occurs.

- It may be caused by:
 - Minute tears in the muscle tissue itself
 - Fluid build-up in surrounding tissue
 - Muscle spasms, and
 - Over stretching and perhaps tearing of the muscle's connective tissue harness and associated tendons [8]. Evidence most strongly suggests that microscopic tears in the muscle and damage to connective tissue associated with the muscles are the prime factors involved in production of DOMS [9].

2. Roles of concentric and eccentric contractions in producing DOMS

Talag tested human subjects for DOMS, following concentric, eccentric and isometric exercise. Talag demonstrated that eccentric contractions affect greater muscular soreness than either concentric or isometric exercise, with the peak occurring after 48 hours, muscular strength also decreased following eccentric contractions and remains depressed throughout the duration of the soreness period.

Clarkson et al show that concentric arm flexion exercises (bicep curls) minimized the DOMS in comparison to arm flexion eccentric exercises. Exercises involving both concentric and eccentric exercises produced a greater perception of soreness. The use of hydraulic resistive devices (hydra fitness) that involve concentric only produced less DOMS 25 hours post-exercise than concentric eccentric combined contractions [9].

3. Clinical sign and symptoms of DOMS

- Muscle soreness and aching beginning 12 to 24 hours after exercise and peaking at 48 to 72 hours.
- Tenderness with palpation throughout the involved muscle belly or at the myotendinous junction
- Increased soreness with passive lengthening or active contraction of the involved muscle
- Local edema and warmth

Muscle stiffness reflected by spontaneous muscle shortening before the onset of pain

- Decreased ROM during the time course of muscle soreness
- Decreased muscle strength prior to onset of muscle soreness that persists for up to 1 to 2 weeks after soreness has remitted.

4. Assessment of DOMS

Delayed onset muscle soreness (DOMS) is the sensation of pain, tenderness, deep ache, and stiffness in muscles. The severity of DOMS can range from mild discomfort and stiffness that can disappear with routine daily activity to severe debilitating pain that limits normal use of muscles and movement, hours after unaccustomed intensity or duration of exercise. An eccentric contraction is referred to as a lengthening of a muscle while the muscle is attempting to develop force and shorten. It has been suggested that this lengthening of the muscle overstretches the sarcomeres, which allows excessive calcium to enter the muscle fibers from the surrounding interstitial fluid.

- Goniometry is often used to detect changes in the range of motion.
- Muscle shortening (SMS) while measures of limb circumference have been used to assess intramuscular swelling and edema brought about by the disruption of the sarcomeres and the formation of protein bound ions that exert increased osmotic pressure.
- blood samples have been used to measure creatine kinase (CK) activity, an indication of muscle membrane damage or increased permeability of the muscle cell membrane [15]
- The level of muscle soreness was evaluated by mean of a Visual

VAS- a Visual Analogue Scale (VAS) is a measurement instrument that tries to measure a characteristic or attitude that is believed to range across a continuum of values and cannot easily be directly measured. For example, the amount of pain that a patient feels ranges across a continuum from none to an extreme amount of pain. From the patient's perspective this spectrum appears continuous \pm their pain does not take discrete jumps, as a categorization of none, mild, moderate and severe would suggest. It was to capture this idea of an underlying continuum that the VAS was devised.

Operationally a VAS is usually a horizontal line, 100 mm in length, anchored by word descriptors at each end, as illustrated in Fig. 1. The patient marks on the line the point that they feel represents their perception of their current state. The VAS score is determined by measuring in millimeters from the left hand end of the line to the point that the patient marks. There are many other ways in which VAS have been presented, including vertical lines and lines with extra descriptors.¹⁶

The day after treadmill walking, the subject was asked to indicate her/his feel of the level of muscle soreness in each lower limb along a 10 cm line ranging from 0 ("no muscle soreness at all") to 10 ("the most severe muscle soreness that I can imagine") [15, 16].

Likert Scale for Muscle Soreness [17]:

Please tick the sentence below that describes your level of muscle soreness over the patient

- ☐ 0 A absence of soreness
- ☐ 1 A light pain felt only when touched / a vague ache
- ☐ 2 A moderate pain felt only when touched / a slight persistent pain
- ☐ 3 A light pain when walking up or down stairs
- ☐ 4 A light pain when walking on a flat surface / painful
- ☐ 5 A moderate pain, stiffness or weakness when walking / very painful
- ☐ 6 A severe pain that limits my ability to move

Ultrasound (US) has been used clinically to visualize and characterize soft tissues of the body. The use of US as a noninvasive method to detect DOMS resulting from intramuscular swelling, has recently been proposed, because it has been difficult to detect small changes in muscle cross-sectional area (CSA) by gross measures of limb circumference. According to Sipila and Suminen, The use of US scanning to quantify muscle damage may have some advantage compared with the other medical imaging modalities such as computed tomography because US is non-ionizing in nature. Ultrasound scanners enable rather specific measurements of muscle CSA, which means that bone, subcutaneous fat, and larger connective tissue structures can be excluded from the analysis, unlike measuring limb circumference [15].

DOMS is a poor reflector of eccentric exercise-induced muscle damage and inflammation, and changes in indirect markers of muscle damage and inflammation are not necessarily accompanied with DOMS.¹⁸

MRI findings in DOMS: MRI is a highly sensitive tool for the diagnosis of muscle diseases. Although it has low specificity, awareness of the potential imaging findings in the various, sometimes rare, muscular disorder is helpful for accurate diagnosis. Overuse is the most common cause of muscle pain and functional impairment. Different degrees of muscle strains up to full interruption of myofibrils and hematoma formation are the rule and are encountered more often in athletes. Focal muscular signal alteration on MRI depends on the presence of hemoglobin

5. Management of DOMS

Amir H Bakhtiary, et al. in their study on "influence of vibration on delayed onset of muscle soreness following eccentric exercise", through their work concluded that vibration therapy before eccentric exercise may prevent and control DOMS.

Lori A. Kuligowski, MS, et al. through their titled "effect of Whirlpool Therapy on the Signs and Symptoms of Delayed-onset Muscle Soreness" concluded that cold whirlpool and contrast therapy are more effective than warm whirlpool or no treatment in alleviating delayed-onset muscle soreness in the elbow flexors [20].

Jay K udani et al. did study on "BounceBack™ capsules for reduction of DOMS after eccentric exercise: a randomized, double-blind, placebo-controlled, crossover pilot study" Through their study they concluded that BounceBack capsules may reduce pain and tenderness in DOMS [21].

Deborah L. MacLachy et al. performed study on "Delayed onset Muscle Soreness (DOMS)". Their results suggested that exercise works more effectively in reducing DOMS than heat or anti-inflammatory drugs.

Christer Malm et al. did study on "Immunological changes in human skeletal muscle and blood after eccentric exercise and multiple biopsies" Finally they concluded that muscular adaptation to physical exercise occurs without preceding muscle inflammation, leukocytes important for repair regeneration and adaptation of human skeletal muscle [15-25].

Declan A. J. Connolly et al. did his work on "Treatment and Prevention of Delayed Onset Muscle Soreness" Their results presented massage, ultrasound, and stretching less promising treatment of DOMS.

Andrew J Vickers et al. did his work on "Time course of muscle soreness following different types exercise" This report described that soreness in runners following long distance running follows a different time course.

Maggie J. Cleak MSc et al. did a study titled as "Muscle soreness, swelling, stiffness and strength loss after intense eccentric exercise", they concluded that repair to damaged tissue is a slow process; strength loss is considered particularly important as it continues when protective pain and tenderness have disappeared.

Michelle A. Cleary et al. studied on "Temporal Pattern of the Repeated Bout Effect Eccentric Exercise ON Delayed Onset Muscle Soreness" They found that effective prophylaxis for perceived pain and muscular tenderness associated with DOMS is the

Sunita Mathur et al. worked on "Delayed Onset Muscle Soreness After Inspiratory Threshold Loading in Healthy Adults" Their findings suggested that intense bout of Inspiratory Threshold Loading results in muscle soreness primarily in the accessory muscles of inspiration, may be insufficient to cause significant muscle damage in healthy adults

Kylie Louise Sellwood et al. studied on "Ice-water immersion and delayed -onset muscle soreness: a randomized controlled trial" They said that ice water immersion for the treatment of DOMS was ineffective in their study.

Shwan M Arent et al. did study on "The effect of theaflavin-enriched black tea extract on muscle soreness, oxidative stress, inflammation, and endocrine responses to acute anaerobic interval training: a randomized, double-blind, crossover study" They described that consumption of theaflavin-enriched black tea extract led to improved recovery and a reduction in DOMS. Antti A Mero et al. performed study on "Effects of alfa-hydroxy-isocaproic acid on body composition, DOMS and performance in athletes" They concluded that HICA supplementation decreased the whole body DOMS symptoms.

Kazundori Itoh et al. did study on "Effect of tender point acupuncture on delayed onset muscle soreness (DOMS) a pragmatic trial" They suggested that tender point acupuncture relieves muscle pain of DOMS.

Kazunori Nosaka et al. studied on "Influence of Pre-Exercise Muscle Temperature on Responses to Eccentric Exercise" They explained that pre-exercise cooling does not affect the magnitude of muscle damage in response to eccentric exercise.

John M. Mayer, DC, PhD et al. did study on "Continuous Low-Level Heat Therapy and Early Phase Treatment of Delayed-Onset Muscle Soreness of the Low Back: A Randomized Controlled Trial" They explained that continuous Low-Level heat wrap therapy was of significant benefit in the prevention and early phase treatment of low back DOMS [25-41].

6.Prevention and control of DOMS

Vibration therapy vibration training (VT) may improve muscle performance. By considering this mechanism, if VT is given before eccentric exercise may prevent DOMS by improving muscular strength and power development strategy, improving kinesthetic awareness, and providing insights into the effects of fatigue, within the vibrated muscles. Thompson and Belanger also showed that VT may increase muscle spindle activities and establish motor unit activity synchronization that may optimize neuromuscular function. By contrast, it has been shown that muscle spindle stimulation by vibration may increase the afferent activities of muscle spindles which may increase background tension in the vibrated muscles.1 Vibration training before eccentric exercise may help the muscles to build up a background tension and optimal neuromuscular activity to overcome the increased passive tension within the exercised muscles during eccentric activities. Thus, vibration training could be used before eccentric activities to control and prevent delayed onset muscle soreness and it might be

a useful method for athletes to prevent any DOMS in their sports activities. VT may improve muscle performance and thus prevent DOMS by prevention of sarcoma disruption, which is caused by high tension development during eccentric exercises [1].

Compression therapy Graduated compression stockings promote blood flow from superficial veins into deep veins [36] . The improved blood flow and prevention of venous stasis reduce edema and help compensate for impaired venous return in conditions such as deep vein thrombosis (Byrne, 2001) and venous insufficiency. Although compression is advocated in the recovery from exercise induced muscle damage [37-42] , there is little information on the effect of compression on intracellular metabolic function. Compression garments maintained muscle function and reduced perceived muscle soreness following eccentric exercise. Compression garments attenuate creatine kinase (CK) release from skeletal muscle into the circulation following eccentric exercise [42-47]. The retention of CK and maintenance of muscle function were attributed to the effect of the compression garments preventing edema within the muscle. Despite these functional and biochemical adaptations, the effect of compression garments on intra-cellular metabolism is not known [48].

Compression garments- Wearing compression garments in the recovery from eccentric exercise may alter the inflammatory response to damage and accelerate the repair processes inside of the muscle.

Graduated compression garments were worn covering the calf and thigh on one leg (Skins ®, Skins Compression Garments, Sydney, Australia – 76% Nylon and Meryl Microfibre, 24% Roica Spandex) in the [48] Continuous low-level heat wrap therapy - A lightweight, disposable, air-activated, commercially available heat wrap has been developed that delivers continuous low-level topical heat to the low back. When the heat wrap is exposed to oxygen, its heat-generating ingredients (iron, charcoal, table salt, water) begin to warm and reach a therapeutic temperature of 40oC within 30 minutes. Each wrap provides approximately 8 hours of controlled heat and is for 1-time use. In contrast to most other thermal modalities, such as hydrocullator packs and electric heating pads, the wearer of the heat wrap can remain active while it is in place. For acute LBP found that continuous low- level heat wrap, therapy is efficacious in terms of pain relief, muscle soreness, and disability. Continuous low-level heat wrap therapy provided some significant benefits in the prevention of symptoms and deficits in self-reported physical function related to exercise-induced low back DOMS It provided superior pain relief and similar improvements in self-reported physical function in the early phase treatment of low back DOMS, compared with cold pack therapy [6].

Effect of temperature- study suggested that pre-exercise cooling does not affect the magnitude of muscle damage in response to eccentric exercise. Similarly, pre-exercise passive muscle warming did not prove beneficial in attenuating indicators of muscle damage. Thus, any beneficial effects of warm-up exercise cannot be attributed to the effects of increased muscle

temperature. Performing general and specific warm-up exercise along with dynamic flexibility exercises may be effective in reducing eccentric, exercise-induced muscle damage and DOMS [41-48].

Effect of Dehydration Skeletal muscle micro damage, indirectly evidenced by DOMS, was exacerbated in hyperthermic participants dehydrated by exercise in a hot ambient environment. Individuals performing novel exercise, particularly with a significant eccentric component, should use caution when training in a hot, humid environment and implement frequent rest and rehydration breaks. In a hyperthermic condition, dehydration exacerbated the signs and symptoms of DOMS after a downhill-running eccentric-exercise perturbation. Dehydration and hyperthermia exacerbate the signs and symptoms of DOMS in healthy males and that these findings have important consequence for athletes training and competing in hot, humid environments. We recommend using caution during novel exercise, particularly with a significant eccentric component, in hot, humid environments and implementing frequent rest breaks for cooling and rehydration to reduce the debilitating effects of DOMS [47].

Eccentric exercise performed when an individual is dehydrated may exacerbate the skeletal muscle damage as a result of reduced intracellular water. Eccentric muscle activity with decreased intracellular water during dehydration has been theorized to lead to structural, contractile, and enzymatic protein denaturation. These structural and functional protein alterations might occur in addition to the initial myofiber and connective tissue damage produced by eccentric muscle tension. Ultimately, dehydration may increase the risk of DOMS in healthy individuals engaged in novel or unaccustomed physical exercise. Study suggested that dehydrated participants who rested and returned to a normothermic condition did not experience increased characteristics of DOMS.

Stretching patients use stretching to prevent injury, decrease soreness, and improve performance. Study suggested that stretching does not improve tissue compliance; rather, the stretching exercises increase stretch tolerance (i.e. reduce pain) during the stretching procedure. Study suggested that stretching before and after exercise do not support the support the role of stretching intervention addressing post exercise muscle soreness. Stretching reduces soreness in the 72 hours after exercising most athletes will consider effects of this magnitude too small to make stretching to prevent later muscle soreness worth carried out by recreational athletes over many months or years can produce meaningful reductions in risk of injury [49-51].

7. Conclusion

In the light of the present document available for DOMS, causes of DOMS are not fully understood and its exact causes are not known.

DOMS is not a serious condition.

In the aspect of treatment exercise works more effectively in reducing DOMS than heat, topical remedies containing methanols or camphors, or anti-inflammatory drugs)

No intervention strategies currently exist for preventing DOMS. The only alternative is to treat the sign and symptoms after they occur. Numerous investigators have attempted to identify treatment for DOMS, but none of the studies reviewed addressed all sign and symptoms.

Because the precise pathology of DOMS is unknown, determining an appropriate course of treatment is difficult.

The study suggested that physical modalities are effective in treating pain and muscle spasm associated with DOMS.

Vibration therapy before eccentric exercise may prevent and control DOMS.

Compression therapy helps in recovery from DOMS.

Herbert RD (2007) warm-up exercises reduces delayed onset muscle soreness.

Hyperbaric oxygen therapy may effective in reducing DOMS.

Continuous low-level heat therapy is useful in treatment and prevention of DOMS. 6 while stretching decreased the risk of injury by 5%. If more prolonged stretching Electrical Muscle stimulation, TENS, ultrasound and superficial heating may effective treatment of DOMS

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