Advances in Delayed-Onset Muscle Soreness (DOMS) – Part II: Treatment and Prevention

Delayed Onset Muscle Soreness – Teil II: Therapie und Prävention

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Schlüsselwörter

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ZUSAMMENFASSUNG

Die Delayed Onset Muscle-Soreness (DOMS) oder auch „verzögert einsetzender Muskelkater" wird zu den ultrastrukturellen Muskelschädigungen gezählt. Als ursächlich werden vorausgegangene exzentrische Kontraktionsformen oder ungewohnte Muskelbelastungen angesehen. Klinische Symptome imponieren in Form einer reduzierten Kraftentfaltung, schmerzhafter Bewegungseinschränkungen, einer Erhöhung des Muskeltonus, Schwellungen sowie Funktionseinschränkungen angrenzender Gelenke. Obwohl die DOMS den milden Schädigungsformen zugeordnet wird, hat sie aufgrund der leistungseinschränkenden Auswirkungen eine große Bedeutung – insbesondere für den Leistungssport. Zur Behandlung und Prävention dieser Muskelverletzung ist bislang ein großes Spektrum an interventionellen Verfahren beschrieben worden. Gegenstand vieler Studien sind verschiedene Wärme- oder Kälteanwendungen, Kompressionstherapien, Massagen, physikalische Therapieformen oder Ernährungsinterventionen. Interventionelle Ansätze haben das Ziel, die Entstehung von ursächlichen Ultrastrukturschäden zu verhindern, die Inflammationsantwort zu limitieren oder eine Symptomlinderung und Regenerationsförderung im Falle einer manifesten DOMS zu erreichen. Die vorliegende Arbeit hat das Ziel, aktuelle Therapieverfahren und Präventionsstrategien zu beleuchten.

ABSTRACT

Delayed-onset muscle soreness (DOMS) describes an entity of ultrastructural muscle damage. The manifestation of DOMS is caused by eccentric muscle contractions or unaccustomed forms of exercise. Clinical signs include impaired muscular force capacities, painful restriction of movement, stiffness, swelling, and altered biomechanics in adjacent joints. Although DOMS is categorised as a mild type of muscle damage, it is one of the most common reasons for compromised

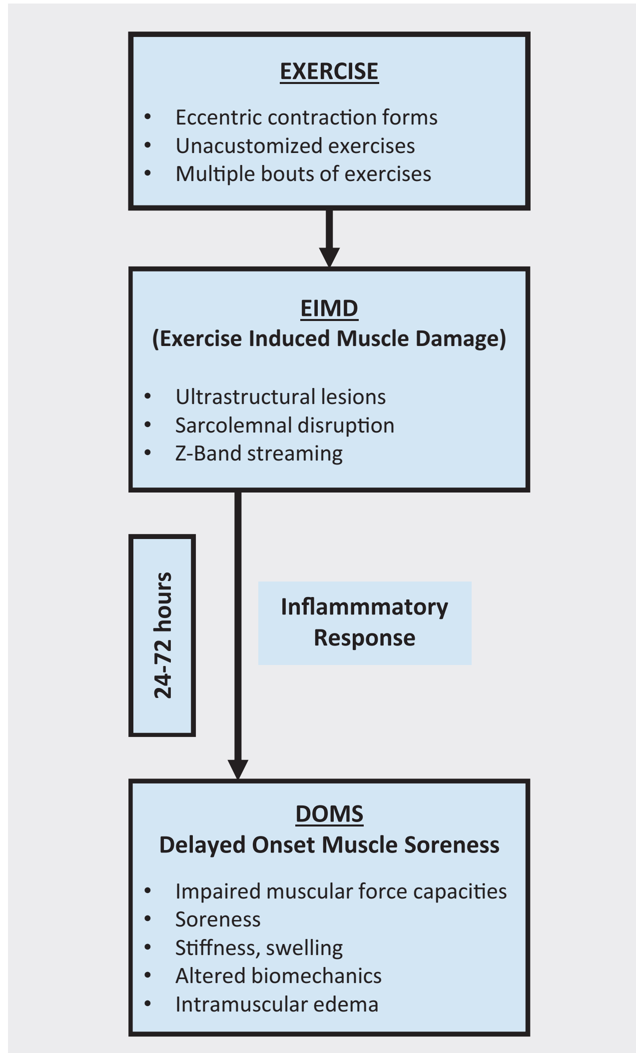
sportive performance. In the last decade, many hypotheses have been developed to explain the aetiology of DOMS, and there are a wide range of different interventions aiming to prevent or alleviate the symptoms. Many studies have evaluated various types of cold or heat therapy, compression, massage, physical therapy or nutritional interventions. Treatment considerations focus on the primary prevention of ultrastructural lesions during exercise, the treatment of the inflammatory response that leads to DOMS, and recovery strategies for manifest DOMS. This narrative review aims to present an overview of the current treatment and preventive strategies in the field of DOMS.

Introduction

Presently, numerous treatment strategies, aiming to prevent or to cover the symptoms, and thereby accelerate recovery, of DOMS have been reported. Especially in elite sports, recovery interventions after DOMS inducing exercises may play an essential role, since prevention and treatment of DOMS, and thereby recovery from exercise induced muscle damage (EIMD), is an integral part of regaining muscular force and performance levels. Currently, the design of an "ideal" recovery regime is an important topic in elite sports [1 – 4].

Based on pathophysiological foundations [5], treatment considerations should focus on different aspects, including the primary prevention of ultrastructural lesions during exercise (prevention of EIMD), treatment of inflammatory responses leading to DOMS, and finally treatment and recovery strategies in case of present signs of DOMS (▶ **Fig. 1**).

A wide variety of different interventions aiming to either prevent or relieve the symptoms of DOMS, and therefore accelerate the recovery from this performance-limiting condition have been reported. The present work on the treatment and prevention of DOMS provides a structured overview, evaluating frequently applied interventions in clinical practice as well as currently discussed methods (▶ **Table 1**).



▶ **Fig. 1** Illustrating the pathophysiological pathway of exercises, Exercise Induced Muscle Damage (EIMD) and Delayed Onset Muscle Soreness (DOMS).

Thermal therapy

Cold water immersion therapy (CWI)

One of the most common recovery strategies used to prevent DOMS in the context of EIMD is cold water immersion therapy (CWI) (▶ **Fig. 2**). Generally, most studies investigated the effects on muscle damage, based on the enzyme activity of muscular creatine kinase (CK), systemic inflammatory response via cortisol and cytokines (IL-6) and athletic performance [6]. The idea of using post-exercise CWI in particular after EIMD and cardiovascular strain is based on the assumption that recovery is enhanced by decreasing tissue temperature and blood flow [7 – 9]. The blood redistribution due to hydrostatic pressure and vasoconstriction has been assumed to facilitate the removal of metabolites from peripheral to central circulation, consequently resulting in a hemodilution and an intracellular-intravascular osmotic gradient [10]. Thereby, it is suggested that through CWI damaged tissue cells and debris can be eliminated from the muscle into the central circulation more easily [9]. Additionally, CWI directly adjusts the sensations of EIMD through its analgesic effects [11, 12]. In summary, CWI is associated with several mechanisms that might be responsible for the enhanced acute and longer-term recovery in the context of DOMS. In fact, it has been suggested that CWI not only evokes peripheral vasoconstriction, but also reduces muscle perfusion. Therefore, oxygen and nutrient delivery might be impaired and anaerobic metabolism may be activated, both being detrimental to recovery process [13]. Some studies suggest that the treatment of EIMD is more effective, when using colder water, because of the greater reductions in muscle temperature

► **Table 1** Structured overview of discussed interventions in treatment and prevention of DOMS.

thermal therapy	▪ cold water immersion therapy (CWI) ▪ whole body cryotherapy ▪ heat therapy
compression	▪ compression therapy during exercise ▪ compression therapy after exercise ▪ intermittent compression therapy
active forms of regeneration	▪ low intensity exercise ▪ stretching ▪ foam rolling ▪ Flossing
physical therapy and acupuncture	▪ vibration therapy ▪ therapeutic ultrasound ▪ extracorporeal shock wave therapy (ESWT) ▪ electromyostimulation (EMS) ▪ massage therapy ▪ acupuncture
oral medications and nutrition	▪ non-steroidal anti-inflammatory drugs (NSAIDs) ▪ vitamin D ▪ branched-chain amino acids (BCAAs) ▪ omega-3 fatty acids ▪ antioxidant supplements

at an unchanged muscle blood flow [14]. Regarding the results of recent meta-analyses, questioning the true efficacy of CWI, the following may be noted. Overall CWI seems to be slightly better in the treatment of DOMS compared to passive recovery methods. Furthermore, water temperatures between 11 – 15 °C for 11 – 15 min were found to yield the best results [15]. Additionally, cooling has been shown to significantly reduce the symptoms of DOMS (for up to 96 hrs) compared to passive control interventions. In DOMS, CWI achieved the best effects compared with other cooling applications [16]. Moreover, the efficacy of CWI seems to be dependent on the mode of previous exercise regarding the secondary effects of EIMD. While there is limited influence on muscle damage caused by single-joint eccentrically based contractions, CWI seems to be more effective in attenuating the effects of EIMD induced by whole body prolonged endurance-based exercises. However, there are studies suggesting that cold water immersion is not more effective than active recovery for minimizing the inflammatory and stress responses in muscles after resistance exercise [17]. It is important to understand these mechanisms and facts for an optimum application of CWI strategies, as a part of a recovery regime [13]. Different results can certainly be biased by different study designs, including differences in water temperature, previous exercise loads, depth of immersion, intervention time, and of course, intra-individual differences [2].

► **Fig. 2** Cold water immersion therapy (CWI) after exhausting exercise of the lower legs.

Whole body cryotherapy

To date, whole body cryotherapy (WBC) by air exposure is another used recovery technique, especially in professional sport because of its supposed anti-inflammatory effects under chronic inflammatory conditions [6]. In the beginning WBC was used for patients as e. g. in rheumatism, rheumatoid arthritis, multiple sclerosis, and psoriasis [2]. Using WBC for purposes like recovery after exhausting exercises commonly involves a single or repeated exposure(s) to extremely cold dry air (below −100 °C), while athletes stand in a chamber for 2 – 5 minutes [18]. Since cold therapies have been shown to facilitate recovery via different mechanisms, the concept behind WBC is to enhance those effects or to shorten the recovery time and restrict the inflammatory process due to its extreme cold temperatures. Thus, WBC is suggested to be beneficial for both structural and functional aspects of muscles following EIMD and DOMS [19 – 22]. However, there is limited information about the proper application of WBC protocols and only few evidence for its efficacy [6]. Similar to CWI, disagreement remains concerning different WBC modalities, frequencies, temperatures, timing in relation to exercises, etc. [23].

Heat therapy

Heat has especially been used to treat soft tissue injuries in clinical and sports rehabilitation designs. The primary therapy target after muscle damaging exercises is to minimize the inflammatory response and the first choice is the application of cooling [24, 25]. In later stages and based on pathophysiological foundations, local and whole-body heat applications can be used [26], but in future the application of heat must be evaluated in the context of the different phases of recovery. In the acute phase after exercise or during the first inflammatory phase, local or whole-body heat applications should be regarded critically, as it may reinforce the inflammatory response. However, its use can be considered during the recovery phase after clinical peak of DOMS, as circulation and tissue perfusion has been described as an essential role in tissue healing [27]. However, recently interest has come up about using heat prophylactically against soft tissue injuries. There are studies on skeletal muscle cells demonstrating that heat attenuates cellular damage and protein degradation [28]. Besides, heat may also upregulate the expression of genes involved in muscle growth and differentiation [29]. Other researches have shown benefits of microwave diathermy before exercise to prevent muscle soreness as well as restoring muscle function after exercise, whereas the latter effects are more variable [30]. Heat is also assumed to have positive effects on strength training gains or rather improving muscle mass [29]. All in all, further research has to be done to investigate the most effective domain of application time of heat therapy and to work out the benefits for restoring muscle function [31].

Compression therapy

Compression garments, which are mainly required for vascular pathology (e. g., deep vein thrombosis or chronic venous insufficiency), and plastic surgery have been developed as popular aids among athletes with the purpose to improve performance or recovery [32 – 34] (▶ **Fig. 3**).

However, the impact of compression therapy in the prevention or treatment of EIMD such as DOMS is the subject of controversial discussions [35]. Although somewhat speculative, it is thought that applying compression generates an external pressure gradient that attenuates changes in osmotic pressure and reduces the space available for swelling [33]. A reduction in osmotic pressure, occurring due to a decrease in exudates, may lessen the degree of chemotaxis, thus attenuating the inflammatory response and the experience of pain [33]. The wide variation in methodological designs combined with the differences in timing and duration of its application, as well as the exercise modality and training status of the population investigated has contributed to the apparently inconsistent findings [33]. Nevertheless, most results indicate that compression garments have limited effects on enhancing performance, but they are effective in aiding the recovery of muscle damage [2, 3, 32, 33].

Compression therapy during exercise

Various mechanisms have been suggested to explain the potential beneficial effects of wearing compression garments during exercise. A support effect has been assumed to reduce microtrauma and muscular damage [36], reduce power expenditure [37], and improve comfort [32, 38]. Performance was found to be unchanged, regardless of the level of compression (from 15 to 46 mmHg at the ankle) in nine endurance trails (e. g. one-hour cycling time-trial in well-trained cyclists, fast-paced continuous 10 km road run or 40 min treadmill runs) [32]. Conversely, Kemmler et al. reported significantly improved performance (time under load, total work) by applying below-knee compression stockings (24 mmHg at the ankle) in male runners [39].

▶ **Fig. 3** Compression therapy at the calf with conventional compression garments (in this case compression class 1, 18 – 21 mmHg).

However, wearing compression garments during exercise did not significantly affect plasma levels of CK or lactate [32]. In terms of DOMS, symptoms were unchanged by compression garments applying 15 to 32 mmHg at the ankle in five studies (e. g., 10 km running, 40 min running on treadmill), but symptoms were reduced in another study that applied 24.4 mmHg during 10 km running [32, 40 – 42]. Overall, wearing compression garments during exercise seems to have little effects, as most studies failed to demonstrate a beneficial effect on immediate performance, performance recovery, or on DOMS [32].

Compression therapy after exercise

Wearing compression garments during the post-exercise period has been shown to be an effective way to reduce clinical symptoms of DOMS and to accelerate the recovery of muscle function, strength and power recover at a faster rate with the use of compression garments [32, 33]. Some previous studies reported that compression garments reduced muscle oscillation and stabilized the array of muscle fibers during the recovery period, which could ease the mechanical stress on tissues [34, 43, 44]. Continuous wearing of compression garments (18 – 21 mmHg) during the inflammation phase of DOMS (60 h) showed a premature normalization of muscle stiffness in the gastrocnemius muscle assessed with acoustic radiation force impulse [45]. Otherwise, the same authors reported no significant effect on the development of muscle edema and muscle soreness [45, 46].

Further reductions in CK levels have been reported, which have been attributed to an attenuation in the release of CK into the bloodstream, improved clearance from the circulation and enhanced repair of the damaged muscle tissue [33, 47]. However, the exact underlying mechanisms remain unknown, as no study of the use of compression therapy during recovery has shown an impact on inflammatory markers or a clear relation between regeneration and applied pressure or wearing time [32, 34].

Intermittent compression therapy

Dynamic compression devices are designed for recovery and rehabilitation. The NormaTec Pulse Massage Pattern (The NormaTec PULSE recovery Systems, NormaTec, Watertown, Massachusetts, USA) is an upwards moving zone-by-zone limb massager, starting at the feet, hands or lower hip and supporting the outflow out of the extremities. There are studies, which have investigated the acute effects of peristaltic pulse EPC (external pneumatic compression) on peripheral conduit and resistance function. As a result, "lower pressure EPC improves conduit artery endothelial function systematically, but only improves reactive hyperemia blood flow locally (i. e., compressed limbs)" [48].

Active forms of regeneration

Active forms of regeneration such as stretching or continued low intensity exercise have been thought to enhance recovery from EIMD or DOMS and have a long tradition [49]. Low intensity exercise has been considered to be an effective method for alleviating pain during DOMS; however, analgesic effects are mostly temporary [50]. It has been proposed that the temporary alleviation of pain during exercise may be due to the breakup of adhesions in the sore muscles, an increased removal of noxious waste products via an increased blood flow or an increased endorphin release during activity [50]. Never the less studies evaluating the therapeutic effects of exercise on the development of DOMS have shown heterogeneous results [50]. Hasson et al. reported a significant decrease in DOMS 48 hours after a high velocity concentric isokinetic exercise of the knee extensors and flexors by performing a stepping exercise 24 hours after the initial training [51]. Otherwise, upper arm ergometry performed 10 minutes immediately after eccentric exercise of the elbow extensors did not show significant differences in muscle soreness compared with a control group [52]. Generally, the contrast in research results can be attributed to differences in exercise protocols, including type of exercise performed, timing of exercise and degree of intensity (maximal vs. submaximal) [50].

A randomized controlled trial evaluating the efficacy of dynamic contract-relax and static stretching on DOMS did not demonstrate any significant impact of different types of stretching in the treatment of DOMS [53]. A systematic review and meta-analysis also concluded that there is a lack of evidence to support the use of stretching (whether performed before, after, or before and after exercise) or low-intensity exercise [54].

Foam rolling (FR), as a method of self-myofascial release, has become a popular recovery intervention [55]. Some studies have evaluated FR and Thera-band roller Massager with regard to recovery enhancing effects under conditions of EIMD [56, 57] and DOMS [58]. The results concerning the effects on performance are inconsistent [58 – 60], but FR reduces the subjective perceived pain after EIMD and by DOMS [58 – 60]. These results do not mean a better recovery of the athletes, but only less pain. At this time the underlying physiological mechanisms are not clear [59, 60].

Another up-coming recreational intervention is called flossing [61]. It is a new method of treatment using elastic bands for tight wrappings of joints or tissues leading to a short-term reduction of the blood supply. Although there is no evidence regarding the effectiveness and exact mechanisms of flossing so far, flossing is already used in both competitive and recreational sports [61]. Propagated effects of flossing are improved regeneration and agility, pain relief, reduction of edema, a myofascial release, a reduced risk of injury and an increase in performance [61, 62]. In a recently published randomized, controlled trial with 42 active, healthy female and male subjects, flossing had neither an effect on clinical symptoms of DOMS nor on regeneration after strength endurance intervals [61].

Physical Therapy and Acupuncture

Despite the above mentioned options for the treatment of DOMS, several other approaches have widely been discussed. In terms of physical therapy, there are diverse concepts deserving attention. First, (whole body-) vibration therapy, which is often been considered as potentially enhancing neuromuscular performance in athletes has been described in several studies to show beneficial effects in alleviating symptoms of DOMS [63]. Otherwise, Dabbs et al. concluded in a randomized controlled trail with 30 healthy, recreationally trained women, that exposure to whole-body vibration did not effectively manage DOMS after high-intensity exercise [64]. Second, therapeutic ultrasound (TU) is controversially discussed. While some authors doubt the effect of TU [65] others report satisfactory results mostly after 48 – 72 h [66, 67]. TU has shown advantages over cryotherapy in the context of DOMS regarding normalization of the range of motion [66]. Third, extracorporeal shock wave therapy (ESWT), which is known to have beneficial effects on muscular pain syndromes such as fibromyalgia [68] did not yet imply significant effects in early stages of DOMS; however, ESWT studies suggest that there can be a beneficial effect on DOMS in mid-term recovery (48 – 72 h) [69]. Fourth, electromyostimulation (EMS), initially supposed to potentially facilitate recovery by an increased removal of muscular metabolites [70, 71], did not yet show evidence that it is favorable over passive rest [71].

Further massage therapy is a widespread and commonly used intervention for post exercise recovery in sports, but uncertainty exists about the evidence of its effectiveness. Most studies have methodological shortcomings, and their results are not uniform. For explaining the mechanisms of massage therapy on DOMS, three main theories have been accounted. First, the modulation of the activity of the parasympathetic nervous system [48]. Second, the increase in blood and lymphatic flow for allowing a rapid clearance of biochemical markers of ultrastructural muscle damage (e. g., CK and lactate dehydrogenase) [49]. Third, the role of psychophysiological response in reducing pain [50]. Poppendieck et al. concluded that post-exercise massage therapy can be relevant particularly for short-term recovery after intensive training [51]. A systematic review concluded that post-exercise massage can be effective for reducing DOMS after strenuous exercises with positive effects on muscle soreness, muscle performance (i. e., maximal isometric force and peak torque) and serum CK levels [52].

Complementary therapies, such as acupuncture, have gained popularity over the last few decades and have appealed to patients, also in the context of DOMS [72, 73]. In a randomized controlled study with 60 participants evaluating the effect of acupuncture on eccentric exercise-induced DOMS of the biceps brachii muscle no beneficial effect could be shown [72]. The traditional acupuncture regimen which was assessed, targeting muscle pain, might have been inappropriate as the DOMS mechanisms seem limited to the muscular unit and its innervation. Therefore, a regionally based regimen including an intensified intramuscular needling (dry needling) should be tested in future studies [72].

The role of oral medications and nutrition

The use of non-steroidal anti-inflammatory drugs (NSAIDs), e. g. diclofenac, is widely used by many sports physicians in the routine treatment of various types of muscle injuries and, of course, in DOMS as well [4, 25]. The ingestion of NSAIDs in DOMS has been considered to offer both pain relief and to limit the inflammatory responses. However, the mildest forms of DOMS do not require treatment with NSAIDs, and some studies suggest that NSAIDs seem to reduce the capacity to repair muscle damage, and that inhibiting inflammation using NSAIDs may have negative effects on the regenerating skeletal muscle [74, 75]. However, based on experimental findings, there is some evidence to support their use with regard to satellite cell activation, which is likely to play a key role in healing and regenerating muscle [76 – 78]. A placebo-controlled study investigating the satellite cell response on eccentric muscle contractions induced by intense neuromuscular electrical stimulation shows beneficial effects employing 1200 mg Ibuprofen/d (48 – 96 hrs post-intervention) with regard to enhanced satellite cell proliferation and accelerated repair of myofibers in the later stages of regeneration [79]. However, it is important to consider that neuromuscular electrical stimulation-induced muscle damage does not represent the conditions of physiological exercises or even eccentric contractions. Vitamin D has gained increasing attention, both in the context of muscle function and in related injuries. Some studies support the potentially beneficial effects of using vitamin D in muscle regeneration, as an interaction between vitamin D, muscular function and physical performance could be demonstrated [9, 28, 60]. However, there is currently no scientific rationale for the comprehensive ingestion of vitamin D after excessive forms of exercises.

Several studies have been conducted to evaluate the effects of nutritional interventions on the expression of DOMS after EIMD. Most of them focused on the ingestion of branched-chain amino acids (BCAAs), caffeine, omega-3-fatty acids, taurine, polyphenols or diverse other synthetic or natural nutritional (antioxidant) supplements such as bilberry or tart cherry juice [80 – 82].

BCAAs, which are mainly metabolized in skeletal muscle [83], have been estimated to promote muscle-protein synthesis and have also been thought to have positive effects on the muscle protein matrix and exercise-related cytokine production in cases of structural and metabolic alterations associated with exercise damage [84]. A recent systematic review including 11 studies concluded that BCAA supplementation could be efficacious in the clinical outcomes of exercise-induced muscle damage. The review demonstrated that BCAAs have positive effects, particularly if the extent of muscle damage was low-to-moderate if the supplementation strategy is combined with a high daily BCAA intake (> 200 mg kg^{-1} day^{-1}) for a long period of time (> 10 days). The intake of BCAA was especially effective if consumed pre-exercise. However, a high heterogeneity was found regarding the different outcomes of studies investigating the effects of BCAA ingestion on EIMD. Some studies in the experimental setting demonstrated the use of caffeine to be effective in reducing DOMS after exercise (5 mg/kg^{-1}) [80, 85]. Omega-3 fatty acids have been assumed to limit anti-inflammatory responses and oxidative stress. Results from existing studies are able to support the efficacy of omega-3-fatty acids in significantly reducing DOMS. Thus, it has been concluded that the ingestion of 1.8 – 3 g of omega-3-fatty acids may be effective in alleviating symptoms of DOMS after exercise [86, 87]. In particular, taurine combined with BCAAs is suggested to be effective in reducing DOMS following eccentric exercises; however, understanding of the exact mechanisms of this effect is lacking [88]. The intake of polyphenols, a component of phytochemicals, has resulted in controversial findings, and their use cannot be fully supported [80]. A systematic review (50 randomized, placebo-controlled trials were included) evaluated the effects of antioxidant supplements for preventing and reducing the severity and duration of DOMS [89]. The authors concluded that there is moderate to low-quality evidence that high dose antioxidant supplementation does result in a clinically relevant reduction in muscle soreness after exercise at up to 6 hrs or at 24, 48, 72 and 96 hrs after exercise [89]. Controversially, Lynn et al. reported in a recently published study a small to moderate increase in exercise-induced DOMS and c-reactive protein after the consumption of polyphenol rich bilberry juice in 21 recreationally trained runners completing a half-marathon [81]. Similar applies to the usage of arnica as a treatment in DOMS. Repetitive topical applications of arnica has been reported as effective in pain relief 72 hours after inducing DOMS by downhill running in 20 well-trained males [90]. It did not affect any performance assessment or blood markers of muscle damage or inflammation [90]. In addition, oral administration of arnica at a high potency did not show beneficial effects in reducing clinical symptoms of DOMS or any significant effect on muscle enzymes in a study with 20 subjects performing a maximal eccentric exercise protocol with the non-dominate elbow flexors [91]. Further there is a wide range of other natural nutritional supplements such as curcumin, tart cherry juice or enzymes (bromelain, trypsin, aescin), which may reduce inflammatory responses and accompanied symptoms of DOMS [82, 92].

Although some studies are able to provide promising results, no nutrition agent was found to demonstrate groundbreaking effects in the prevention and manifestation of DOMS. Finally, as a weakness, most of the studies are compromised by small sample sizes, used different doses, different ingestion periods, or investigated different parameters. Thus, strong evidence to support the general use of diverse nutritional supplements is still lacking. In advance to a substitution of dietary supplements a previous determination of serum levels of e. g. vitamin D or even omega-3 fatty acids is generally recommended. Furthermore, in the field of nutrition supplements, chemical contamination by prohibited substances must be taken into account.

Conclusions

There is a wide range of available methods to accelerate the recovery process, minimize muscle soreness and optimize the recovery of DOMS impaired muscular force capacities.

Due to the wide varieties of different strategies in therapy of DOMS, the responsible sports physician has still the difficult task to define the optimal treatment regime for every single athlete in a case by case decision. Further, physicians have to stay informed about future developments as a superordinate strategy has not been found yet. Generally, the time of application in context of the different healing phases should be considered. One of the most common strategies used to prevent DOMS in case of EIMD is CWI. Studies have demonstrated promising results with regard to recovery, although effects on performance enhancement remain unclear. Compression, particularly applied during the post-exercise period, has been shown to be an effective way to reduce the clinical symptoms of DOMS and to accelerate the recovery of muscle function. In addition to these two methods, the majority of studies have focused on diverse cold and heat interventions, physical therapy, active forms of regeneration, massage or medication and nutrition strategies, but there is still no clear evidence to support these interventions in general.

Conflict of Interest

The authors declare that they have no conflict of interest.

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