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**Review Article**

Determining the Benefits of Massage Mechanisms: A Review of Literature

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Abstract: Many coaches, athletes, and sports medicine professionals hold the perception, based on observations and encounters, that massage can provide several benefits to the body. These include improved blood flow, reduced muscle pressure and neurological excitability, and increased sense of well being. Massage can produce mechanical pressure, which is expected to increase muscle mass, compliance, resulting in increased collection of joint motion, decreased unaggressive stiffness, and decreased energetic stiffness, known as biomechanical mechanisms. Mechanised pressure might help to enhance blood circulation by increasing the arteriolar pressure, and accumulating muscle tissue temperature from rubbing. Regarding the massage technique, mechanical pressure on the muscle is likely to increase or decrease nerve organs excitability as measured by H-reflex, which is known as neurological mechanisms. This is seen in parasympathetic activity (as assessed by heart rate, blood pressure, and heart rate variability) and junk levels (as simply measured by cortisol levels following therapeutic massage, causing a relaxation response), known as physiological mechanisms. A reduction in anxiety and an improvement in mood condition also cause relaxation, which is referred to as psychological mechanisms after the massage. Post-exercise, therapeutic massage has been recognized to lessen the severity of muscle soreness, but massage does not have any effects on muscle practical loss. Nevertheless, regarding the belief that massage therapy has benefits for sports athletes, there are no clear effects of different types of massage (Petrissage, Effleurage, Friction) or the appropriate timing of massage (pre-exercise and post-exercise) on performance, recovery from injury, or as a personal injury prevention method. Explanations are lacking because the mechanisms of each massage technique have not been broadly investigated. Therefore, this article investigates the possible mechanisms of massage and provides a discourse on the limited evidence of therapeutic massage on performance, recovery, and muscle injury prevention. The main purpose of this article is to examine mechanisms of massage and its benefits in performance, muscle recovery, and injury prevention. This study may help coaches, sport and health professionals, and researchers to understand massage mechanisms and benefits for performance, muscle recovery, and injury prevention.

Keywords: *Massage benefits, Massage mechanism, Blood Flow, Massage Technique*

1. Introduction

Therapeutic massage is believed to increase muscle mass blood flow and muscle tissue temperature [1], thereby enhancing performance [2]. It is also reduces cells adhesion and increase muscles flexibility [3, 4] which could help to decrease injury risk factors [5].

Therapeutic massage has been used for rehabilitation and relaxation for thousands of years around the world. Latest

research from the United Kingdom demonstrated that in the past years, therapeutic massage treatment was administered for about 45% of the total amount of time in physiotherapy treatment. Therapeutic massage is used in general approaches, including preparation for competition, during competitions, and in assisting restoration from competition, rather than treatment for specific problems [6].

Therapeutic massage involves the application of mechanical pressure on the muscle tissue in order to reduce

tissue adhesion. Increased muscle-tendon compliance is believed to be attainable by mobilising and elongating reduced or adhered connective cells. This leads to less stiff muscle-tendon unit [11]. Biomechanically, three main measures are accustomed to assessing muscle-tendon unit conformity; dynamic passive stiffness, powerful active stiffness, and stationary joint end range of motion [5].

A single study conducted by Stanley [12] examined the effects of therapeutic massage on passive stiffness. According to this study, a 10-minute Effleurage had simply no significant effects on unaggressive Gastrocnemius stiffness properties as compared to a 10-minute rest. The pressure of Effleurage might possibly not have been enough to produce the mechanical effects of massage. Also, if Effleurage could create a reflexive response, the enhancements made on muscle properties might be present in the contractile elements (active muscle mass stiffness) rather than passive aspects of muscle. Further research is required to investigate the effects of other massage therapy techniques such as Petrissage and Friction, which provide even more mechanical pressure on muscle tissue and passive properties of muscles.

According to the identified online literature, there is no research on the effects of therapeutic massage on active stiffness. The amount of active muscle stiffness depends upon passive joint properties, the intrinsic muscle and joint properties, and the effects of stretch out reflex [13]. Massage might be able to change active muscle stiffness simply by changing the level of neurological service. However, the optimal level of muscle mass, stiffness that benefit the dual performance and injury avoidance is still unknown.

Stationary flexibility is defined as the range of motion available in a joint or series of joints [5], and it is usually measured with a goniometer [14]. The majority of research that has evaluated the effects of therapeutic massage on muscle and combinatorial tissue have been based on mobility measurement [15, 4, 16]. For example, Leivadi [15] investigated the consequence of neck and back massage therapy on neck extension and shoulder abduction after therapeutic massage was applied to the ulterior region of the neck. The product range of neck extension movement was limited by anterior muscle tissue and ligaments, bony contact between spinous procedures [14]. Therefore, throat extension was not a good end result measure for the effectiveness of massage in this study. In other research, Nordschow and Bierman [4] found that finger to floor ranges increased significantly after massage from the back and lower extremities. Nevertheless, this study did not provide an appropriate control group, and sufficient evidence on whether the subject had therapeutic massage or control is lacking. The masseuse measured the distance between the fingertips and the floor, which may have caused bias during dimension. When the effects of massage upon a lower extremity range of motion had been compared with the other pre-exercise activities such as warm-up and stretching [16], massage increased just the ankle dorsiflexion range of motion. Meanwhile, stretching significantly increased almost all lower extremity range of motion measurements. Thus, the

effectiveness of massage about range of motion is still questioned, particularly when compared with more economical techniques just like stretching. The following are recognized physiological mechanisms employed in massage that are beneficial to the body.

1.1. Increased Skin and Muscle Temperature

Shallow skin friction increases regional heating, and consequently, causes hyperaemia within the massaged area. In this regard, regional heating increases local blood flow [17]. There is established proof that skin and muscle mass, temperature increases after therapeutic massage application, known as Effleurage technique. Longworth [18] reported an increase in pores and skin temperature during a six-minute back again massage, but skin heat returned to baseline level after ten minutes. Later, Drust, Atkinson, Gregson, French and Binningsley [1] reported an increase in skin and intramuscular temperature (2. 5 cm) of the Vastus lateralis muscle irrespective of the massage period (5-10 and 12-15 minutes of Effleurage). Although it was revealed that massage boosts skin [18] and intramuscular temperature [1], such effects upon skin and intramuscular temp might not be relevant to muscle blood circulation.

It is still questionable if increased skin and intramuscular temperature [1] without increasing muscle tissue blood flow [19, 20] and muscles compliance [12] would be beneficial to improve performance or prevent accidental injuries. The other limitations which are obvious from Effleurage technique supervision were that skin temperatures quickly returned to primary level [18], and lean muscle temperature did not increase deeper than 2.5 cm in profound muscle temperature [1]. This may lead to the implication that massage therapy (Effleurage technique) may not be appropriate as a preparation and/or precautionary strategy for exercising.

1.2. Increased Blood Flow

A number of authors have agreed that massage could increase blood circulation. Study results have already been inconclusive largely due to the nature of their limitations. Besides smaller test size, many of these studies had no reported statistical analysis, neither did they use a control group [10, 21, 22, 23, 24].

The venous occlusion pethysmography exhibited underestimation of blood flow because of the inflation of the cuff, and was very sensitive to movement artifacts [19, 20]. The changes of blood flow could not be indicated quantitatively [23]. Moreover, the venous occlusion pethysmography technique could hardly be used to measure blood circulation during actual massage [19, 25, 20]. Pulsed Doppler ultrasound has been utilized to investigate muscle blood flow, and has indicated that hands-on massage did not affect the flow of blood in the muscle after remedying the muscle [19, 25]. However, the ultrasound utilized in these studies detected modifications in large artery and line of thinking, but did not detect microcirculation in muscle that could be impacted by massage. In summary, there is an

insufficient evidence confirming that therapeutic massage does anything significant (with a few exceptions) for blood flow physiological response. The exclusive studies to explore blood flow with limited technique problems [19, 20] have demonstrated no change in total muscle mass blood flow.

1.3. Parasympathetic Activity

Therapeutic massage has shown some evidence of raising parasympathetic activity by minimizing heart rate, reducing blood pressure [18, 26, 27, 28, 29], elevating relaxation substances such as hormones [30], and increasing heart rate variability [31]. Most studies in this area have been conducted in nursing using a specific series of massage called “back massage”, and has been performed in older people [26, 27, 28]. One study looked into people with chronic pain [30], whilst other studies used combinatorial tissue massage and myofascial trigger point massage [31]. Consequently, only two studies, which usually met the criteria (participants had been healthy persons and Swedish massage utilized as the intervention) had been reviewed.

The effects of back therapeutic massage on several psychophysiological directories of arousal such as heart rate, blood pressure, galvanic skin response, Electromyography, skin temperature, and psycho-emotional response using the State-Trait Anxiety Inventory were examined in thirty-two female staff and college students in a nursing school [32, 18]. The participants had been massaged on the back intended for six minutes using a sluggish stroke technique (Effleurage). Heart rate, blood pressure, and skin heat increased after the massage, suggesting an increase in autonomic arousal level. Also the galvanic skin response increased, indicating a lower degree of sympathetic stimulation. The disparity in responses of the psychophysiological parameters might be due to people having a unique responsive design. The participants in the research were healthy females and were not in a stressful scenario. Therefore, it may have been difficult to display an excellent relaxation response. In some studies [33], there have been no significance within stress, pulse, and temp after having a 30-minute Swedish back and massage therapy in nine skilled female students, one day prior to a main academic examination. Only respiratory system rate decreased considerably. These results may assist the unique response routine, whereas massage can only generate some practices, implying parasympathetic responses in healthful female participants.

1.4. Pain and Muscle Spasm

Therapeutic massage has been applied in order to reduce pain [15, 34, 36, 37, 38]. The feasible, responsible mechanisms are nervous, physiological (biochemical substances), and mechanical (realignment of muscle mass fibres). Massage may decrease pain by activating the neural-gating mechanism in the spinal-cord. Tactile information from therapeutic massage might Stimulate large, fast nerve fibres and then, prevent the smaller, slower nerve fibres that detect pain. This kind of effect, presumably results from regional lateral inhibition in the spine [35] and explains

why coming in contact with the painful area is an efficient strategy for relieving pain. Nevertheless, there are no objective reports to support this idea. Massage therapy can increase biochemical chemicals such as serotonin [15], which is a brain chemical that plays a role in reducing discomfort [35]. Physiotherapists usually use massage therapy to break the vicious routine that causes muscle spasm and muscle pain. Muscle spasm causes muscle pain straight by stimulating mechanosensitive soreness receptors or simply by compressing the blood vessels leading to ischaemia [35]. Massage might help to rearrange muscle fibres and increase microcirculation.

The long run effects of a 30-minute therapeutic massage, twice a week for four consecutive weeks were analyzed in 30 college dance students [15]. A progressive relaxation remedy group was used for assessment. Both groups reported reduced state of anxiety levels and depressed mood subscale [39]. Nevertheless, the particular massage group revealed a significantly lower saliva cortisol after the massage session. The research did not state the time of blood collection, therefore the cortisol level should be interpreted cautiously because of the effects of circadian tempo [35]. The progressive relaxation remedy was not an appropriate control group, as it was an active relaxation approach which the participants had to perform by themselves, while massage therapy was obviously a passive relaxation technique used by the massage therapist. The rest group completed their exercises at home by following a documented tape, which raises the void of compliance to the intervention. Accordingly, further studies associated with massage on anxiety have to provide more appropriate control organizations.

1.5. Relaxation

The importance of massage on relaxation has already been investigated using valid forms. However, indicating the amount of relaxation is questionable because the questionnaire is composed of six scales; tension, depression, angriness, vigour, fatigue, and misunderstandings [39]. Only the tension, vigour, and fatigue subscales are appropriately intended for relaxation measurement, and it is additionally considered too long to complete [40] as there are 65 items in the original version and 72 in the bipolar edition. Interestingly, there are no forms available to allow a direct analysis of relaxation level. Weinberg [41] reported a preliminary study associated with massage on mood improvement in 183 physical education students. Massage intervention was compared with several physical activities including swimming, jogging, tennis, and racquetball. The students completed a battery of psychological forms before and after each intervention such as the State Anxiety Products by hand, and the high and the general activation subscales coming from Thayer's [42] adjective checklist [32, 42]. Surprisingly, only the massage and operating groups reported a significant mood enhancement with significant decreases in tension, fatigue, anxiety, anger, and depression. Only the massage group showed a significant decrease in the Thayer's [42] high activation subscale and the scores of State Anxiety Products.

A similar study conducted by Hemmings [43] compared the psychological effects associated with massage, lying resting, or perhaps touching control during boxing training. Therapeutic massage application during training increased the tension and fatigue subscales, which are relevant to measurement of rest. Both studies by Weinberg [41] and Hemmings [43] showed significant positive psychological effects owing to massage, despite the mood of the participants.

1.6. Recovery from Fatigue

Great perceived psychological benefits of therapeutic massage using the Perceived Recovery scale have been shown throughout the recovery phase of boxing performances and after training programs. Despite simply lack of changes in physiological fatigue signals such as blood lactate and heart rate, nine boxers reported that massage positively influenced the perception of restoration following boxing performances, and seemed to be a useful recovery technique. The Perceived Recovery level is a useful inquiry because it is short and straightforward to understand. However, the Recognized Recovery scale has not been traditionally used in studies. To date, there is absolutely no published article reporting the correlation between Perceived Restoration scale and physiological signs of fatigue [43, 45].

2. Methodology

Literature was located using three computer databases (PubMed, google scholar, and ScienceDirect) in addition to manual journal searches. The computer databases provided access to biomedical and sport-oriented journals, serial publications, books, theses, conference papers, and related published materials since 1964. The key search phases used included sport massage, massage performance, sport injury, delayed onset muscle soreness, injury prevention, range of motion, and muscle stiffness. This study did not include any articles not published in English, scientific journals; articles that focused on a specific type of massage or articles that focused on the effects of massage in special populations. The use of normal, healthy participants, age, gender, and fitness in the articles were the inclusion criteria.

In selecting the articles, differences and the massage techniques such as effleurage and petrissage were not excluding factors. The article must have used Swedish-type massage as an intervention, and should have discussed the

possible mechanisms of massage in relation to biomechanical and/or neuromuscular properties of muscle, sport performance, rate of injury, and muscle soreness.

3. Result and Discussion

Therapeutic massage involves several techniques including effleurage, petrissage, and rubbing. Each technique is used for diverse purposes and provides different results. Stanley [12] used an Effleurage way of ten minutes on the cripple muscles, and did not discover any change in passive tightness. Generally, massage therapists use Effleurage techniques to stimulate the parasympathetic nervous system and the relaxation response. Consequently, the massage technique used in the aforementioned study might not have been suitable to produce changes in passive rigidity. Petrissage and friction will be the techniques to mobilise profound muscle tissue, skin, subcutaneous tissue, and boost local circulation.

Therapeutic massage is believed to benefit sports athletes by enhancing performance and recovery, as well as promoting rest through biomechanical, physiological nerve, and psychological mechanisms. Regardless of the general belief of the advantages of massage, there are limited scientific data on possible methods of massage. Mechanical pressure from massage is thought to increase muscle compliance. A number of studies reported an increase in stationary flexibility as measured by joint range of motion, but these studies were methodologically flawed. New research reported poor effects of therapeutic massage (Effleurage technique) on powerful flexibility as measured by passive stiffness. Studies upon physiological mechanisms such as the adjustments of blood circulation, hormonal amounts, and psychophysiological parameters including blood pressure and heart rate, continue to be inconclusive. The explanations may be due to the unique response design of individuals and the variety of massage interventions (electronic, massage technique, duration of massage therapy, and pressure of massage) used in each study. The consequences of massage on neurological components have been reported to reduce the amplitude of the Hoffman response. Nevertheless, the results were limited to the Petrissage technique. Many studies reported that massage may promote relaxation by enhancing psychophysiological response. There are several western massage techniques, which are mostly employed in different circumstances for their benefits to the body. Some of these techniques are summarized in Table 1 as follows.

Table 1. Summary of typical western massage techniques.

Techniques	Definition	Suggested clinical advantage
Effleurage	Gliding or sliding movement over the skin with a smooth, continuous motion [7].	Stimulate the parasympathetic nervous system and evoke the relaxation response. Enhance venous return.
Petrissage	Lifting, wringing, or squeezing of soft tissues in a kneading motion, or pressing or rolling of the tissues under or between the hands [7].	Mobilize deep muscle tissue or the skin and subcutaneous tissue. Increase local circulation. Assist venous return.
Friction	An accurately delivered penetrating pressure applied through the fingertips [8].	Treat muscle spasm or breaks up adhesions from old injuries.
Tapotement	Various parts of the hand striking the tissues at a fairly rapid rate [9].	Stimulate the tissues, either by direct mechanical force or by reflex action.

Therefore, additional studies are needed to investigate the biomechanical, physiological, nerve, and psychological mechanisms for every massage technique. The outcomes will help to provide appropriate massage applications for specific purposes of sports activities. Well handled studies that have examined the opportunity of massage to influence overall performance, recovery or injury-risks are relatively few. Limited research has investigated the effects of pre-exercise, massage on performance. The results are inconclusive due to the improper massage techniques and end result measures used. There is limited or no study that has looked at the effects of pre-exercise massage on injury prevention. Therapeutic massage is widely administered among events because it is believed that massage might help to enhance restoration and prepare athletes for upcoming events. Unfortunately, any scientific data to back this claim is hardly found. A large amount of research on massage has reported the psychological benefits of therapeutic massage between events. Several studies have reported that post-eccentric exercise and massage could help to lessen muscle soreness sensation, and could not affect the muscle practical loss.

Therapeutic massage is believed to benefit sports athletes through its biomechanical, physical, neurological, and psychological systems. Research has reported the effects of therapeutic massage on physiological (investigated simply by blood flow and blood-borne substances), neurological (investigated by H-reflex), and psychological (investigated by questionnaire and psychophysiological guidelines such as heart rate, blood pressure) mechanisms. There are limited data on the possible mechanisms of massage, especially mechanical components of pressure and movement of massage on muscle mass properties such as passive or perhaps active muscle stiffness. There are many limitations of previous studies on the effects of massage upon performance and injury avoidance, which have led to inconclusive outcomes. Therefore, further research is clearly required to establish the possible advantages of massage.

The unclear description associated with massage on muscle blood circulation led to uncertain benefits intended for performance and recovery coming from fatigue. Only Petrissage continues to be studied and shown to decrease the Hr-eflex. Other massage methods have not been examined when it comes to their neurological effects. Consequently, there is no evidence to support the claim that some massage approaches (e.g. Tapotement, vibration) can increase neuromuscular excitability. The lack of studies on the mechanised effects of massage on muscle tissue properties such as active and passive stiffness, justifies unclear information on the biomechanical systems of massage. The knowledge of the exercise-induced muscle soreness mechanism and the components of massage will help to pick the appropriate massage technique, lifelong massage application, and time for application of massage. Therefore, even more research on the effects of therapeutic massage is needed to clarify whether massage therapy is beneficial for enhancing overall performance, recovery from damage, or

reducing the risk of muscle injury. The effects of different types of massage therapy (e.g. Petrissage, Effleurage) or the appropriate timing of massage (pre-exercise versus post exercise) on performance, injury recovery, or as a personal injury prevention method also needs to be examined.

3.1. Evidences for Massage on Performance, Recovery and Preventing Muscular Injury

Massage has been used for prevention, recovery, and enhancing performances particularly in sports. The following are evidences for massage on performance, recovery, or muscular injury.

3.1.1. The Effects of Massage on Performance

Sport massage is used in both pre and post-events in an attempt to boost athletes' performance, overcome exhaustion, and help recovery [46]. An increase in muscle blood flow might hasten the delivery of oxygen, increase muscle heat, and buffer blood pH level, which would then promote the performance of exercise [2]. Theoretically, improved muscle blood flow ought to help to remove waste products following exercise, and would enhance delivery of protein and other nutrition needed for muscle repair [25]. Increased lymph circulation could reduce post-exercise, swelling and stiffness simply by reducing muscle interstitial content material, and thereby reduce muscle mass discomfort [47]. Nevertheless, there are no data to aid these ideas, and the few studies on massage and blood flow have shown no increase in blood flow. Online literature search identified just two studies associated with pre-exercise massage on overall performance. Wiktorsson-Moller [16] found that 6-15 moments of Petrissage, with the purpose of promoting relaxation, comfort and ease, reduce muscle strength. Nevertheless, the author used Isokinetic movement to check muscle strength. Research has demonstrated that the tests of muscle function were not suitable to monitor performance [56]. There were simply no relationships between the percentage of modifications in the tests of muscular function (concentric and eccentric compression of Isoinertial and Isokinetic tests) and the changes in efficiency (sprinting and cycling) following an 8-week weight-training program [56]. Another study associated with 30 minutes of whole-body Swedish pre-exercise massage, including effleurage, petrissage and tapotement in 14 sprinters, showed that mean stride frequency was not significantly different among massage and control organizations [57]. However, it should be noted that the absolute stride frequency was obtained in the trial right after the massage. Stride frequency must be combined with a stride length to determine functionality. Therefore, the effects of pre-exercise therapeutic massage on performance are not yet proven due to the lack of well conducted studies.

3.1.2. The Effects of Massage on Recovery

It is believed that one of the optimum advantages of sport massage has been always to overcome fatigue and reduce restoration time, especially during intervals of competition,

and consequently, improve performance at the next celebration. Even though many leading sports athletes believe that massage is an important part of their success [54, 58], the effects of therapeutic massage itself are still questioned. Therapeutic massage can improve some physical markers [59], but some studies have shown no effect on any kind of recovery parameters [43].

To examine the effects of massage on restoration, several studies provided therapeutic massage between sport sessions. Nevertheless, there were some limitations during these studies, leading to inconclusive data. For example, Monedero and Apporte [60] administered combination remedies (active exercise and massage), so the true benefits of specific massage treatments are still not clear. Some studies had issues with credible data, including little sample size [43, 61] and insufficient statistical analysis [59]. An appropriate style such as cross-over design, use of a control group (placebo treatment), and maximisation of motivation of individuals in both control and massage groups are elements which need to be considered in massage studies in order to reduce psychological effects.

Curative massage therapy can facilitate soft cells healing in a number of ways. Therapeutic massage may help reduce both main oedema and the possibility of supplementary oedema caused by the pressure of increased fluid in regards to trauma [3, 49]. Starkey [49] found that mixture treatments including cold, workout, and mechanical massage can reduce the total time dropped from practice by around two days when compared to the normal snow, compression, and elevation treatment. Unfortunately, the published report showed nor the results section neither the statistical analysis. Practitioners apply massage to the site of the injury because they expect a therapeutic massage to improve blood circulation to the area of the injury and, consequently, to help improve healing. The mechanical pressure of massage is generally utilized to treat adherent or caught connective tissue in order to bring back fibres to a more regular alignment. Nevertheless, there is limited data to support these recommended mechanisms.

3.1.3. The Effects of Massage in Preventing Muscular Injury

Sport massage has been used for centuries in an attempt to prevent and cure injuries [3, 46, 8, [47]. Massage is considered in enhancing muscle relaxation [4, 16], reducing muscle tension and soreness [20, 21, 48], promoting the healing process [49], and consequently, improving athletic performance [50, 51, 52]. Massage is also thought to provide a soothing, sedative, invigorating feeling, and can give the athlete confidence by the positive reaction that takes place within the body [41, 43, 44, 45]. Massage might be an effective way to prevent acute injuries resulting from abnormal tissue conditions (muscle tears in tight muscle) and chronic injuries caused by wear and tear [53] by rearranging the muscle fibres [54]. As a result of these suggested benefits, manual massage may be a useful modality to enhance performance and prevent injury for athletes who use their

muscles strenuously. Sport massage may help to optimise positive-performance factors, including healthy muscle, combinatorial tissues and normal mobility [53]. Massage is used to minimize negative-performance factors such as dysfunctional muscle mass and connective tissue, limited range of motion, pain and anxiety [53]. Therefore, preventive, therapeutic massage is commonly recommended to help sports athletes prepare both physically and mentally for any forthcoming event [7]. In addition, sports activities massage is believed to reduce injury-potential factors. Even though therapeutic massage has benefited several injury-risk elements such as increased range of motion [15, 4, 16], decreased pain [34, 55], and anxiety [15, 41], there have been no treatment studies that assessed the effects of these types of possible injury prevention tactics. There is no clear evidence that massage can actually improve overall performance, enhance recovery, or stop muscular injury. Also the amount of massage benefits compared with other strategies such as jogging or stretching has not yet been looked into.

DOMS is a very important problem intended for coaches and athletes, since it causes chronic pain and diminishes muscle function and ability, combined treatment and active recovery in bloodstream lactate removal to take part in sport [62]. DOMS commonly occurs between 24 and 72 hours, following unaccustomed eccentric exercise [63, 102, 64, 65]. The consequences of damage to muscle function include continuous loss of muscle strength [66, 67, 102, 68, 69], soreness sensation [65, 68, 69], reduced range of motion [67], increased muscle tightness [66], increased resting metabolic rate [70], and perturbed athletic performance [71, 72, 73]. These types of changes might increase the likelihood of sports injury.

The sequence of DOMS occasions consists of the mechanical tension of exercise on muscle mass fibres [63, 74, 75, 64, 76], causing sarcomeres to rupture [77], followed by calcium homeostasis disturbance. The damage of sarcoplasmic reticulum or muscle membrane layer can increase intracellular calcium mineral and trigger calcium-sensitive paths [78, 79]. The calcium activated neutral protease plays a role in the ultrastructural muscle tissue damage [102]. The inflammatory response to damaged muscle fibres triggers a transfer of liquid and cells to the broken tissue [81]. The increased fluid produces bloating after injury. Neutrophils and macrophages migrate to the other sites and play a role in both the damage and restoration processes [102]. The exact mechanisms to describe how soreness development and why there is a delay in pain sensation are not fully understood [14, 75, 80, 82].

A number of treatments which aim to stop or reduce the severity of muscle damage have been looked into, including acupuncture [83], ultrasound [84, 99], Cryotherapy [86], compression [66, 87], anti inflammatory drugs [88], Hyperbaric oxygen therapy [89], warm-up [90, 103], stretching [90, 91, 92], and massage [93, 94, 95, 48, 20, 96, 97]. These treatments have already been applied as a prophylactic and a therapeutic intervention. Nevertheless, the benefits of these treatments continue to be inconclusive. From

a medical point of view, the treatment given prophylactically is more desirable for minimizing or preventing injury, and for reducing additional injuries, chronic pain, expense of injury treatment, and periodically lost from training actions.

Therapeutic massage is one of the treatments commonly used to ease DOMS because it is thought to boost local blood and lymph flow, decrease oedema, and minimize pain. Significant reductions in soreness perception of DOMS after massage have been reported [98, 95, 48, 20]. Some studies described the mechanism of DOMS reduction by increasing neutrophils [48] and decreasing blood Creatinine kinase [48, 95], while some researchers did not explain the mechanism whatsoever [20, 98]. However, many researchers reported that massage was not helpful in reducing DOMS [93, 94, 96, 97, 99]. The unclear mechanisms of massage may also lead to improper massage application. In practice, therapeutic massage is often applied immediately after workout in order to enhance blood circulation. The consequence of massage on blood circulation continues to be questionable as described earlier. The eccentric exercise, which usually induces muscle damage, will not produce waste products that require extra blood flow. Research, which looked into the effects of massage immediately after work, found a decrease of DOMS 48 hours after training, but did not find any kind of change in blood circulation [20]. Also, some did not find any increase associated with massage immediately after exercise [96, 97].

A few researchers have speculated that massage may reduce DOMS sensation by decreasing muscle mass oedema. However, in studies conducted by Hasson [93] and Lightfoot [94], large quantity and soreness sensation would not change after massage and/or 24 hours following exercise. Massage performed two hours post-exercise was reported to benefit DOMS simply by reducing an inflammatory procedure [48]. The neutrophil ideals in the massage group had been significantly higher than in the control group at eight and 24 hours. The authors believed that the elevation of the neutrophil counts was the result of the mechanical action of therapeutic massage by the shearing of the neutrophils from the vessel walls. The increased blood flow from the suggested physiological mechanism of massage therapy might prevent the migration of the neutrophils from the circulation into the injury sites. Thus, the neutrophil values would be raised in the blood count. Two studies used the process of Smith's [48] approach to examine the effects of massage application two hours following eccentric exercise [100, 101]. Farr tout autant [101] and Hilbert [100] reported that massage performed two hours post-exercise was successful in reducing soreness feeling. It is important to note that a research conducted by Farr [101] investigated massage on one lower-leg, and used the additional leg as the control group. Therefore, it is likely that therapeutic massage might provide a psychological benefit, as only soreness experience – the subjective solution reported by the participants – was reduced after massage therapy application. There was simply no benefit of massage for avoiding muscle strength and function reduction (as determined by isometric and isokinetic tests and getting height

respectively) [100, 101]. Interestingly, the two studies did not find any kind of change in neutrophil count.

4. Conclusion

Massage is believed to benefit sportsmen through its biomechanical, physical, neurological, and psychological devices. Research has reported the effects of massage on physiological (investigated by simply blood flow and blood-borne substance), neurological (investigated by H-reflex), and psychological (investigated simply by questionnaire and psychophysiological recommendations such as heart rate, blood pressure) mechanisms. There is limited information on the possible mechanisms of massage, especially mechanical aspects of pressure and movement of massage on muscle mass houses, such as passive or perhaps energetic muscle stiffness. Therefore, there is no evidence to support the claim that some massage techniques (e.g. Tapotement, vibration) can increase neuromuscular excitability. Understanding the mechanism of exercise-induced muscle soreness and the mechanisms of massage will help to select the appropriate massage technique, duration of application, and time of application. The effects of different types of massage (e.g. Petrissage, Effleurage) or the appropriate timing of massage (pre-exercise versus post-exercise) on performance, recovery from injury, or as an injury prevention method also needs to be examined. Simply, no published studies have reported the effects of pre-exercise massage around the severity of muscle harm. Massage can increase muscle mass temperature and blood flow, and that might help to increase muscle compliance and minimize muscle stiffness. Nevertheless, research on the effects of therapeutic massage on passive stiffness has not supported this claim.

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