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Soft-Tissue Techniques in Sports Injuries Prevention and Rehabilitation

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Abstract

Participation in sports, in addition to its positive effects, leads to injuries caused by contact with the opponent or the high loads that develop on the musculoskeletal structures during the sports activities. Sports injuries mainly include (a) acute injuries such as muscle strains and ligament sprains, tendon injuries, dislocations and subluxations, fractures, and skin injuries but also (b) overuse injuries such as tendinopathies and painful myofascial syndromes. Many therapeutic techniques are used to treat these injuries, such as therapeutic exercise, various electrotherapy procedures and soft tissue techniques. Soft tissue techniques aim to promote health and well-being through their mechanical effects on the body's soft tissues such as friction, compression, tissues sliding and myofascial release. Sports soft-tissue procedures are applied either directly with the hands of therapists such as classical massage or with the use of special equipment such as tools made of stainless steel (ERGON instrument-assisted soft tissue mobilization), elastic ischemic bandages (Kinetic flossing technique) and cups (cupping therapy). The following chapter analyzes the therapeutic effects of the above therapeutic interventions by presenting recent scientific evidence that supports their effects on the soft tissue's dysfunctions of the human body and various pathological conditions.

Keywords: sports injuries, sports massage, IASTM, muscle flossing, cupping therapy

1. Introduction

Sports participation, both at the amateur and professional levels, is widespread among all age groups. However, the rising number of athletes and increasingly intense competition have yielded both positive results, such as better quality of life and performance, and adverse effects, such as a higher risk of sports injuries. The etiology of sports injuries includes a set of intrinsic and extrinsic risk factors, such as the specific characteristics of each athlete and environmental influences. Intrinsic risk factors include biological characteristics, such as gender, age, weight, height, strength and flexibility asymmetries, anatomical asymmetries, incomplete recovery from previous injuries, joint instability, and the athlete's psychological state. Extrinsic risk factors include the type of sport, environmental conditions, the level of sport (amateur/professional), the athlete's skill level, training errors, the playing surface, the lack of protective equipment, and the specific kinetic prototype of each sport.

Sports injuries are endemic to high-energy sports due to tissues being overloaded during specific sports activities. More specifically, repeated exposure to the high mechanical loads associated with sports activities induces pathological postural adaptations and causes injuries to myofascial structures. Such adaptations and micro-traumas alter the physical properties of the connective tissue, leading to myofascial scarring and fibrosis. Furthermore, inflammatory responses to this tissue damage can alter the structure of myofascial tissues, leading to pain and hypersensitivity and thus limiting an athlete's joint range of motion, strength, and performance. The structural adaptations discussed above can adversely affect an athlete's functionality, decreasing their performance and increasing the risk for sports injuries.

Various therapeutic strategies have been used to prevent and treat the sports pathologies and dysfunctions associated with biomechanical deficits and overuse. The most popular therapeutic interventions in sports include soft tissue techniques applied directly by the therapists by using their hands (sports massage) or by using specific equipment, as in the case of instrument-assisted soft tissue mobilisation (IASTM) techniques, as well as muscle flossing techniques and cupping therapy. Sports massage, IASTM, flossing, and cupping techniques are applied to an athlete's soft tissues to treat myofascial dysfunctions, alleviate hypersensitivity in myofascial tissues, release scar tissues and adhesions, decrease pain, improve functional performance and joint range of motion (ROM), reduce delayed-onset muscle soreness (DOMS), and accelerate recovery. This chapter reviews the studies regarding the effectiveness of the aforementioned soft tissue techniques for sports-injury prevention and rehabilitation and for improving athletes' functional capacities and physical properties.

2. Soft-tissue techniques in sports-injury prevention and rehabilitation

2.1 Sports massage

Sports massage involves performing soft tissue-manipulation techniques on athletes to maximise performance and prevent or repair injuries. The sports massage techniques aimed at maximising performance and preventing injuries are divided into pre-competition (i.e. before the sports event) and post-competition massage techniques. When a sport includes breaks, massage is often performed during such breaks [1].

2.1.1 Sports massage techniques

Massage aimed at repairing sports injuries is mainly applied in the physiotherapy laboratory during rehabilitation. The techniques of applying pressure and mobilising an athlete's anatomical structures are delivered either by the physiotherapists using their hands or special massage equipment.

Sports massage is predominantly based on the techniques based on the Swedish massage techniques and includes manipulations such as slips-kneading, kneading, twisting, percussion, and vibration [1, 2]. The main difference between sports and classic massage is that the two forms of massage serve different purposes and are therefore applied differently. For example, in most cases, sports massage is applied with more pressure because athletes' bodies require a more aggressive approach due to sports adjustments. In addition, there are manipulations, such as stripping massage (i.e. special transverse-friction massage), that are used almost exclusively in the rehabilitation of sports injuries [1, 2].

2.1.2 Massage in different sporting conditions (before, during, and after the sports event)

The effects and goals of sports massage are divided according to the mechanical, physiological, nervous, reflexive, and psychological outcomes. The massage goals vary depending on the period when they are applied (before, during, or after the sports event). For example, the massage techniques applied before the sports event are mainly meant to prepare athletes by increasing performance and reducing the risk of sports injuries [3].

The positive effects of pre-game massage on athletic performance are based on the theoretical principles that massage yields the following benefits: (a) increased skin and muscle temperature; (b) increased metabolism; and (c) increased blood circulation, which improves oxygen transport to tissues and leads to a better balance in blood flow [4]. The preventive effects of sports massage in terms of injuries have been attributed to (a) improved passive and active elasticity, (b) increased muscle activation and performance, and (c) the psychological stimulation of the athlete [5]. However, some of these theoretical effects of pre-game massage have not been strongly supported by research as relevant research findings have been limited or yielded conflicting results.

The relationship between massage and an increase in surface temperature has been confirmed by previous research. Several studies have shown that massage via the rubbing of the skin and the subcutaneous tissues increases the local skin and intramuscular temperature and leads to hyperaemia [6–14]. It has been reported that even a 6-minute massage of the back significantly increased the area's temperature, which returned to pre-massage levels after 10 minutes [11].

Similar effects were confirmed in a study conducted by the Laboratory of Therapeutic Exercise and Sports Rehabilitation at the University of Patras, Greece, which found that sports massage in the gastrocnemius and quadriceps areas of young basketball players increased the skin temperature of said areas, with the temperature returning to normal after about one hour. This finding is of special clinical interest because increased tissue temperature reduces pain and increases the metabolic rate, which can improve the elasticity of collagen and result in better functionality as well as a possible prevention of musculoskeletal injuries. Finally, increased skin temperature leads to an increase in vascular permeability and better oxygenation [15].

However, although pre-game massage increases surface and intramuscular temperature, such changes may not directly affect local blood and lymph circulation as studies have shown that massage can lead to significant [5, 14, 16, 17], moderate, or even zero increase in blood circulation [18–22].

The conflicting research findings on the effects of massage on blood circulation can be attributed to several factors. First, the positive effects of massage on skin temperature seem to subside relatively quickly [10]. Second, the increase in intramuscular temperature does not seem to exceed 2.5 points in muscle depth, meaning that it does not significantly affect the main vessels of the muscle [11].

In addition, researchers have mainly investigated deep effleurages rather than other manipulations. Moreover, the main techniques used for evaluating blood circulation (venous occlusion plethysmography, the Xenon-washout technique, Doppler ultrasound) have run into significant validity problems. Another researched factor that clearly influences the effect of massage on blood circulation is the intensity of the pressure applied to the tissues. Evidence supports the academic and sensible theory that classic relaxation massage leads to lower blood pressure, while intense athletic massage leads to increased blood pressure [17].

The relationship between massage and improved elasticity has been confirmed by several studies [23–29] that have shown positive muscle-elasticity adjustments after the application of massage. Studies have found that pre-game massage is associated with a relatively short-term (up to 24 hours) improvement in the elasticity of hamstrings [23–25, 29, 30] and plantar flexors of the ankle joint [31] in athletes and non-athletes. Improved muscle elasticity is causally related to the massage techniques applied. Intense and dynamic movements, such as intense deep-friction [30] in combination with eccentric exercise [32, 33], contributes more effectively to a short-term increase in tissue elasticity. This improvement is attributed to the reduction of myotendinous stiffness and increased stretch tolerance [30].

In contrast to elasticity improvements, scholars have not conclusively determined the effects of massage on the production of tension (strength), with some studies reporting a relative increase of post-exercise muscle strength after massage as assessed by various laboratory and functional tests with college students [27] and volleyball athletes [34], and other studies showing a significant reduction in post-exercise strength produced immediately after the application of massage [23–25, 29, 30, 35].

Finally, pre-game massage seems to significantly improve athlete psychology, with massage being associated with a reduction in pre-game stress in athletes, which contributes to better performance [36] by reducing stress hormones (cortisol and norepinephrine) and increasing serotonin levels [36, 37].

2.1.3 Pre-game massage

The manipulations performed to prepare an athlete for a sporting event mainly involve effleurages (superficial and deep), petrissage (flat petrissage), stimulating rolling, and kneading. These manipulations are mainly applied to the athlete's muscular groups that will be overloaded and will receive more use depending on the movement patterns of each sport. Considering that almost all sports, under normal conditions, are related to and depend on the movement of the lower extremities, the pre-game massage is logically focused mainly on the preparation of the muscles of the lower extremities. In addition, pre-game massage should also prepare (a) the body's central point (trunk), which provides the biomechanical basis for the initiation and proper execution of athletic movements, and (b) the upper limbs in cases of sports whose movement patterns include extensive use of the upper limbs (handball, volleyball, basketball, etc.).

Raising the temperature of the soft tissues before exercise is imperative to prepare the muscles for the intense loads that will follow in the game [38]. Massage can improve the temperature of the superficial muscle tissues, thus better preparing the athlete to enter the sports field [39].

The Laboratory of Therapeutic Exercise and Sports Rehabilitation at the Department of Physiotherapy at the University of Patras, Greece, has obtained positive results when it comes to studying massage and pre-game preparations: Charalampopoulou et al. concluded that soft tissue techniques, including IASTM and massage, can raise the skin temperature in basketball players for 15 minutes after the massage application [15].

2.1.4 Massage during the game

In sports that involve a break or breaks between competitive efforts, massage can improve athletic performance by allowing the athletes to temporarily cool-down (physically and psychologically) and preparing (activating) them for the continuation of the competition [4]. The main problems that an athlete faces during intense

and competitive exercise are physical as well as psychological. Physical adaptations include muscle pain, increased muscle tone (spasm) of particularly stressed limbs, and edemas-hematomas. Psychological adaptations depend on various factors (the competition's importance, half-time result, etc.) and may include either personal competitive stress for better individual performance or psychological pressure for better team performance and goal achievement (in the case of team sports).

Depending on the manipulations chosen and the way they are performed (slowly superficially, superficially, in-depth), sports massage during half-time can lead to initial cool-down and reduction of the painful muscle tone and muscle excitability and to neuromuscular readiness as the game recommences [40, 41]. Moreover, massage can also reduce competitive stress and calm the athlete [42–44].

The research efforts that have examined this parameter have, despite their disadvantages (no control group, small sample of examinees), highlighted a significant correlation between massage and the improvement of the athlete's psychological parameters [42–44]. In terms of psychological rehabilitation, massage has been associated with a significant improvement in an athlete's sense of physical recovery, an outcome that is very important for the continuation of competitive efforts [45–47].

2.1.5 Massage techniques after the game

The main problems that an athlete faces after the competition (depending on its intensity and duration) are (a) fatigue from the accumulation of metabolism and waste products, (b) the accumulation of edemas and possible hematomas resulting from the excessive use of and strain on the athlete's anatomical structures, and (c) the immediate and delayed onset muscle soreness and the significantly increased muscle tone (spasm) of the limbs. Due to these effects and adjustments, athletes' physical properties (muscular strength, endurance, elasticity, proprioception) decrease significantly, and recovery should indirectly aim to correct these issues.

Post-competition massage as a means of passive rehabilitation can significantly contribute to an athlete's recovery and reduce the aforementioned physiological adaptations, but to a lesser extent than active recovery (e.g., aerobic running) [48–50].

Initially, by increasing blood flow to the muscles [51–53], massage can speed up the removal of useless metabolism products after exercise and improve the transport of oxygen, protein, and other nutrients necessary for muscle recovery and restart, leading to homeostasis [51, 54–56]. In addition, massage can significantly reduce feelings of fatigue and muscle pain as massage can help reduce the concentration of carcinogens (lactic acid) after exercise by improving blood flow to the muscles and subsequently increasing oxidation [57–59]. However, it should be noted that although massage leads to a significant reduction in the levels of lactic acid in the blood after intense exercise (compared to passive rest), active recovery (aerobic running) [49, 50, 59] the combination of massage and active rehabilitation [60] clearly exhibits better metabolic effects. In addition, massage has been shown to contribute positively to athletes' (soccer players') recovery in terms of heart rate and blood pressure compared to passive rest, with soccer players exhibiting better heart-rate recovery after lower extremity massage compared to active and passive recovery modes [50].

In summary, increased lymphatic circulation and venous resuscitation resulting from the application of sports massage after intense exercise can reduce the swelling and hematomas created during the exercise. The aforementioned adaptations, together with the local increase in temperature, can contribute to reduced muscle tone and improved relaxation [61–63]. The reduction of the concentration

of hematomas and edemas caused by intense and prolonged exercise leads to a reduction of pain through a corresponding reduction of hydrostatic pressure and irritation of the sensory receptors of pain [64]. These outcomes of post-game massage are well supported by several studies that have shown that massage can reduce the intensity of DOMS in athletes and thus contribute to faster and better recovery [63, 65].

Finally, massage has been found to lead to faster recovery of strength levels compared to passive movement or rest as 5 minutes of massage (rolling, flat kneading) resulted in better grip strength of healthy people (non-athletes) after maximum exercise [16, 66]. Two additional studies examining the recovery of isokinetic power in the quadriceps muscle described improvement and increase of isokinetic power after 6-minute and 10-minute massages [67, 68].

2.1.6 Therapeutic sports massage

The soft tissue techniques of sports massage used to treat sports injuries are mainly applied in the physiotherapy laboratory during the rehabilitation phase. These techniques are performed by the sports physiotherapists as well as the athletes themselves in the case of self-massage with special equipment, such as a foam roller.

An important difference between therapeutic sports massage and the classic therapeutic massage has to do with the fact that in the case of therapeutic sports massage, the massage is not applied exclusively to the massaged area in a relaxed position but can also be combined with active (concentric-eccentric) or passive movement of the involved muscle group [33].

2.1.7 Goals of therapeutic sports massage

The main goals of therapeutic sports massage are the mobilisation of hematomas-edemas in the subacute phase of sports injuries, the alignment of injured tissue fibres, the release of adhesions, and the recovery of the elasticity of various tissues [69]. The main techniques used to achieve these objectives are the linear techniques of classic massage, except in the case of regaining elasticity and adhesion release, which requires special massage techniques, such as stripping massage, transverse friction massage, and aggressive forms of myofascial massage-mobilisation, such as foam roller, IASTM, and cupping therapy.

2.1.8 Mobilisation – reduction of edemas/hematomas

Massage can play an important role in repairing sports injuries by helping to reduce the concentration of both primary edemas caused by the injury and secondary edemas caused by increased hydrostatic pressure in the injured area [3, 70]. In addition, in cases where the injury has damaged several blood vessels and has led to a significant accumulation of hematomas, massage can mobilise this accumulation of blood and drastically reduce the healing time of an injury through the application of mechanical pressure to the vessels and tissues in general and the subsequent increase in local blood and lymphatic circulation [4, 26, 71–73].

By applying mechanical pressure to the tissues and vessels, massage mobilises the content of the valvular veins and the lymphatic channels in a more central direction (towards the heart), thus facilitating the entry of the interstitial fluid into the vessels [74, 75]. At the same time, vascular congestion can be reduced via the reduction of the median pressure, thus improving the diffusion-supply of the tissues [13].

Improved drainage of fluids in the injured area also restores the normal osmotic pressure of the interstitial fluid, a process that is equally important to the vascular adjustments seen after the application of massage. These theoretical effects of massage on venous return and lymphatic circulation are supported by findings from studies of animals, which have shown that massage significantly increased lymphatic circulation compared to diathermy and active and passive exercise when applied to dogs [76, 77] and pigs [78].

2.1.9 Massage application to reduce swelling/hematoma (aggressive massage techniques)

The massage that aims to mobilise fluid elements (edema/hematoma) in athletes has a clearly accelerated-aggressive form, and its execution (pressure, direction, massaging point) can lead to high pain (VAS scale 7–8) during application. This aggressive massage technique uses straight manipulations and mainly deep slips and special massaging techniques (stripping massage) because circular strokes are not allowed in the acute stage of injuries and in the phase when the fibres of the injured tissue are immature or, even worse, have not been restored yet.

The basic manipulations (effleurage-kneading) begin more centrally than the site of the injury. Through the mobilisation-increase of the venous return of large vessels, the massage techniques are meant to “empty” the injured areas and to create an environment (negative pressure) suitable for the mobilisation of the edema-hematoma located in the periphery of the injured area. Immediately afterwards, massage techniques are once again applied directly to the injury using straight manipulations from the periphery towards the centre. Through direct mechanical effect, swelling and hematomas are directed towards the trunk or from deeper to more superficial layers, which ultimately facilitates hematomas removal. These manipulations have been described in a study by the Laboratory of Therapeutic Exercise and Sports Rehabilitation at the University of Patras, Greece, in which aggressive massage techniques were performed to speed up the recovery of a professional football player after a 1st degree hamstring strain. The results of the study were encouraging as recovery time was reduced to almost half of the usual time and the footballer resumed full training and participation in games in 15 days. The soft tissue techniques used to remove the edema were stripping massage, cupping therapy, and IASTM techniques [79].

The application of the manipulations described above leads to significant pain due to pressure on the injured tissues and increased hydrostatic pressure, which, in turn, increases the irritation of the sensory receptors of pain. However, the aggressive approach drastically accelerates the reduction of the accumulation of metabolic substances and blood-hematoma and enables the process of fibre re-adhesion to begin sooner. The application time ranges between 5 and 10 minutes, and the pressure/intensity of the techniques must be alternated (mild to intense/deep-surface) to be more tolerable for the athlete. Immediately after the mobilisation of the edema-hematoma, cryotherapy should be applied to reduce (via vasoconstriction) the amount of the mobile fluids that will return to the massaged-injured area.

2.1.10 Massage for aligned fibre re-adhesion and reduction of scar tissue

In the subacute phase of the injury, when the swelling-hematoma has been removed and tissue re-adhesion and scar tissue deposition begins, massage also plays a critical role in facilitating the proper repair of the injured area. The application of straight manipulations (deep kneading, soothing rolling, tapping linear strokes) in the direction that the fibres of the injured anatomical area are normally

arranged in creates a tendency for linear re-adhesion as well as reduction of adhesive deposition and scarring.

Proper alignment and reduction of the amount of hard connective tissue in the injured area reduces the loss of elasticity and strength experienced in the presence of adhesions [1, 2, 80], thus reducing the risk of the recurrence of injury [2]. In addition, massage can “dissolve” fibrous deposits that can impede the flow of interstitial fluid by clogging tiny pores of the fascia, which restores the circulation of interstitial fluid [3].

These significant effects of massage on tissue repair have been supported by research on animals that have technically suffered muscle strain and received massage as basic treatment in randomised studies. The massaged muscles had normal microscopic illustrations in contrast to the non-massaged muscles, which showed histological adaptations such as (a) dislocation of the myofibrils, (b) significant deposition of connective tissue, (c) persistent hematomas, (d) increased number of fibroids in the connective tissue, and (e) enlargement of the blood vessels accompanied by the thickening of their walls [63].

2.1.11 Massage application in delayed-onset muscle soreness (DOMS)

DOMS generally describes the tenderness and pain of muscles that develop hours or even days (24–72 hours) after specialised and demanding sports training (eccentric-plyometric) [81].

This negative adaptation after intense exercise leads to decreased elasticity of the anatomical structures involved (upper and lower extremities) and to clearly reduced muscular strength [5, 65]. Several theories for DOMS have been proposed, including the activation of free nerve endings by (a) lactic acid accumulations, (b) muscle and ligament injuries, (c) exit to the intracellular space of intramuscular enzymes, and (d) prostaglandins [81]. Histological examinations of muscle cells after eccentric loadings have revealed structural cellular adaptations (migration of cellular elements) that cause local edema and inflammation [65, 82].

In addition, connective tissue injury is evidenced by the high concentration of hydroline and hydroxylysine in athletes’ urine after eccentric exercise [81]. Theoretically, and based on the previous chapters, the fact that massage can move fluids from the intercellular and interstitial spaces and reduce the accumulation of metabolic products [48, 51, 54–56] may have a positive effect on reducing DOMS. This is confirmed by several studies that have shown that massage can significantly reduce muscle sensitivity because of eccentric-plyometric muscle activity and contribute to improving the rate of tissue healing and the reduction of cellular inflammation by improving the supply of nutrients and oxygen to the tissues [34, 56, 65, 83–85].

Moreover, massage can lead to faster recovery of muscle strength, which is significantly reduced after eccentric exercise [20, 81, 86, 87].

Finally, several studies have recorded reduced muscle soreness, lower perception of fatigue, and improved perceived recovery [16, 20, 45, 88] at variable intervals after the massage, ranging from 24 to 96 hours.

2.1.12 Effects of massage on the inactivation of trigger points

The creation of painful trigger points is one of the painful syndromes and injuries of the musculoskeletal system that have been observed after intense exercise. These points refer to localised areas of high sensitivity that are usually located within a stretched muscle bundle. The clinical feature of these myofascial trigger

points is that they cause intense focused pain during compression as well as other symptoms, such as reported pain, muscle dysfunction, and autonomic phenomena.

The causes of such pain triggers include biomechanical body abnormalities, injuries, chronic inflammation, and psychological factors but may also be the result of tissue overuse during exercise [89, 90]. Beyond focused pain, the negative adaptations caused by the existence of areas of excessive tension and ischemia include reduced elasticity and deficient strength production and muscle function in general [89]. In addition, pain triggers have been blamed for causing painful muscle spasms (cramps) during exercise [91].

The treatment of such pathological signs of pain includes, among others, techniques that combine cryotherapy and stretching (stretch and spray), electrotherapy (tens, ultrasound), and massages of various kinds [90, 92].

The treatment of painful trigger points has been part of classic massage techniques and therapy techniques that rely on ischemic compression of trigger points, leading to the deactivation of said points and to the reduction of pain symptoms. In particular, the application of massage in the form of either classic-Swedish massage [93, 94] or ischemic pressure [95] significantly reduced the intensity of pain in patients with painful trigger points in the trunk (lumbar and cervical region) [96] and the thigh muscles (hind thighs) [97].

2.1.13 Application of ischemic pressure to deactivate painful trigger points

Ischemic pressure deactivates painful trigger points via two main mechanisms: ischemia and the following hyperaemia as well as local and focused tissue stretching. Ischemic pressure initially creates a reduction in local perfusion; once the pressure is removed, hyperaemia occurs in the area, which can help clear the muscle of inflammatory derivatives and pain metabolites, thus desensitising the nerve endings. In addition, constant local pressure on the trigger points will lead to continuous stretching that can potentially “solve” painful adhesions and reduce muscle spasms [89].

In a study by Fousekis et al. at the University of Patras, ischemic pressure techniques were applied to amateur soccer athletes on painful lower-back trigger points to evaluate the effectiveness of these techniques in pain. From the very first week of application, the participants reported a decrease in pressure sensitivity according to VAS and a pain reduction as ischemic pressure was effective for treating trigger points [98].

2.2 Instrument-assisted soft tissue mobilisation (IASTM): the ERGON IASTM technique

Mobilisation techniques using special tools made of stainless steel are a form of aggressive mobilisation of soft tissues. There are several variations of such tools (Myobar, Fibroblaster, Smart Tools, Rockblade, Hawkgrasp), but the Graston and ERGON tools are the most prevalent ones in research.

Soft tissue techniques using special equipment require tools designed to adapt to the various tissues, shapes, and curves of the body. These tools are used for the following purposes: (a) to detect and release scar tissue, adhesions, and fascial sclerosis; (b) to increase blood circulation; and (c) to reduce muscle tone and pain [99–101].

Significant advantages have been reported in using such tools rather than one's hands when evaluating the abnormalities of tissues, although a stainless-steel tool is inferior to the human hand in the first stage of the standard evaluation, which

involves tissue palpation for the assessment of temperature, humidity, edema, and muscle spasms in the superficial tissues of the body [102].

Massaging the tissues with special tools enhances a therapist's sense and information about the condition of the tissues as the fatty areas of the therapist's fingers that come in contact with the patient's body compress the tissues, while the tools have a narrower edge to separate them [102, 103].

According to the manufacturers, the tools act as percussion instruments: when in contact with hard fibrous tissue, they transmit an echo (vibration sensation) to the therapist's hand, improving their ability to recognise and evaluate adhesions and fibrous deposits [101, 102]. In addition, the use of such tools allows the mobilisation of deep and hard structures without overloading the therapist's fingers.

In particular, IASTM techniques in conjunction with cross-friction massage can reduce scar tissue deposition after an injury, reduce the hardness of preformed connective tissue deposits, and facilitate the healing of chronic overuse injuries by re-damaging tissues and linearly re-connecting them [96, 101, 104–107].

IASTM techniques also appear to lead to changes in microvascular morphology and hyperaemia [108] and to increased fibroblastic mobilisation and activation, an adaptation that leads to regeneration and repair of the injured collagen [101, 104, 107]. These adaptations have been supported by studies with animals and individual case studies with humans [100, 101, 103–106, 108, 109].

For example, a study of mice that underwent controlled rupture of the medial lateral ligament in their knee and were treated with an IASTM treatment showed that the ligaments that received the Graston massage were stronger (43.1%), harder (39.7%), and could absorb up to 57.1% and more load until break point compared to untreated ligaments. In addition, specific ligaments during the microscopic analysis showed better arrangement and alignment of the newly formed collagen [108].

Such findings were attributed by the same researchers to increased perfusion and the change in the microvascular morphology observed after the application of IASTM techniques to the inner lateral ligaments of mice [109].

2.2.1 IASTM technique applications

There are several IASTM techniques, the most well-documented being the Graston and ERGON techniques. ERGON IASTM TECHNIQUE is an innovative therapeutic approach that combines static and dynamic manipulations of the body's soft tissues with special clinical equipment meant for the treatment of pathological conditions. The technique takes its name from the Greek word "ergon," which etymologically means "what a person produces with their work, manual or mental, scientific or artistic."

With the ERGON IASTM TECHNIQUE, the therapist can induce short-term and long-term adaptations to the soft tissues of the human body. The techniques follow specific application rules and parameters. Poor application of techniques and non-compliance with the correct parameters may lead to the opposite result and cause injuries to the treated area.

2.2.2 IASTM diagnostic applications

The general evaluation of the patient is followed by the evaluation of the injured anatomical area using the ERGON TOOLS. A scan of the soft tissue is performed with a special diagnostic application technique, namely the Ergon Technique Scanning Procedure (ETSP). ETSP is based on a specific use of the ERGON TOOLS that allows detecting scar tissue, adhesions, and fascial hardening/shortening.

2.2.3 IASTM in sports rehabilitation

Several studies have shown the beneficial effects of the ERGON IASTM TECHNIQUE in sports rehabilitation. In recent years, techniques that rely on stainless steel tools have been gradually accepted by therapists. More and more researchers are developing treatment protocols to investigate the usefulness of such techniques in various musculoskeletal and sports pathologies.

2.2.4 Effects of ERGON IASTM on edema mobilisation.

A study by the Laboratory of Therapeutic Exercise and Sports Rehabilitation at the University of Patras, Greece, involved performing aggressive massage techniques to speed up the recovery of a professional football player after a 1st degree hamstring strain. The results of the study were encouraging because the combination of stripping massage, cupping therapy, and IASTM techniques reduced the recovery time to almost half of the standard recovery time [110].

2.2.5 Effects of ERGON IASTM on pain reduction

Myofascial pain reduction after IASTM application has long been theoretically connected to the following three mechanisms: (a) local temperature and blood flow increase, (b) localised tissue manipulation and stretching, and (c) reduction of fascial adhesions and restrictions [111–114].

The importance of ERGON techniques for reducing pain has been investigated by Fousekis et al. in 2016, who reported an immediate reduction in pain and pressure sensitivity in soccer players with trigger points in the lumbar area [98].

Furthermore, deep pressure may mask the perception of pain, possibly in connection with endorphins [115, 116]. Using IASTM, applying deep pressure becomes easier as the tools' edges are harder than the tips of a therapist's fingers.

2.2.6 Effects of ERGON IASTM on increasing skin temperature

In sports rehabilitation, increasing blood circulation and tissue temperature are strategic goals for the proper preparation of athletes before a game or a practice session.

The tool angle used when treating tissue should be considered for a more targeted treatment of specific pathologies. Research shows that a greater angle of application results in higher tissue temperature for longer periods of time. More specifically, temperature value and permanence have been examined at 20°, 60°, and 90° application angles. The temperature increased with each application angle but was higher at the 60° and 90° angles. It is worth noting that at 60° and 90° angles, the temperature rise was almost the same. In conclusion, if the goal of the treatment is to maintain increased temperature for a long time, a greater angle, such as a 90° angle, is advisable [79].

In addition, soft tissue techniques using IASTM have been shown to be more effective at raising temperature in basketball players after 15 minutes of application compared to the use of massage and foam rollers [15].

2.2.7 Effects of ERGON IASTM on increasing elasticity

One of the most noteworthy outcomes of ERGON IASTM techniques is the effect that such techniques have in the therapy of remote areas – that is, when techniques are applied in one anatomical area to induce adaptations in a different one.

This therapeutic approach is based on the existence of 12 specific myofascial meridians (fascia lines) that control the human body, as proposed by Thomas W. Myers [116]. Fibres are interconnected along each myofascial meridian collagen, resulting in the continuity of many functions, such as muscle relaxation.

Myofascial release techniques that use the ERGON IASTM TECHNIQUE improve the elasticity of muscles in adjacent areas. Two studies showed improved elasticity in hamstrings and hip abductors following treatments in the trunk and the upper part of the lateral line (ribs and quadratus lumborum), respectively.

One study showed improved elasticity in hamstrings following treatment aimed at the trunk area of the body. More specifically, 60 university students with shortened hind thighs performed the “sit and reach test” once a week for one month. Participants were divided into three groups: in the first treatment group, manipulations were performed on the hamstrings; in the second treatment group, on the trunk; finally, the third group was the control group, with participants receiving no treatment. In each session, the participants from all groups were evaluated in terms of hamstring elasticity using an angle meter in the straight leg raise (SLR) test. Statistical analysis showed that both treatment groups improved hamstring elasticity in four weeks [117].

A second study showed improved hip-abductor elasticity following treatment in the upper part of the lateral line (ribs and quadratus lumborum). Participants received one treatment per week for six weeks to increase the elasticity of hip abductors. The techniques were applied to the upper part of the lateral line (ribs and quadratus lumborum), to the lower part of the lateral line (the iliotibial band), and, finally, to the entire lateral line. Elasticity improved almost to the same degree in all three groups [118].

Furthermore, the effect of soft tissue mobilisation on the remote parts of the myofascial meridian can extend to the interconnection of non-adjacent anatomical areas. As shown in a study conducted by the Laboratory of Therapeutic Exercise and Sports Rehabilitation at the Department of Physiotherapy at the University of Patras, Greece, there was a significant improvement in hip abductor elasticity and an increase in the hip abduction ROM following applications on scalene muscles [111].

Therefore, in their clinical practice, therapists should include the IASTM treatment of remote areas and points that connect through the fascia lines during the acute phase of the injury. Such immediate interventions will ensure that the elasticity of the treatment area is improved or maintained without the pain and discomfort that would otherwise be caused by direct treatment of the actual injured area.

2.2.8 Effects of ERGON IASTM on the restoration of the biomechanical function of joints

The ERGON IASTM techniques improved the ROM and athletic performance in 15 professional volleyball athletes, who underwent ERGON treatment once a week for a total of three weeks. The athletes performed specific tests before and after each intervention, which included measuring the ROM of flexion and the internal and external rotation using an angle meter as well as carrying out shoulder functional assessments using the functional throwing performance Index test (FTPI) and the one-hand shot put performance test (OSP). The results showed that the intervention with the ERGON IASTM TECHNIQUE led to better outcomes in improving the ROM compared to the foam roller and the elastic bandage [119].

ERGON techniques can also be combined with neuromuscular exercises aimed at improving the supraspinatus tendinosis. The study by Fousekis et al. in 2017 provided primary evidence that the mobilisation of soft tissue in combination with specialised therapeutic exercise can offer faster therapeutic results in the ROM and in the reduction of pain [120].

In conclusion, the ERGON IASTM TECHNIQUE is a new technique that, based on the latest research evidence, can contribute significantly to sports rehabilitation. More specifically, it enables therapists to improve the ROM, reduce pain, improve the performance of athletes, increase the temperature of the tissues, and improve blood circulation within a few sessions.

2.3 Muscle blood flow occlusion: the kinetic flossing technique

The elastic ischemic bandage is another popular tool in the rehabilitation and prevention of sports injuries. Initially, applications of the ischemic bandage were aimed at improving the performance of athletes. The technique involves an elastic band, made of rubber-latex material, with which the therapist applies an ischemic pressure to the treated limb. The size of the bandage depends on the size of the anatomical structure. Techniques are usually performed in combination with kinesiotherapy or joint mobilisation techniques.

The technique results in multiple effects that require further research. Seemingly, it produces several hemodynamic and biomechanical adaptations.

Hemodynamically, there is an immediate reduction in local blood flow. The removal of the bandage is followed by sharp hyperaemia that increases fibroblastic activity. These normal hemodynamic adjustments after the application of the bandage contribute to (a) the regeneration and restoration of the injured collagen, (b) the removal of inflammation derivatives and pain metabolites, and (c) the desensitisation of the nerve endings and thus to the reduction of local pain and sensitivity [121, 122].

Biomechanical adaptations include compressing and decompressing tissues and correcting the position of the joints and the posture of patients [123, 124].

Research has shown that ischemic bandaging has positive impacts on improving the ROM. More specifically, researchers have evaluated the use of the ischemic bandage for the dorsal flexion ROM and noted an immediate improvement [123, 125].

Also, two more studies have found a significant increase in the ROM of the humerus joint after using the ischemic bandage [125, 126]. The use of the ischemic bandage has also been shown to have positive impacts on athletic performance. More specifically, the application of 2' on the ankle joint brought about an improvement in jumping ability and in acceleration in 52 and 69 athletes, respectively, with this improvement being maintained for 45' [127, 128]. Finally, a study performed in 2018 found that the use of the ischemic bandage had a positive impact on DOMS [129].

In conclusion, the muscle flossing technique seems to be a basic or additional treatment tool for the rehabilitation and prevention of sports injuries. Although it is a new technique that needs to be researched further, the ischemic bandage seems to improve the peripheral joints ROM, DOMS, and athletic performance.

2.4 Cupping therapy

The negative pressure massage technique involves the use of suction cups, which, when applied to targeted areas of the body, lead to myofascial decompression, in contrast to the adaptation observed during classic massage manipulations, when the soft tissue layers are compressed.

There are various techniques for applying cupping therapy. The most prevalent are the static application, which involves small incisions being made in the skin (wet cupping), and the dynamic application, which involves the suction cups being moved to adjacent tissues after application.

Theoretically, the effectiveness of the technique is based on the decongestion and suction of blood and other components that accumulate in deep tissues,

the removal of which leads to increased arterial and lymphatic circulation and relief from painful muscle hypertension. During the application of this technique, the created negative pressure leads to the decompression of the myofascial area and the movement of blood and other components to the superficial tissues. This can help in pathological conditions in which congestion of inflammatory extravasations and toxins, such as deep accumulations of blood and swelling or the presence of myofascial adhesions and fibrosis and the presence of pain trigger points [130, 131].

The main mechanism behind the use of cupping therapy involves vascular-blood adaptations. In particular, the decompression of the injured areas and the removal of inflammatory agents and blood can lead to a local increase in blood and lymphatic circulation and thus to better oxygenation and tissue metabolism [130]. Cupping therapy has also been associated with a decrease in pathological conditions, such as migraines [132] fibromyalgia [133], neck pain, arm pain and back pain [131, 133–135], and carpal tunnel syndrome [136]. The reduction of pain observed after the application of cupping therapy is based on the reduced irritation of the pain receptors due to the reduced concentration of edema and hematomas in the tissues [5].

In addition, local vasodilation can lead to increased parasympathetic activity and local muscle relaxation [130, 137]. It should also be noted that no research has shown negative adaptations in the human body due to the use of cupping [131, 138]. A study by Liu et al. to control the skin temperature after cupping therapy at acupuncture points in patients with neck pain showed an immediate rise in temperature after the suction cups were removed from the skin. Afterwards, the temperature decreased gradually, with the temperature returning to pre-treatment levels after 30 minutes [139].

2.4.1 Clinical applications of negative pressure massage (cupping therapy)

2.4.1.1 Static application

For static application, suction cups are placed on the skin to create negative pressure for a period of 5–15 minutes, depending on the athlete's tolerance. The application is done without using an emollient. The patient will initially feel a superficial discomfort that will gradually change into a feeling of deep heat.

The application can be done for all areas of the human body as there are cups of many sizes.

Cupping therapy can be used either for pain trigger points or for an area of general sensitivity (e.g. back pain).

Local application can help move hematomas-swelling from deeper layers of tissue to the surface and is used in the treatment of muscle strains. This technique is applied in combination with stripping massage (using hands or IASTM tools) and is particularly effective in mobilising post-traumatic edema-hematomas.

Initially, cupping therapy is applied directly to the injured tissues to move the edema-hematomas to the surface. This is followed by deep massage applied from the periphery towards the centre of the body by hand or using special tools, such as the ERGON TOOLS. This step is performed to mobilise accumulations. The research by Fousekis et al. describes in detail the procedure that was used for an athlete with a hamstring strain, which reduced the recovery time by 50% [110].

2.4.1.2 Dynamic application

In addition, the local application of cupping therapy can be used in combination with stretching to increase elasticity. For example, to increase the elasticity of the

IT band, 4–5 suction cups can be applied along the band, which allows the band to be stretched. Immediately after the removal of the cups, strong circular signs of ecchymosis appear on the body, pointing to the hyper-circulation of the area and a mild skin injury. Depending on the metabolism of each athlete, these signs take 2–7 days to disappear.

Cupping therapy is also used in combination with kinesiotherapy and simultaneous movement of the cups on the tissue. For example, to increase the elasticity of the hamstrings, the cups can be applied to the treated area, and while the athlete performs a self-stretch, the therapist moves the cup in the area.

Dynamic cupping therapy is becoming increasingly known for improving the elasticity of the injured area and improving the range of motion [140].

In the dynamic treatment, while the suction cup is being moved, it is necessary to use a special massage emollient. Immediate vasodilation leads to increased blood flow, which facilitates healing as well as lengthening and improving short muscle movement [139].

Research conducted to evaluate the elasticity of the hamstrings showed a significant increase in motion range of the hip and the knee via the SLR test, although the strength of knee flexion was not increased according to the tests performed on an isokinetic dynamometer [141].

Scholars have reported that cupping therapy is useful in reducing pain. A study by Fousekis et al. in 2016 demonstrated the effectiveness of cupping procedures in reducing pain in soccer players with painful trigger points in the lumbar area of the spine, with the participants showing an immediate reduction in pain and pressure sensitivity [98].

2.4.1.3 Massage using cupping therapy

Massage that involves the use of cups is gradually becoming more widespread in the treatment of myofascial problems in athletes. In addition, it is used as an aggressive approach to reduce swelling and hematomas. For the application of this type of massage, the use of emollient is required so that the cups can be moved smoothly.

The application is done by initially placing the suction cups upon the treatment area. When it comes to areas of intense spasms, suction cups can remain in static application for a few minutes (5–15) before being moved. The application for the reduction of edema and hematomas and their suction towards the surface of the skin can be done either locally as mentioned earlier or by movement. In the latter case, the application must be carried out in two phases, as is done in muscle stripping massage. The first phase involves placing the cups on the periphery of the injury and the moving the suction cups towards the centre at a very slow pace. The second phase involves applying the cups directly on the injured area and again moving the suction cups towards the centre in an attempt to move the deep hematomas and swellings to the centre and towards the surface.

3. Conclusions

Soft tissue techniques have been used since ancient times for the treatment of various pathologies. Their goal is to promote health and wellness through the body's response to mechanical effects such as compression, sliding and decompression of tissues. Therapists apply various techniques either manually or with the use of tools to achieve therapeutic goals. Techniques are divided, depending on the goal, in appeasing and stimulating. Mechanisms activated during soft tissue techniques as well as the effects of the techniques on different pathological conditions have been

and still are being systematically researched. It is crucial for therapists to select the appropriate technique to evaluate and treat tissues. For this, good knowledge of the parameters of each technique is needed as well as setting specific treatment objectives such as improving elasticity, increasing ROM, reducing pain and spasm, and increasing athletic performance. Massage, ERGON IASTM TECHNIQUE, KINETIC FLOSSING and cupping therapy are commonly used for the rehabilitation of various musculoskeletal conditions. In order to achieve optimal results, these are often part of treatment protocols which include additional techniques and/or therapeutic exercise. All four have been proven to serve well either as basic or secondary treatment options for sports injuries prevention and rehabilitation.

More specifically, sports massage is beneficial before, during and after the game. Before the game, therapists apply specialized techniques to prepare muscles for the intense loads, especially on the limbs, or/and to prepare the central body (trunk) which constitutes the biomechanical basis for the initiation and proper execution of movement. During the game, sports massage mainly serves as psychological support for tackling competitive stress as well as for improving performance at the next phase of the game. Through stimulating aesthetic receptors, it reduces painful muscle tone and muscle excitability while at the same time improving the sense of physical recovery. Massage after the game increases blood circulation, reduces the feeling of fatigue, and muscle pain, reduces the intensity of DOMS in athletes and consequently contributes to faster and fuller recovery. Massage after the game has been found to lead to faster recovery of strength levels compared to passive movement therapy. It can also play an important role in repairing sports injuries through reducing the concentration of edemas caused especially when in combination with cupping therapy, and IASTM techniques. Finally, massage is particularly useful in scar tissue treatment and painful trigger points mobilization.

ERGON IASTM TECHNIQUE allows sports physiotherapists to detect abnormalities of the soft tissue such as scars, adhesions, restrictions, trigger points via the initial scanning procedure. Post injury, ERGON IASTM TECHNIQUE is effective in mobilizing edemas, in combination with aggressive soft tissue techniques, thus speeding up recovery time. It reduces the pain through local increase of the temperature and of tissue elasticity by minimizing adhesions. Its most significant contribution is the increase of elasticity. Research done at the Laboratory of Therapeutic Exercise and Sports Rehabilitation at the Department of Physiotherapy of the University of Patras, Greece, has shown the technique's effect in elasticity increase throughout an entire myofascial line/meridian in cases of application only in one of its parts. Lastly, ERGON contributes to the restoration of biomechanic function in combination with therapeutic exercise.

KINETIC FLOSSING is a relatively new soft tissue mobilization technique showing multiple benefits for musculoskeletal rehabilitation. Therapeutic mechanisms include hemodynamic and biomechanical adaptations. Its effects include increasing ROM, enhancing athletic performance, and reducing DOMS.

Cupping Therapy is a well-known technique used from ancient times in many cultures which utilizes negative pressure for soft tissue decompression as well as mobilizing blood and superficial tissues. Its clinical value lies in drawing hematomas-edemas from deeper layers of tissue towards the surface and removing these in combination with other forms of aggressive soft tissue techniques. In addition, cupping therapy increases elasticity of tissues and improves ROM of injured joints, and contributes to pain reduction.

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