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REVIEW ARTICLE

The Effects of Flexibility Exercise, Cold Compresses, and Massage on Muscle Recovery in Elite Athletes: Focusing on Literature Review

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ABSTRACT

Background. For athletes, post-competition muscle recovery is an important factor in the next competition. As recovery conditioning methods, the effects of flexibility exercise, cold compresses, and massage therapy were analyzed through literature collection. **Objectives.** The purpose of this study is to find out which conditioning methods and which protocols should be applied in terms of recovery to effectively to aspect on blood supply. **Methods.** For papers researched between 2000 and 2022, 213 papers were collected using the keywords muscle recovery, blood circulation, flexibility exercise, cold compress, and massage using the Web of Science search engine. **Results.** Each protocol was effective when applied 48 hours after the competition, and all protocols showed a recovery effect by blood circulation. In the case of stretching, there were many papers applied to high-intensity anaerobic athletes, and in the case of cold compresses, there were many results in response to bruises and muscle inflammation. In the case of massage, the results showed that it should be performed 24 hours after the competition, when the muscles can recover on their own, rather than immediately after the competition. **Conclusion.** Conditioning methods were applied to aid recovery by rapidly supplying blood to muscles oxidized by micro-damage and lactic acid accumulation after competition. All of the investigated conditioning methods were based on blood circulation, and a study to set the application area based on motor points will be needed when creating a protocol.

KEYWORDS: ***Muscle Recovery, Flexibility Exercise, Cold Pack Compress, Massage, Blood Circulation, Intramuscular Motor Point.***

INTRODUCTION

In the case of athletes, long-term training is essential to improve performance, and it is often difficult to properly recover muscles depending on the game schedule (1, 2). In general, muscle damage from intense training can be transient, ranging from minutes to hours, and inadequate recovery impedes musculoskeletal tissue growth and regeneration and causes secondary damage such as chronic fatigue, microtrauma, and stress fractures (3). This leads to poor performance and has a devastating effect on players (4-6). An athlete's post-game recovery encompasses everything from rest, nutrition, and sleep, but what needs to be applied more quickly during training and competition is muscle recovery. Elimination of lactic acid and DOMS (Delayed Onset Muscle Soreness) after muscle exercise can compensate for motor impairment, as muscle

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recovery between training or associated with training and competition completes an athlete's bio balance to maximize performance (7-10).

Muscles interfere with blood acidification and ATP synthesis according to accumulated fatigue after activity, so there are previous studies to improve physical function and lower injury rates by regulating blood circulation (4, 11, 12). Post-exercise, flexibility exercise, massage, and application of cold compresses after exercise reduce lactic acid removal and hydrogen ions in the muscles (13, 14). Therefore, it is necessary to apply effective treatment to tired muscles to supply oxygen to the blood, remove lactic acid, and induce energy regeneration in the liver (15). In previous studies where flexibility exercises were applied as a way to quickly create this phenomenon, muscle relaxation activities can prevent muscle damage and fatigue at the beginning and the end of training and competition, and the results vary depending on when, how, and how long you do it. Static stretching both hypertensive and dynamic stretching had significant effects on reducing lactate levels (16).

In the case of massage, which is another muscle recovery method, mechanical pressure reduces the passive stiffness of muscles and increases arterial pressure, which has the effect of helping muscles recover quickly (17). In addition, fluctuations in heart rate and blood pressure after massage activate parasympathetic nerve activity, helping to return the excited body to a stable state (18). It is theorized that massage may enhance analgesic effects and muscle recovery by mediating pain control systems (e.g., nociceptor and mechanoreceptor sensitization and/or regulation of diffuse noxious inhibition) within neurological models (19, 20). The greatest effect of massage is reduction of muscle pain, increase of blood flow and parasympathetic nerve circulation, reduction of inflammatory response and related trigger points, and physiological studies are showing that it helps in muscle recovery (17, 21, 22).

Cold compresses, suggested as an effective post-exercise recovery method, can lower the initial degree experienced by athletes against intervention and waste circulation by reducing intracellular fluid movement, muscle edema, and cardiac output (23). The recovery method using temperature can be divided into cooling water therapy, immersion, and thermal pathology, according to a previous study cold sensation starts at 15 degrees, cold water therapy is applied based on the temperature of 15 degrees or less and immersion is 16-35 degrees (24-26). The temperature at which core body temperature rises is 36 degrees or higher, and although it is difficult to suggest the time set in previous studies for both cooling and thermotherapy, it helps demand athletes to recover it (27, 28).

Massage, which was referred to as a mechanical compression method in previous studies, induces the Hoffman reflex to generate low-intensity electrical stimulation of the afferent nerve of the muscle spindle. This has the effect of regulating the heart rate and blood output by stimulating the parasympathetic nerve that causes synaptic excitation of motor neurons (29). Massage also prevents muscle tissue from stiffening by preventing cell adhesion (30). This recovery method increases plasma endorphins in the body, lowers arousal levels, and is believed to enhance both acute athletic performance and recovery from intensive physical activity due to potential underlying physiological mechanisms (31). Previous research has suggested that massage after training and competition boosts metabolism by helping blood circulation and sympathetic/parasympathetic nerve activity (32). Muscles are innervated by nerve branches extending from the spinal nerves. If the muscle is equally divided into 5 parts, a better prognosis can be expected if massage is performed based on the area where the motor nerve mainly penetrates, that is, the area where the motor point is concentrated (33). This study is necessary to establish a conditioning protocol to be applied in the future by collecting the effects of blood circulation on muscle recovery and various methods of helping blood circulation, such as flexibility exercises, cold packs, and massages, based on previous studies. This study is necessary to establish a conditioning protocol to be applied in the future by collecting the effects of blood circulation on muscle recovery and various methods of helping blood circulation, such as flexibility exercises, cold packs, and massages, based on previous studies.

MATERIALS AND METHODS

The databases used in this study are Web of Science and Pubmed, and the keywords used to collect the papers are blood circulation and muscle recovery, flexibility exercise and

recovery, the effect of cold packs, massage, and athlete's recovery. The intervening studies between 2000 and 2022 were collected and limited to literature mentioning muscle recovery and blood circulation. 213 papers were collected and referred to in this study.

This study mainly collected papers applying flexibility exercises, cold compresses, and massage therapy for the recovery of athletes after sports games and training. The main purpose of flexibility exercise is to increase muscle length, but it also includes contents related to the improvement of joint range of motion and rehabilitation. In the thesis applying cold compresses for recovery of athletes after sports games and training, the contents of the effects of cold compresses were collected by referring to studies using various temperatures for compresses. Massage is related to mechanical pressure and studies using hands and props were included. Studies that tested the effects of massage from the neurological and musculoskeletal perspectives were also included anatomical study of intramuscular motor points was also collected to present conditioning areas (Figure 1).

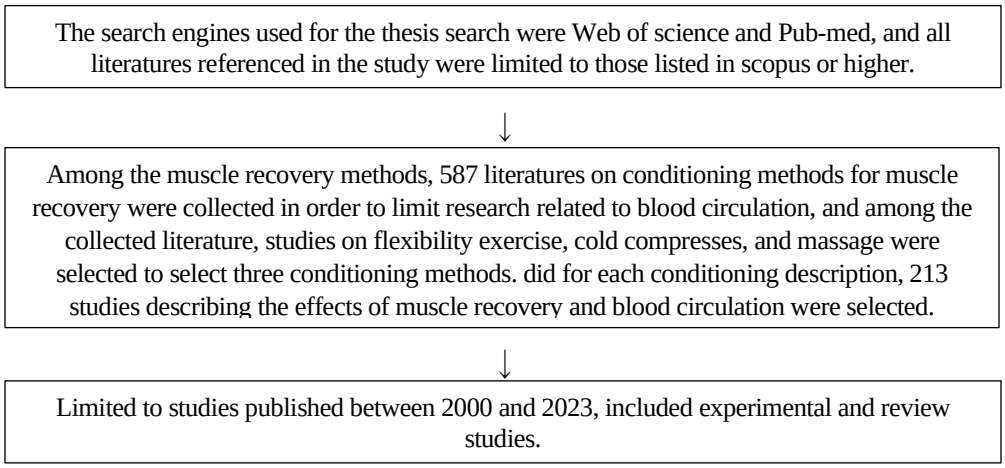

Figure 1. The order of progression for the study.

RESULTS

Flexibility exercise. Studies applying flexibility exercises as recovery exercises claim that muscle flexibility helps muscles adapt quickly to changes in their environment, preventing microtrauma that can occur during competitions and training. The hamstring, which is a knee joint flexor, is located at the back of the thigh and is characterized by strong contractility, so athletics, soccer, and rugby players who progress with the knee bent are often injured due to lack of flexibility of the hamstring. At this time, if the muscles have good elasticity, trauma can be prevented, and micro-damaged muscles can recover quickly after the game (43, 44). In addition, some studies have shown that flexibility exercise applied to the lower extremities increases the range of motion of the hip joint by more than 25 degrees and increases the length of the knee flexors by about 10%. Gradually, this can have a beneficial effect on an athlete's ability to perform the movement (45).

After performing rest, stretching, swimming pool, and immersion after the game for professional sports (soccer and rugby) players repeated weekly in the United States and Australia, 93% of the stretching group showed an immediate recovery response and 62% of the respondents showed an immediate recovery response the day after the game. Respondents who applied flexibility exercises had a greater recovery effect (42).

In a study comparing the control group and the group to which the muscle injury protocol was applied to confirm the effect of flexibility exercise, there was a significant change in muscle length change involved in the knee joint in the injury exercise group (pre-test = 19.4±6.2cm, post-test = 26.6±6.9cm). This is a result that shows that flexibility exercise is helpful for muscle recovery (34) (Table 1).

Table 1. A study on the use of flexibility exercise for muscle recovery

Year	Title	Author	Participants	Methods	Effect
2005	Effects of immediate post-competition recovery procedures on muscle soreness, power, and flexibility levels over the next 48 hours	Dawson et al	17 Western Australian Football League (WAFL) players	15 repetitions of 2-3 30-second stretches across multiple muscle groups and joints	Recovery exercises have helped players recover after competitions.
2007	Effect of flexibility training on symptoms of exercise-induced muscle damage : A Preliminary study	Dawson et al	17 Western Australian Football League (WAFL) players	15 repetitions of 2-3 30-second stretches across multiple muscle groups and joints	Recovery exercises have helped players recover after competitions.
2011	Effects of Flexibility Training on Eccentric Exercise-Induced Muscle Damage	Chen et al	Thirty young men, who had not performed regular resistance, aerobic, or flexibility training in the past 1 year	Performed three times a week for 8 weeks, and all subjects performed six sets of 10 maximal isokinetic	The range of motion (ROM) of the hip joint increased by 25- Less susceptible to damage.
2012	The Effect of Immediate Post-Training Active and Passive Recovery Interventions	E. Rey et al	Professional soccer players	20-minute flexibility exercise intervention after anaerobic exercise	Active recovery induced significant differences in rebound jump performance after 24 hours of the training session
2012	Anatomy, physiology, and biomechanics of hamstring injury in football and effective strength and flexibility exercises for its prevention	Ivan Z	Football players	Stretching for the initial and final part of physical activity because it is helpful for faster preparation for activity, and it accelerates muscle recovery from fatigue	Improved sprint performance and flexibility, increased muscle soreness recovery
2017	Effect of self-myofascial release on myofascial pain, muscle flexibility, and strength: A narrative review	Kalichman et al	Flexibility exercise using self-myofascial release, stretching, foam rolling, pain ball, lacrosse ball, golf ball, tennis ball, and stick for patients with myofascial pain syndrome	It helps to reduce the restrictive barriers or fibrous adhesions observed between layers of fascial tissue.	
2019	A meta-analysis of the effects of foam rolling on performance and recovery	Wiewelhove et al	Routine before and after driving	Foam rolling	Improved sprint performance and flexibility, increased muscle soreness recovery

Compresses. Cold compresses are used as a protocol for recovery because the method of application is simple and can be easily applied in the field. Soccer, a high-intensity aerobic game with an occasional back-to-back game schedule, uses techniques such as running, changing direction, jumping, and tackling to cause glycogen depletion, dehydration, and muscle damage. Due to the nature of the game, it is necessary to run in a wide stadium for at least 45 minutes, and the need to quickly recover from muscle fatigue when a player is given a break is a factor that determines the performance. For this reason, many studies have been published on the application of cold compresses to soccer players. As a result of applying cold compresses at 10 to 15 ℃ to the leg muscles for 5 to 15 minutes after a game of professional soccer players, it was found to have a beneficial effect on muscle strength recovery and blood circulation in the

affected area (2, 35, 36). It was explained that this is because it relieves acute inflammation of damaged muscles (37).

Another paper, which investigated the effect of cold compresses on muscle pain reduction after 24 hours and 48 hours after the game in 7 athletes, reported that cold compresses within 24 hours were effective in reducing muscle pain (38). Studies have shown that topical cold compresses (temperature range: 9-10 °C, duration range 10-20 minutes) have beneficial effects on anaerobic capacity, i.e., maximal strength and sprinting capacity in soccer players (39, 40). Muscles with elevated temperatures after competition suffer microdamage due to the expression of thermoproteins, and creatine kinase levels rise. If you apply cold compresses at this time, the direction of blood circulation changes, helping to stabilize the muscles with micro-damages. Therefore, in a study that confirmed whether cold compresses on soccer players affected the reduction of lactate and creatine kinase levels in soccer players, the most significant effects were reported in the cold compress group than in the warm compress group (38-41) (Table 2).

Massage. Massage application in the field of sports is a method that has been applied for a long time by health practitioners and physical therapists who are practitioners in the medical field, which is a method of recovery after intense exercise (42). Previous studies applying exercise concerning musculoskeletal injury as a result of examining 300 works of literature from 1950 to 2000, it was confirmed that sport massage was frequently reported. Forms of palmar massage include effleurage, petrissage, and deep transverse friction massage. The effleurage techniques are performed along the length of the muscle, usually in a distal to proximal sequence.1-3,8 These techniques are practiced throughout the massage routine. Petrissage techniques include kneading, squeezing, and scooping strokes. These techniques are usually performed with pressure that is deeper than the patient can tolerate (1-3, 8). Deep transverse friction massage (also called cross friction massage) is performed using the fingers as a force moving across the target tissue (43-46).

Boxing, which has 3 to 15 rounds of matches, is a tournament match, with a break of 30 seconds to 1 minute during the match, but a break of more than 1 hour until the next match. At this time, as a result of applying a total of 20 minutes of massage to the massage arms, legs, back, and shoulders, it was confirmed that it was helpful for boxers to reduce lactate levels and improve boxing performance in the next match (47).

In a study of massage technique, area, and application time, the application of Effleurage for 15 minutes after exercise showed effects on muscle recovery and performance improvement, as well as reducing muscle fatigue and lactic acid levels. In addition, it was reported that massage application after exercise is effective in reducing pain after 48 hours when muscle pain mainly occurs (48, 49).

In a thesis that checked blood circulation with muscle and skin temperature after exercise and measured overall fatigue, it was found that the massage intervention increased blood flow in the area to be recovered, which resulted in faster recovery of fatigue compared to the control group (50). In dormancy, the skeletal muscles produce 20% of the heat. A small motor activity increases thermogenesis to 50 – 80%, whereas heavy muscular work increases this parameter to 400 – 500% (51, 52). Heat output increases considerably with skin blood flow growth. The volume of blood circulation elevation has a similar effect. The application of massage regulates the speed of blood circulation, so it is effective for reducing skin temperature and resting (53) (Table 3).

In studies applying flexibility exercise, cold compresses, and massage, the subjects were mainly aerobic/anaerobic high-intensity exercise groups, power and endurance athletes. Restorative conditioning applied to them was applied to the muscles of the lower extremities, which were mainly used, and motor point studies of the leg muscles were collected with a focus on this. The hamstrings involved in hip extension and knee joint flexion can become stiff due to excessive activity, which can interfere with the function of the lower limbs. Severe hamstring stiffness causes musculoskeletal complications and deviations in gait patterns (54). It was said that the intervention of phenol or alcohol injection, which is a denervation agent, in severe hamstring spasticity can improve the movement pattern by increasing the length of the hamstring. The presentation of such exercise points can be a conditioning application point for players. The areas where motor points are concentrated in this study are 40-45% of the femoral head of the long head of the biceps, 50-55% of the lateral side of

the femoral head in the short head, and 10% of the inner side of the femoral head for the semitendinosus. In a study on the motor points of the tibialis posterior muscle, which serves to prevent excessive pronation of the foot and distribute weight, it was reported that motor points were concentrated from the fibular head to the 0-30% point (33).

Table 2. A study on the application of cold compresses for muscle recovery

Year	Title	Author	Participants	Methods	Effect
2006	Physiological Response to Water Immersion A Method for Sport Recovery?	Wilcock et al	Athletes	That is gaining popularity as a means to enhance Post-competition or post-training recovery is immersion in water	Intracellular-intravascular fluid shifts, reduction of muscle edema, and increased cardiac output, which increases blood flow and possible nutrient and waste transportation through the body
2009	Effect of water immersion methods on post-exercise recovery from simulated team sport exercise	Ingram et al	Eleven male athletes	Within 24 hours after exercise, immersion in cold water (10°C) for 2 to 5 minutes was repeated three times	Decrease in muscle pain score 24 hours after application of cold compress
2011	Cryotherapy and soccer-induced muscle damage	Ascensão et al	Twenty male junior soccer players	Applicable within 30 minutes of the end of the jump and 20m run, 24 and 48 hours after the play	After 30 minutes of cold compress, the activity of creatine kinase is reduced.
2012	COLD WATER IMMERSION AFTER COLLISION EXERCISE	Pointon & Duffield	10 male, club level, team sport players	Within 10 min of exercise, cold water immersion (TCWI) was applied for 9 min at (9.2 °C ± 0.2 °C), repeated twice for a total of 20 min.	Mean sprint time was significantly increased
2013	Recovery in Soccer	M. Nédélec et al.	Soccer players	Apply cold compress at 9–10°C for 10–20 minutes after exercise	Beneficial effects on anaerobic performance, maximal strength
2016	Use of cold-water immersion to reduce muscle damage and delayed-onset muscle soreness and preserve muscle power in jiu-jitsu athletes	Fonseca et al	Jiu-jitsu athletes	Application of cold compresses between 24 and 48 hours after competition	Decreased lactate dehydrogenase (LDH) levels
2016	Mechanisms of Recovery Following Cold Water Immersion	Ihsan, Watson, & Abbiss	High-intensity exercise group	CWI performed in between successive bouts of exercise	Might ameliorate CNS fatigue
2020	Efficacy of Repeated Cold-Water Immersion on Recovery After a Simulated Rugby Union Protocol	Barber, Pattison, Brown, & Hill	Rugby players	Application of protocol 101 using CWI	Application of heat compresses 24 hours and 48 hours after the competition has a significant effect on pain reduction

Table 3. A study on the application of massage for muscle recovery

Year	Title	Author	Participants	Methods	Effect
2000	Effects of massage on physiological restoration, perceived recovery, and repeated sports performance	Hemmings et al	Eight male amateur boxers	Average (30 strokes/min) and Petrissage (50–60 strokes/min) massage techniques are applied to key muscles in the legs (8 minutes), back (2 minutes), shoulders, and arms (10 minutes).	Decreased blood lactate levels and improved performance
2004	Effect of massage on intramuscular and skin circulation	Mori H et al	Thirty males who had never experienced back pain.	Effleurage, kneading, and compression techniques were applied to the lumbar and sacrum region for 5 minutes.	Increased muscle blood volume (MBV) and skin blood flow (SBF) and reduced fatigue
2008	The role of massage in sports performance and rehabilitation	Brummitt.	A survey of 300 recovery studies on the application of sports massage between 1950 and 2000		It has been reported that Effleurage, Petrissage, and deep transverse friction massage techniques have good recovery effects
2008	Effectiveness of Sports Massage for Recovery of Skeletal Muscle From Strenuous Exercise	Best et al	A collection and analysis of studies on the effects of sports massage from 1950 to 2007	After strenuous exercise, massage 3 times at 15-minute intervals and apply massage 1 hour after exercise	Improve muscle peak torque, sit and reach, strength, clear lactic acid, normalize blood flow and electromyography
2011	Cardiovascular responses to passive static flexibility exercises are influenced by the stretched muscle mass and the Valsalva maneuver	Farinatti et al	Asymptomatic volunteers (N = 22) with the following characteristics were recruited: age, 22 ¡ 3 years; weight, 73 ¡ 6 kg; height, 175 ¡ 5 cm	They performed two exercises: four sets of passive static stretching for 30 seconds of the dorsiflexion (DF) of the gastrocnemius and the hip flexion (HF) of the ischiotibialis	Both the stretched muscle mass and the VM influence acute cardiovascular responses to multiple-set passive stretching exercise sessions
2015	Physical rehabilitation and thermoregulatory processes in athletes with disabilities	Rudenko et al	Twenty qualified athletes 32-45 years of age	Observation of skin temperature change after applying massage for 6 months	Skin temperature reduction effect by controlling blood circulation speed
2016	Effects of massage on physiological recovery in male bodybuilders	Kargarfard et al	Participants (IN=30) were healthy males (28.77 ± 3.54 years old)	A 30-minute standardized supine massage was performed 2 h after muscle soreness induction.	Creatine kinase level, muscle pain reduction, physical condition recovery effect
2020	Effect of sports massage on performance and recovery: a systematic review and meta-analysis	Davis et al	Identification of 29 eligible studies recruiting 1012 participants on the effects of manual massage on measures of sports performance and/or recovery.		Massage significantly improves strength, flexibility, and DOMS after jumping and sprinting

DISCUSSION

The most important part of muscle recovery is blood circulation. Muscles have many blood vessels because they receive oxygen and nutrients through hemoglobin in red blood cells (55). Thus, blood circulation affects muscle health and function. As a representative example, it has been reported that flexibility exercises, cold compresses, and massages that train the stomach all affect recovery by controlling blood flow and speed (56, 57). Control of blood flow to skeletal muscle is essential to meet the oxygen demand of contracting skeletal muscle and prolong exercise. At the systemic level, a major determinant of this overall response is the production of cardiac output due to an increase in heart rate and stroke volume that can meet both the oxygen demand of contracting muscles and the perfusion pressure of other organs. In humans, these demands can be modulated by muscle stretching flexibility exercises, and changes in external temperature and pressure (57, 58).

After the game, athletes experience exercise-induced muscle damage. As a way to recover from this, the literature that applied flexibility exercise, cold pack, and massage was collected to identify the protocol that showed the most significant effect, and the analysis of this is as follows (59). As a flexibility exercise method for muscle recovery, proprioceptive neuromuscular facilitation (PNF) training is mainly applied. PNF presents movement patterns and holding times and talks about breathing during movement. This means that the detailed application of flexibility exercises helps to make muscles flexible and protect against micro-damages caused by external pressure. In a study that applied flexibility exercise to muscle recovery, it was found that it was mainly applied to the hip and knee joints of high-intensity aerobic athletes such as soccer and rugby. The fact that there are many such preceding studies is that the hip and knee joints are affected by muscle elasticity, and the decrease in flexibility of the quadriceps and hamstrings, which are characterized by high contractility and stiffness, relates to thigh injuries (51, 60).

It was a common protocol for the application of flexibility exercise to be carried out consecutively at least twice a week within 48 and 72 hours after exercise, and maximum voluntary performance or static stretching was helpful for the application of stretching (61). In addition, stretching was mainly applied to the muscle group involved in the range of motion of the hip and knee joints, which seems to be because the thigh muscles are exposed to pain and loss of muscle strength due to strong contraction force. Therefore, in the case of stretching, it seems to be effective for the recovery of soccer, rugby, and runners, which are high-intensity aerobic events, and the protocol of at least 3 weeks and up to 5 consecutive times at least twice a week within 48-72 hours after the game is considered to be the most effective (37, 62).

A recurring claim in research on muscle recovery methods is that the time required to repair micro-damaged muscles is within 48 to 72 hours. Since the muscles damaged by activity after exercise are inflamed, cold compresses are said to temporarily block blood flow and help recovery. Applying cold compresses immediately after a game has the effect of lowering the level of lactic acid, a substance that causes muscle fatigue. Cold compresses appear to alleviate pain by constricting blood vessels due to changes in external temperature, preventing excessive blood flow, and immediately dulling the nerves that control pain and movement. In the case of cold compresses, the application time may vary depending on the sensitivity of the subject's skin, but the effect of reducing pain was shown even when repeated 3 times for 2 to 5 minutes on the area requiring recovery immediately after the game. This is thought to be effective because changes in skin temperature momentarily numb the skin and dull the sense of pain.

It is commonly reported in several papers that massage after exercise has an effect of relieving muscle pain, and it has been reported that massage within 48 to 72 hours after exercise reduces the oxidation process of muscles (63). The reason why it is repeatedly suggested that the most appropriate time to apply the muscle recovery protocol is within 48 to 72 hours is because the recovery time required through muscle self-regeneration is 24 to 48 hours. Massage is thought to help the gas exchange of cells by applying external pressure to the muscles to promote blood circulation. Therefore, massage is thought to help remove lingering oxidation in the muscles after exercise by promoting arteriovenous circulation to the extremities and microvasculature (64-68).

Based on the motor point study on the leg muscles, the muscles on the back of the legs are thought to be an important part of athletes in all

sports because they are involved in muscle power and are directly related to gait. In the proposed recovery conditioning, it seems to be an important factor in creating a setting protocol for areas to be compressed and steamed. The fatigue points and motor points of the muscles that are talked about in the current sports world are also related from a neurological point of view, and if research on this is continued, scientific data will be obtained.

CONCLUSION

Flexibility exercise or massage was effective when applied for 20 minutes within 48 to 72 hours after the competition, and cold compresses were effective when applied within 24 hours after the competition at a temperature of 15 degrees or less and not exceeding 15 minutes.

APPLICABLE REMARKS

- In the case of flexibility exercise, it was found to be effective for athletes performing high-intensity exercise or for fast muscle fibers, and it was said that repetition of motions was more effective than repetition of motions by allocating the number of times and sets to motions. Maintain muscle lengthening motions for long periods. In the case of cold compresses, it can be applied mainly when power is used or when minute damage is suspected, and the temperature and application time should be considered depending on the subject. Massage may have subjective differences depending on skill level and tools used, but it was found to have a recovery effect in any case as it can help the subject's whole body blood circulation. It should be recognized that different effects may occur depending on the sport.

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AUTHORS' CONTRIBUTIONS

Study concept and design: Seung-Ku Nam, Je-Hun Lee. Acquisition of data: Na-Young Yoon. Analysis and interpretation of data: Na-Young Yoon, Je-Hun Lee. Drafting the manuscript: Seung-Ku Nam, Je-Hun Lee. Critical revision of the manuscript for important intellectual content: Soo-Won Uh. Statistical analysis: Na-Young Yoon, Je-Hun Lee. Administrative, technical, and material support: Soo-Won Uh, Je-Hun Lee. Study supervision: Na-Young Yoon, Soo-Won Uh.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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