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Research on the Effect of FM Fascia Manipulation on Delayed Muscle Soreness

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Abstract: *The objective of this study was to investigate the effect of Fascial Manipulation (FM) fascia manipulation on delayed muscle soreness, and to study its intervention mechanism, and to seek a therapeutic method to alleviate symptoms related to DOMS. Twenty-four subjects who met the inclusion criteria were selected and divided into an experimental group (n=12) and a control group (n=12) using a random number table method. Delayed-onset muscle soreness was induced in the biceps by eccentric training. The experimental group received FM fascial manipulation intervention immediately after exercise, and at 24 hours and 48 hours post-exercise, with each intervention lasting 30 minutes, for a total of three times. Muscle circumference, joint range of motion, and subjective fatigue score (BRS-6) were observed as indicators. Data were collected before exercise, immediately after exercise, and at 24 hours, 48 hours, 72 hours post-exercise, and immediately after the first, second, and third FM manipulation interventions for analysis. Compared with the control group, the joint range of motion and subjective fatigue level of the subjects in the experimental group were significantly improved at 48 hours and 72 hours after the intervention, with the differences being statistically significant ($p<0.05$); The muscle circumference of the subjects in the experimental group showed no statistically significant difference compared to the control group ($p>0.05$); Compared with pre-intervention, the immediate data after the intervention and the data at the next time point in the experimental group showed a trend of first decreasing and then slightly increasing (joint range of motion first increased and then decreased), with no statistically significant differences ($p >0.05$). FM fascial manipulation intervention can effectively improve the symptoms of DOMS after exercise and has a therapeutic effect on DOMS, especially on joint range of motion and subjective fatigue level, while the improvement in muscle circumference is not significant.*

Keywords: *Delayed-onset muscle soreness, Fascial Manipulation, Muscle circumference, Joint range of motion*

1. Introduction

In the field of sports and exercise medicine, discomfort with Muscle Soreness that appears 24 to 72 hours after exercise is commonly referred to as Delayed Onset Muscle Soreness (DOMS). Symptoms of DOMS usually appear 24 hours after a sudden increase in exertion or new, non-habitual exercise, reach a peak at 48 to 72 hours, and then gradually reduce symptoms over four to five days until they disappear[1]. The typical symptoms of DOMS are tenderness and sensitivity to pain, accompanied by muscle stiffness and limited movement. Delayed onset muscle soreness can interfere with an athlete's normal training and daily quality of life, and can even lead to insomnia. Currently, treatments for DOMS include vibration therapy, massage therapy, acupuncture therapy, intramuscular application, and treatment with biochemical and physical factors. The application of these treatments provides more options and possibilities for the treatment of DOMS[2].

As a safe and non-invasive treatment technique, FM Fascial Manipulation has been widely used in medical and rehabilitation fields at home and abroad in recent years. Studies have shown that FM fascial manipulation intervention has significant effects on pain caused by dense fascia, cervical spondylosis caused by dystonia, muscle stiffness and pain, and low back pain[3-6]. Although there have been studies that have confirmed that the FM fascia maneuver can treat a variety of conditions, little research has been done on the FM fascia maneuver and DOMS. Therefore, this study will use FM fascia manipulation to treat DOMS of biceps after centrifugal exercise, observe its intervention effect, explore the mechanism of FM fascia manipulation to treat DOMS, and provide new methods and ideas for intervention of DOMS.

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2. Study Object and Method

2.1. General Information

Twenty-four college students from Lingnan Normal University were selected as subjects. The basic information of subjects in each group was shown in Table 1, and there was no significant difference in inter-group test ($p > 0.05$). The subjects were divided into experimental group (FM, n=12) and control group (CG, n=12) by random number table method. The experimental group underwent FM fascia manipulation after DOMS modeling, while the CG group did not perform any intervention after DOMS modeling. All subjects understood the specific experimental procedures and requirements, and voluntarily signed the informed consent, and no subject fell off during the experiment.

Table 1: Basic information of subjects.

Groups	n	Age (years)	Height (cm)	Weight (kg)
Control group	12	19.92±1.16	173.41±5.60	61.33±4.97
Experimental group	12	19.58±0.90	173.50±6.94	63.08±9.40

2.2. Subject Selection Criteria

2.2.1. Inclusion criteria

All subjects are required to meet the following conditions: First, they should voluntarily participate in the experiment, understand the purpose, process, rights of participants and possible dangers of the project, and sign informed consent. Second, the subjects were older than 18 years and younger than 25 years. Third, the subjects had no cardiovascular disease, neuromuscular related disease, no physician-diagnosed disease unsuitable for exercise, and had never taken relevant drugs for cardiovascular disease. Fourth, the physical examination of the subjects was normal, and there was no musculoskeletal injury in the past 3 months. Fifth, the subject has not participated in vigorous physical activities for nearly one month and can guarantee that he will not participate in physical activities outside the experiment during the experiment. Sixth, subjects had no recent muscle soreness.

2.2.2. Exclusion criteria

The subjects should be excluded if they have any of the following conditions: First, the subjects' compliance is poor and there are behaviors that affect the successful completion of the experiment. Second, the subjects were unable to complete the experiment modeling. Third, the subjects could not receive the measurement and intervention at the prescribed time. Fourth, the subject experienced an adverse event and was unable to continue to complete the test. Fifth, the subjects voluntarily quit.

2.3. Molding Method

In this experiment, referring to the former artificial modeling method[7], the biceps muscle was modeled by centrifugal contraction training, which is most prone to DOMS. First, the subject sat on a priest's bench to ensure that the subject could only flex and extend the elbow at will, and avoid compensatory movement of other joints. Each group trained using a 6RM (Repetition Maximum) weight of a dumbbell bend determined. The training side hand selected the non-handedness of the subject.

The subject places his arms behind the priest's chair and leans his torso forward slightly. The test hand is held backwards on a dumbbell relative to the subject's 6RM weight. The subject starts with a 90 degree elbow bend and gradually and slowly extends the elbow to a 170 degree elbow extension position. Then, with the assistance of the test staff, the subject will return to the 90 degree elbow bend position and repeat the above exercise. The whole training process consisted of two sets with a 5-minute rest between the groups. Each training session should be performed 25 times, and each session is expected to last about 50 to 70 seconds.

2.4. Intervention Methods

Inform subjects of possible situations during manual manipulation before treatment, so as not to be too nervous and cause intervention failure. Subjects were supine with full exposure of upper chest and upper extremity skin. All subjects were treated by the same professional therapist. The therapist performed the manipulations using cross friction massage[8].

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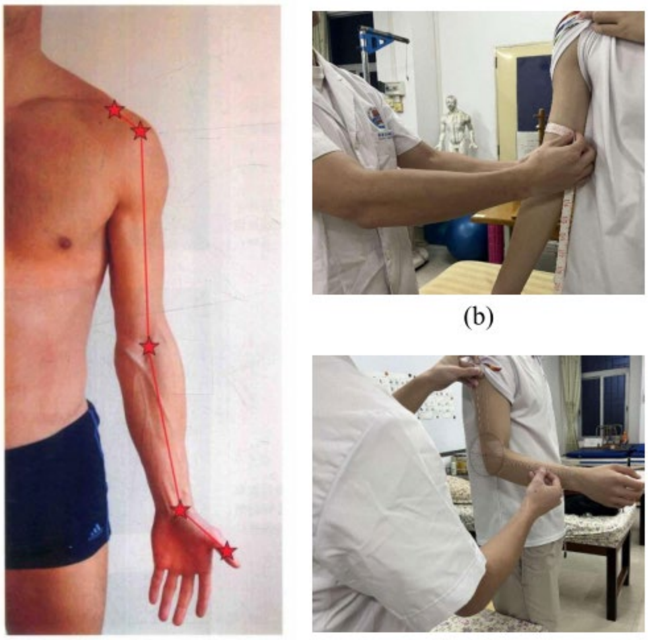
Specific location: Anterior-shoulder segment CC: clavicular-coracoid-axillary fascia. The therapist passes the elbow joint or the interphalangeal joint through the subcoracoidal groove to target the fascia causing the pain. Anterior-humerus segment CC: The anterior upper deltoid, parallel to the head of the humerus, the therapist places the interphalangeal joint above the anterior deltoid, identifying the most severe area for treatment. Forward - elbow segment CC: Flat deltoid distal stop down, on the brachial fascia of the biceps, therapist uses the interphalangeal joint for treatment. Forward carpal segment CC: where the fibers of the flexor carpi radialis and flexor pollicis longus join, the therapist uses the interphalangeal or elbow joint on the abdominal muscle of the flexor carpi radialis. Anterior-phalangeal CC point: The junction of flexor pollicis brevis and flexor pollicis longis (thenar), the therapist uses the interphalangeal joint to massage the densest point here. Each of the above points was treated for 5 minutes each, and the treatment time was 25 minutes in total. See Figure 1 (a) for specific locations[9].



(a) (b) (c)

Figure 1: (a) Illustration of CC points on the upper limb, (b) Schematic diagram of muscle circumference measurement, (c) Schematic diagram of joint range of motion measurement.

2.5. Observation Indexes and Methods

2.5.1. Measurement of Muscle Circumference

Measure the circumference of the subject's biceps in a relaxed state. The subject is in a standing position with feet shoulder-width apart and arms naturally hanging down, keeping the body relaxed, remaining still during the test, relaxing the arms so that the biceps are completely relaxed, and measuring the circumference of the thickest part of the upper arm with a tape measure.

2.5.2. Joint Range of Motion Measurement

The subject is standing with the arm on both sides of the body and the elbow joint is close to the torso, the shoulder joint is rotated outward, the palm is turned upward to make a fist, the forearm is supinated, a protractor is placed on the external epicondyle of the humerus, the axis of the protractor is located on the external epicondyle of the humerus, the fixed arm is parallel to the long axis of the humerus, and the movable arm is parallel to the long axis of the forearm, then the subject slowly bends the elbow to the maximum range of joint motion, and the elbow flexion Angle is measured[10].

2.5.3. Subjective Fatigue Score

In this study, the six-point behavior rating method (BRS-6) was used as the subjective fatigue rating. BRS-6 is similar to the current mainstream visual analogue scale (VAS), but BRS-6 uses the impact of pain on behavior to express pain intensity more closely to the lives of subjects, has certain objectivity, is easy for subjects to understand, and is more suitable for evaluating the subjective fatigue feeling of biceps. BRS-6 expresses pain intensity in terms of the effect of pain on their behavior. On a scale of 1 for each scale, from 0 no pain to 5 severe pain inability to perform normal work and study, there are 6 scales (0

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to 5), and the statements of the 6 scales are: First, no pain. Second, there is pain but easy to ignore. Third, there is pain that cannot be ignored and does not interfere with daily work. Fourth, there is pain that cannot be ignored and interferes with concentration. Fifth, there is pain, can not be ignored, all daily work is affected, but life can be basically self-care. Sixth, severe pain, need to rest or bed rest.

2.6. Statistical Analysis

SPSS25.0 statistical software was used for statistical processing of the experimental data obtained in this study, and the data were expressed as mean ± standard deviation ($\bar{X}$±SD). After testing, all the data in each group were in line with normal distribution. Independent sample t test was used for inter-group differences, and paired t test was used for intra-group differences. $p < 0.05$ indicates a significant difference, $p < 0.01$ indicates a very significant difference.

3. Results

3.1. Changes of Muscle Circumference in Each Group before and After Exercise

Table 2: Changes of muscle circumference in each group before and after exercise (X±SD, unit: cm,).

1Groups	Before sports	Immediately after exercise	24h after exercise	48h after exercise	72h after exercise
Control group(n=12)	25.18±1.81	26.55±1.80	25.63±1.76*	25.83±1.84*	25.94±1.85
Experimental group(n=12)	24.86±2.06	26.43±2.00	25.83±2.01	26.22±1.98	26.28±2.13$^{\&}$

Note: * means that compared with the same group immediately after exercise, $p < 0.05$; & means $p < 0.05$ compared with the control group at the same time.

As shown in Table 2, compared with immediately after exercise, muscle circumference of the experimental group had no significant difference at all time points after exercise, while muscle circumference of the control group increased significantly at 24h and 48h after exercise ($p < 0.05$). Compared with the control group, there were significant differences in muscle circumference in the experimental group 72 hours after exercise ($p < 0.05$).

3.2. Changes of Joint Motion in Each Group before and After Exercise

Table 3: Changes of joint motion in each group before and after exercise(X±SD, unit: degrees).

Groups	Before sports	Immediately after exercise	24h after exercise	48h after exercise	72h after exercise
Control group(n=12)	135±6.14	125.01±4.52	128.58±6.80*	130.69±5.07*	131.38±5.25**
Experimental group(n=12)	137.25±4.83	124.25±8.45	130.08±7.09*	135.17±7.22$^{**\&\&}$	138.83±4.37$^{**\#\&\&}$

Note: # indicates that compared with the control group, $p < 0.05$; * means compared with immediately after exercise, $p < 0.05$, ** means compared with immediately after exercise, $p < 0.01$; && means $p < 0.01$ compared with 24h after exercise.

The data in Table 3 showed that compared with immediately after exercise, the joint motion of the experimental group and the control group increased significantly at all time points ($p < 0.05$), but the joint motion of the experimental group increased more significantly ($p < 0.01$); Compared with the control group, the joint motion of the experimental group was significantly increased 72h after exercise ($p < 0.01$).

3.3. Changes in the subjective fatigue degree of each group before and after the experiment

The data in Table 4 show that compared with the value immediately after exercise, the experimental group and the control group have significant differences in the subjective fatigue degree scores at each time point ($p < 0.05$). Inter-group comparison showed that the subjective fatigue score of the experimental group was significantly lower than that of the control group 72h after exercise ($p < 0.01$). Within the group comparison, the experimental group had significant difference in 72h, 24h and 48h after exercise ($p < 0.01$).

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Table 4: Changes of the subjective fatigue degree of each group before and after exercise (X±SD, unit: min).

Groups	Before sports	Immediately after exercise	24h after exercise	48h after exercise	72h after exercise
Control group(n=12)	1.17±0.72	4.95±0.32	3.63±0.91**	3.73±1.10*	3.21±0.84**
Experimental group(n=12)	0.75±0.75	4.88±0.31	2.71±1.42**	2.5±1.46**	1.0±1.02##**&^

Note: ## means $p < 0.01$ compared with the control group; * means the ratio immediately after exercise $p < 0.05$, ** means the ratio immediately after exercise $p < 0.01$; & means the ratio to 24h value, $p < 0.05$, ^ means 48h ratio, $p < 0.05$.

4. Discussion

Delayed onset muscle soreness (DOMS) often occurs after a sudden increase in intensity or an unaccustomed exercise, especially one involving repeated centrifugal contractions of the muscle. The mechanism of DOMS is complicated. In recent years, many theories have been developed to explain the mechanism of DOMS, including the theory of mechanical injury, the theory of muscle spasm, the theory of lactic acid accumulation, the theory of inflammation, the theory of energy consumption and metabolic regulation enzyme inactivation, as well as the synergistic generation of NGF and GDNF on DOMS[11-12]. According to the theory of mechanical injury, the damage of muscle cell membrane, the damage of muscle cytoskeleton and the mechanical wear of cell contractile components are all mechanical injuries[13]. When the muscle repeatedly carries out high-intensity contraction exceeding the capacity of the cell membrane, it may lead to the damage of the cell membrane, and then increase the permeability of the cell membrane, leading to a series of reactions[14]. Mechanical injury can lead to an increase in calcium ions in muscle cells, resulting in calcium overload that leads to metabolic damage. In addition, studies have shown that there is inflammatory cell infiltration and inflammatory factor infiltration between fibers, and local inflammatory response can also lead to pain, resulting in skeletal muscle damage[15]. DOMS can cause muscle soreness and stiffness, affecting muscle strength and range of motion in joints that can limit athletic performance and daily activities. Commonly used methods to relieve symptoms of DOMS include acupuncture, hot and cold compresses, stretching and massage. But most provide only temporary relief from the pain, with limited help for recovery. By intervening with the FM fascia technique, we can precisely target the area where DOMS has occurred. This intervention can effectively relieve the tension and pain in the specific area, promote blood circulation, accelerate the elimination of metabolic waste, further relieve muscle adhesion phenomenon, and reduce the risk of further injury.

FM Fascial Manipulation is a technique created by physiotherapist Luigi Stecco for the treatment of fascial dysfunction. In this technique, which primarily works on deep fascial tissue, the FM fascial manipulation divides the body into 14 segments, including the head, neck, chest, waist, pelvis, scapula, shoulder, elbow, wrist, finger, hip, knee, ankle, and foot, all composed of six myofascial units (MF units). These units consist of the muscle fibers of the single and double joints, their deep fascia (including the epimuscular membrane), and their joints[16], which move in one direction on a single plane. In the FM fascia manipulation technique we can find some specific points called coordination centers (CC) and fusion centers (CF). They represent the tension network and healing matrix of our body. These points have specific positions in the corresponding segments (such as neck, shoulders, knees). CC can be found in these areas where muscle power is concentrated and classified into corresponding sequences (series of CC points between segments). CF is divided into fusion centers of diagonal and spiral chains, which are located near joints and support bands. The CC and CF points on a chain communicate and interact with each other through various connective tissues. The main mechanism by which FM fascial manipulation is used to treat fascial dysfunction is to restore the viscoelastic properties of the intertissue by increasing the temperature and restoring the sliding between the fibers, and remove the excess HA (hyaluronic acid) from the matrix[10]. Deep fascia friction will break the pathological cross-linking between the HA chains, making the extracellular matrix more elastic and flexible[17]. HA in the body can act as a lubricant (maintaining the viscous consistency of normal tissue), allowing fascia layers to slide between each other and protect muscles[18]. HA can stimulate stellate cell proliferation when the onset of DOMS results in muscle tissue damage. When the body repairs muscle cells after exercise, it secretes a large amount of HA, causing small molecules of HA to accumulate, triggering inflammation and increased viscosity, and

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free nerve endings. This eventually leads to stiff activity and pain.

In this study, it was found that the subjective fatigue degree and joint motion of the experimental group were significantly improved at 24h, 48h and 72h after the intervention compared with immediately after the modeling ($p < 0.05$), while the control group was improved only at 24h, and there was no significant change in other time periods, suggesting that FM fascia manipulation can alleviate the symptoms of post-exercise DOMS. Reduce the degree of subjective fatigue and increase the degree of joint motion after DOMS. This may be related to the fact that FM fascia manipulation can restore intertissue viscoelastic properties, remove excess HA from the matrix, and help restore fascia sequence chains. Muscle circumference of the experimental group and the control group showed a trend of first decreasing and then increasing at 24h ~ 72h after exercise, with no significant difference between the two groups ($p > 0.05$). The muscle circumference of the experimental group decreased after 24h compared with that immediately after the modeling, which may be due to the increase of muscle circumference caused by muscle congestion immediately after the modeling, while DOMS did not occur at this time. However, after 48h after exercise, the reaction of DOMS reached its peak, with ultrafine muscle structure changes, serum enzyme increase, myosinemia, partial myofilament dissolution and rupture. Studies have found that skeletal protein of skeletal muscle membrane, especially dystrophin, is obviously missing after centrifugal exercise. The reason is that muscle strength will decline again and some pathological changes of muscle tissue will occur in 24h ~ 48h after exercise. Some scholars call this phenomenon "secondary injury" of muscle. And at this stage, there will be loss of anti-muscular dystrophin and intermediate filament protein, resulting in inflammatory cell infiltration and swelling of muscle cells, which is ultimately manifested as an increase in muscle circumference[19-20].

In this study, although the overall value showed a trend of improvement after modeling, the immediate data at each intervention time point showed a trend of first decrease and then slight increase compared with the data at subsequent time points (in which the joint motion showed a trend of first increase and then decrease). The reason for this change, in addition to the effectiveness of FM fascia manipulation itself, may also be related to the role of massage manipulation included. Because FM fascia manipulation requires deep compression of fascial tissue, it has a certain massage therapeutic effect in actual operation. In terms of soft tissue treatment, traditional massage has many functions such as eliminating muscle adhesion and promoting soft tissue repair, which can achieve the effects of activating channels and collages, promoting blood circulation and removing blood stasis. He Zhou et al. found that massage can improve the level of IGF-1 through research. Its role in promoting skeletal muscle repair and growth has become more significant. It stimulates the proliferation of muscle satellite cells by activating multiple signaling pathways including MAPK/MEK. It also plays an important role in myoblast proliferation and differentiation by promoting the expression of MyoD and p21, thus slowing down skeletal muscle fibrosis[21]. Therefore, after the application of FM fascia manipulation, joint range of motion and subjective fatigue were improved to some extent, however, the change of muscle circumference was not significant.

5. Conclusions

FM fascia manipulation can improve the symptoms of DOMS after exercise, and play a therapeutic role in DOMS. In particular, it has great influence on joint motion and subjective fatigue degree, but the improvement of muscle circumference is not obvious.

6. Limitations and Future Prospects

In this experiment, muscle circumference, joint motion and subjective fatigue degree were selected as indicators to evaluate whether DOMS improved, and the experimental observation indicators were relatively simple. Further studies can be conducted by adding evaluation indexes (such as blood and urine indexes, etc.), recruiting more subjects, and increasing experimental groups (such as stretching group, instrument treatment group, etc.) to further investigate the mechanism of FM fascia manipulation.

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