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Effects of Tissue Flossing Band Combined with Muscle Energy Techniques on Delayed Onset Muscle Soreness in College Students after Exercise

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Abstract: *This study aims to evaluate the efficacy of combining Tissue Flossing Band with Muscle Energy Techniques (METs) on Delayed Onset Muscle Soreness (DOMS), and to establish an optimized intervention protocol for clinical and athletic application. Twenty-four eligible subjects were recruited and randomly assigned to an intervention group (n=12) and a control group (n=12) using a random number table. DOMS was induced in the biceps brachii through eccentric contractions. Subsequently, the intervention group received the combined intervention of a Tissue Flossing Band and METs immediately after exercise, at 24h post-exercise, and at 48h post-exercise. Changes in upper arm circumference, subjective pain perception, and elbow joint range of motion (ROM) were observed before and after the experiment in both groups. Compared with immediately after exercise, the intervention group exhibited highly significant decreases in pain perception at all post-exercise observation time points ($p<0.01$); elbow ROM significantly increased at 24h and 72h post-exercise ($p<0.05$), but no significant change was observed at 48h ($p>0.05$); and upper arm circumference significantly decreased at 24h and 72h post-exercise ($p<0.05$). Compared with the control group, the intervention group demonstrated highly significant improvements in elbow ROM at all post-exercise observation time points ($p<0.01$). No significant difference in upper arm circumference was found between the groups ($p>0.05$), whereas subjective pain perception in the intervention group was significantly lower at 48h and 72h post-exercise ($p<0.05$). The Tissue Flossing Band combined with METs can effectively alleviate the symptoms of DOMS and shorten its duration, representing an effective method for DOMS management.*

Keywords: *Delayed onset muscle soreness, Tissue Flossing Band, Muscle energy techniques*

1. Introduction

With the improvement of living standards and the enhancement of health awareness, physical exercise has become an important way for the public to improve their quality of life. However, due to the lack of scientific and systematic fitness guidance, many sports enthusiasts often experience Delayed Onset Muscle Soreness (DOMS) after high-load exercise, mainly manifested as muscle pain, decreased strength and limited joint movement[1]. DOMS not only affects the daily life and work of athletes, but also reduces their athletic performance and even increases the risk of secondary sports injuries. At present, common methods for alleviating DOMS include physical therapy, acupuncture, massage, static stretching and cupping, etc[2-3]. Although these single therapies have certain effects, they have problems such as complex operation, high cost, large individual differences and limited therapeutic effect. Studies have shown that fascia compression band intervention can reduce the pain of DOMS[4], and muscle energy technology can increase the joint range of motion of DOMS[5]. However, this method is still controversial at present, which makes its research results unable to be generalized. Compared with single therapy, the combination of multiple intervention methods for DOMS may have better therapeutic effects[6]. For this purpose, this study adopted the intervention method of fascia compression bands combined with muscle energy technology to explore the effect of the combined intervention plan on DOMS, analyze the mechanism of action of fascia compression bands and muscle energy technology, with the aim of providing a scientific basis for the recovery of muscle injuries after exercise.

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2. Study Object and Method

2.1 General Information

In September 2025, subjects were recruited through the campus information platform at a university in Zhanjiang, Guangdong Province. The inclusion criteria were: male college students aged 18-24 years; no vigorous exercise within the past week and agreement not to participate in any other exercise training during the experimental period; no contraindications to exercise; no history of fracture, surgery, or open trauma in the upper limbs; voluntary participation and signed informed consent. The exclusion criteria were: presence of cardiovascular or cerebrovascular diseases or other chronic conditions; history of elbow joint surgery; long-term requirement for high-intensity exercise training; history of allergy to rubber or latex that would preclude completion of the experiment.

A total of 24 male college students who met the inclusion criteria were selected as participants and were randomly divided into an experimental group (n=12) and a control group (n=12) using a random number table method. There were no significant differences in demographic indicators such as age, height, and body mass between the two groups (see Table 1). All participants were informed of the experimental procedures, purposes, and risks, and provided written informed consent voluntarily. This study was approved by the Ethics Committee of Lingnan Normal University, and all procedures strictly adhered to medical ethical standards.

Table 1: Basic information of subjects.

Groups	n	Age (years)	Height(cm)	Weight(kg)
Experimental group	12	19.92±0.79	174.75±7.69	67.33±6.14
Control group	12	20.00±1.00	173.50±6.94	63.08±9.40

2.2. Method

2.2.1 Molding Method

In this study, the maximum number of repetitions was used to estimate the 1RM (Repetition Maximum, RM) of the subjects. After warming up, the subjects chose a suitable weight and performed sitting dumbbell arm curls with their non-grip hands. The subjects sat on the pastor's stool, with their feet naturally touching the ground and their chests pressed against the inclined board on one side of the stool. The researcher uses the inclined plate on the side opposite the participant's stool to immobilize the upper arm and limit compensatory forces from other body segments. When the subject is performing concentric contractions, the dumbbell is bent to the maximum elbow flexion position. During eccentric contractions, the dumbbell is slowly lowered to a slightly bent position. Participants were instructed to exhale during concentric contractions and inhale during eccentric contractions, continuing until voluntary exhaustion. Then, the researchers multiplied the 1RM table by the corresponding estimation coefficient, calculated and estimated the weight of 1RM, and recorded it. After the subjects fully recovered, modeling was conducted[7].

After the test, the subjects were modeled in a sitting position with their arms bent. The subjects sat on the pastor's stool, with their feet naturally touching the ground and their chests pressed against one side of the stool's inclined plate. They used the other side of the stool's inclined plate to fix their upper arms and limit the compensatory force from other parts. The subjects were modeled with a weight of 6RM. During the modeling process, the subject bent the dumbbell to the maximum elbow flexion position and slowly lowered the dumbbell to a slightly bent position during eccentric contraction. Subsequently, with the assistance of the test staff, the subject returned to the maximum elbow flexion position and repeated the above action. The entire training process consists of 2 sets, with a 3-minute break between each set. Each set of training requires 25 repetitions, and it is estimated that each set of training lasts approximately 50 to 70 seconds.

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eccentric contractions until exhaustion. Then, the researchers multiplied the 1RM table by the corresponding estimation coefficient, calculated and estimated the weight of 1RM, and recorded it. After the subjects fully recovered, modeling was conducted[7].

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2.2.2 Intervention Methods

The experimental group was intervened with fascia compression bands combined with METs. Before the intervention, the purpose and method of the intervention were explained to the subjects to eliminate their tension and obtain their cooperation. The subject was in a sitting position. The therapist used a fascia compression band to wrap around the subject's upper arm from the distal end to the proximal end at approximately 50% strength. No tension was applied during the first wrap, and each wrap covered half of the previous one. The therapist passively extended the subject's elbow and shoulder joints backward, then passively pronated the forearm to stretch the biceps brachii to the 'restraint point' (the therapist extended and internally rotated the subject's shoulder and elbow joints backward to the position where resistance was felt, and this position was called the restraint point). Then, the subject was required to flex the elbow with 20 to 30% of the maximum force for 10 seconds. Then, stretch the biceps brachii to a new "restraint point" for 30 seconds of static stretching. Repeat this process three times. It is expected that each intervention will last for 240 to 260 seconds, with one intervention immediately after the exercise, 24 hours after the exercise, and 48 hours after the exercise. The control group received no intervention at all and only engaged in regular daily activities, maintaining their original lifestyle.

2.2.3 Observation Indexes

2.2.3.1 Measurement of upper arm circumference

The stiffness and swelling of the biceps brachii of the subjects were reflected by the circumference of their upper arms. The subject stands or sits with the elbow joint straight and the arm naturally hanging down, keeping the body relaxed. During the test, the subject remains still, relaxes the arm, and uses a tape measure perpendicular to the upper arm. The thickness of the thickest part of the upper arm is measured three times and recorded respectively, accurate to two decimal places. The average of the three measurements is taken[8].

2.2.3.2 Joint Range of Motion Measurement

The joint protractor measures the active range of motion (AROM) of the subject when bending the elbow, that is, the amplitude of motion generated by the subject through active force application without the aid of external force. The subject was in a standing or sitting position, with the elbow joint pressed against the trunk, the shoulder joint externally rotated, the forearm supinated, the palm facing upwards, the axis of the protractor aligned with the lateral epicondyle of the humerus, the fixed arm parallel to the long axis of the humerus, and the mobile arm parallel to the long axis of the forearm. The patient's forearm was flexed to the maximum range of joint motion, and the values were measured and recorded[8].

2.2.3.3 Subjective pain degree score

In this study, the six-point Behavioral Scoring System (BRS-6) was used to assess the subjective pain sensation of the subjects. Using BRS-6 instead of VAS to express the pain intensity is closer to the subjects' lives, has a certain objectivity, is convenient for the subjects to understand, and is more suitable for evaluating the subjective fatigue sensation of the biceps brachii. BRS-6 expresses the intensity of pain based on its impact on behavior. Each level is scored out of 1, ranging from 0 points for no pain to 5 points for severe pain that prevents normal work and study, with a total of 6 levels (0 to 5 points). The expression of the 6 levels is as follows: No pain; There is pain but it is easy to ignore; There is pain that cannot be ignored and does not interfere with daily work; There is pain that cannot be

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ignored and distracts attention; There is pain that cannot be ignored, and all daily work is affected, but life can be basically taken care of by oneself. Pain intensity was assessed using the Six-Point Behavioral Rating Scale (BRS-6) [9].

2.2.4 Statistical Analysis

The experimental data obtained in this study were statistically analyzed using SPSS 29.0 statistical software. The data were expressed as mean ± standard deviation (X ± SD). The data of each group conformed to the normal distribution. The independent sample t-test was used for the differences between groups, and the paired sample t-test was used for the differences within groups. A p value <0.05 was considered statistically significant.

3. Results

3.1 Comparison of subjective pain perception scores of the two groups of subjects before and after the intervention

Table 2 data shows that compared with immediately after exercise, the subjective pain perception of the experimental group at each observation time point after exercise was significantly reduced ($p<0.01$). Compared with the control group in the same period, the subjective pain sensation in the experimental group was significantly reduced at 48 hours and 72 hours after exercise ($p<0.05$), while there was no significant difference at 24 hours ($p<0.05$).

Table 2: Changes in subjective pain levels before and after exercise in the two groups (minutes)

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)	0.21±0.40	3.96±0.50	2.75±1.37**	2.54±1.05**#	0.78±0.73**#

Note:* means that compared with the same group immediately after exercise, *p<0.05*, ** means that compared with the same group immediately after exercise, *p<0.01,* #means *p <0.05* compared with the control group at the same time,## means p <0.01 compared with the control group at the same time.

3.2 Comparison of the upper arm circumference of the two groups of subjects before and after the intervention

Table 3 data shows that compared with immediately after exercise, the upper arm circumference of the experimental group was significantly reduced at 24 hours and 72 hours after exercise ($p>0.05$), while there was no significant change at 48 hours after exercise ($p>0.05$). Compared with the control group in the same period, there was no significant difference in the upper arm circumference of the experimental group at each observation time point after exercise ($p>0.05$).

Table 3: The changes in upper arm circumference before and after the two groups of exercises (cm)

Groups	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)	25.46±1.38	27.10±1.56	26.29±1.43*	26.68±1.47	26.23±1.38*

Note:* means that compared with the same group immediately after exercise, *p<0.05*, ** means that compared with the same group immediately after exercise, *p<0.01,* #means *p <0.05* compared with the control group at the same time,## means p <0.01 compared with the control group at the same time.

3.3 Comparison of joint range of motion between the two groups of subjects before and after the intervention

Table 4 data shows that compared with immediately after exercise, the joint range of motion in the experimental group significantly increased at 24 hours and 72 hours after exercise ($p<0.05$), while there

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was no significant difference at 48 hours ($p<0.05$). Compared with the control group in the same period, the joint range of motion in the experimental group was significantly improved at each observation time point after exercise ($p<0.05$).

Table 4: The changes in joint range of motion before and after exercise in the two groups (°)

Groups	Before sports	Immediately after exercise	24h after exercise	48h after exercise	72h after exercise
Control group (n＝12)	135.00±6.14	125.01±4.52	128.58±6.80*	130.69±5.07*	131.38±5.25
Experimental group (n＝12)	141.50±2.10	134.17±3.59	137.75±2.45**##	135.50±3.58##	140.17±2.79**##

Note:* means that compared with the same group immediately after exercise, *p<0.05*, ** means that compared with the same group immediately after exercise, *p<0.01,* #means *p <0.05* compared with the control group at the same time,## means p <0.01 compared with the control group at the same time.

4. Conclusions

4.1 The influence of fascia compression bands combined with METs on subjective pain perception in college students with DOMS

In this study, fascia compression bands combined with METs were used to intervene in delayed muscle soreness after college students' exercise. It was found that this method had a positive improvement effect on the subjective pain sensation of DOMS college students. The research results show that after the intervention, compared with the control group, the subjective pain sensation of the experimental group was significantly reduced at 48 hours and 72 hours after exercise ($p < 0.05$), indicating that the combination of fascia compression bands and METs can effectively alleviate the symptoms of DOMS and reduce the pain caused by DOMS. The fascia system runs through organs, muscles, bones and nerve fibers, and has characteristics such as genetic differences, fluidity, stickiness and slipability. Deep fascia contains a large number of nosorreceptors[10]. Fascia compression bands and METs may effectively relieve the pain caused by DOMS by stimulating mechanical receptors, reducing the viscosity of hyaluronic acid in muscle tissue and promoting blood circulation. Fascia compression bands can cause blood flow reperfusion, promote the release of nitric oxide, further dilate capillaries, and remove some harmful products in muscle tissue[11]. METs relieve muscle pain by stimulating fascia through rhythmic muscle contractions, improving capillary blood flow, reducing inflammatory factors, and regulating the downward pathways of pain[12]. It is worth noting that there was no significant change in pain perception 24 hours after exercise ($p>0.05$), possibly at this observation time point, the inflammatory response and pain sensitization process of DOMS were still in the initiation stage and had not yet accumulated to the threshold level sufficient to induce significant subjective pain perception[13-14].

The results of this study also show that compared with immediately after exercise, the pain sensation of the experimental group at 24, 48, and 72 hours after exercise decreased extremely significantly ($p < 0.01$), suggesting that the combination of fascia compression bands and METs has an excellent effect on relieving pain. The pressure and shear force generated by the wrapping of fascia compression bands can activate the superficial mechanical receptors under the skin, thereby inhibiting the nerve impulses emitted by pain receptors[15]. METs inhibits the transmission of noxious stimuli at the spinal cord and brainstem levels by pulling mechanoreceptors[16], and there may be a combined benefit between the two. In addition, the fascia compression band combined with muscle energy technology eliminates the adhesion points of myofascia and alleviates muscle soreness by increasing the local temperature and reducing the viscosity of hyaluronic acid[17-19]. When the fascia compression zone is removed, the reperfusion of blood flow at the compressed site promotes the clearance of metabolic waste and the renewal of tissue fluid, thereby achieving anti-inflammatory, de-swelling and analgesic effects[11,20]. The reduction of subjective pain after DOMS can not only improve the muscle discomfort of college students after exercise and enhance their exercise experience, but also reduce the restrictions of DOMS on subsequent exercise participation, avoid the decline in exercise enthusiasm caused by pain, and at the same time lower the risk of sports injuries caused by muscle pain.

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4.2 The influence of fascia compression bands combined with METs on the muscle circumference of DOMS college students

DOMS can lead to a passive and temporary increase in muscle circumference. Essentially, it is caused by the inflammatory response during the repair process of minor muscle fiber damage, resulting in the exudation of tissue fluid and subsequent edema, rather than an increase in the cross-sectional area of muscle fibers[21]. The results of this study show that compared with those immediately after exercise, the upper arm circumference of the experimental group decreased significantly at 24 hours and 72 hours after exercise ($p < 0.05$). This might be related to the fact that the combination of fascia compression bands and METs promoted local tissue blood circulation and effectively reduced muscle tone, thereby lowering muscle stiffness. It is worth noting that compared with the control group, the upper arm circumference of the experimental group did not show significant improvement at 24 hours, 48 hours and 72 hours after exercise ($p>0.05$), indicating that the long-term effect of fascia compression band combined with METs intervention on the upper arm circumference of DOMS college students is not ideal. The reason may be related to the pathophysiological changes of skeletal muscle during the occurrence of DOMS. The accumulation of inflammatory factors such as histamine and bradykinin in the biceps brachii caused by the ultrastructural changes of delayed skeletal muscle fibers, as well as the infiltration of neutrophils and monocytes at the injury site, leads to muscle cell edema and subsequently presents as muscle swelling[22-23]. Although swelling is relieved immediately after exercise by improving blood circulation and reducing muscle tone, it cannot fundamentally inhibit the pathological process of inflammatory factor accumulation and muscle cell edema. Therefore, it is difficult to show a better intervention effect than the control group in long-term observations.

4.3 The influence of fascia compression bands combined with METs on joint range of motion in college students with DOMS

The direct change brought by DOMS to joint range of motion is that within 24 to 72 hours after exercise, the range of motion of the joint is significantly reduced, manifested as stiffness and limitation in joint flexion, extension, rotation and other activities, which is a functional disorder caused by muscle fiber inflammation and edema and increased muscle tone[24]. The results of this study show that compared with those immediately after exercise, the joint range of motion in the experimental group was extremely significantly improved at 24 hours, 48 hours, and 72 hours after exercise ($p < 0.01$). This may be related to the improved sliding ability of the fascia. The fascia slides with the help of a matrix, which is composed of mucopolyglycoproteins or glycosaminoglycans (such as hyaluronic acid, keratin, etc.). High-density Hyaluronic Acid (HA) and low-density collagen can be more conducive to the sliding between fascia. In the human body, the matrix constantly changes its state to meet the body's needs. When the local tissue matrix dehydrates, its viscosity increases, and metabolites and toxins will also be stored in the matrix[25]. When delayed-onset muscle soreness occurs, chronic inflammation can cause adhesion of fascia tissue and increase the viscosity of hyaluronic acid, thereby limiting fascia function. By applying pressure to the muscles with fascia compression bands, not only can the adhesion points of the muscles and tendons be eliminated, but also the viscosity of hyaluronic acid can be reduced to improve the sliding property of the fascia. At the same time, fascia compression bands can improve joint range of motion, and the PIR produced by METs can also have a good effect on improving joint range of motion and reducing muscle tension[26-27]. Therefore, the combination of the two may have a synergistic effect on improving joint range of motion.

The results of this study show that compared with the control group in the same period, the joint range of motion in the experimental group significantly increased at 24 hours and 72 hours after exercise ($p < 0.05$), while there was no significant change at 48 hours after exercise ($p > 0.05$). The reason might be related to the severe deformation of the ultrastructure of skeletal muscle 48 hours after exercise, the disordered arrangement of muscle filaments, and the disappearance of muscle segment structure[20]. Fascia compression bands can cohesive synovial fluid to separate the articular surface, improve the accessory movement of the joint, and thereby increase the flexion range of motion of the elbow joint. Meanwhile, METs can accelerate metabolism and inhibit sympathetic nerve tension[16,28]. The synergistic effect of the two may be the reason for effectively improving the range of motion of the joint. The significant improvement in joint range of motion can further alleviate the muscle stiffness and limited movement caused by DOMS, help college students quickly restore limb function, reduce the trouble caused by the inconvenience of limb movement after exercise, and further enhance the recovery effect after exercise.

In conclusion, the combination of fascia compression bands and METs can effectively alleviate the

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symptoms of delayed onset muscle soreness, reduce the duration of delayed onset soreness, and is a better method for intervention in DOMS. However, this study still has some limitations. Due to the constraints of conditions, only subjective pain sensation, joint range of motion and upper arm circumference were used as observation indicators in the selection of indicators. Subsequent studies can incorporate observation indicators such as blood, muscle ultrastructure and muscle strength. Researchers should conduct prospective studies to further explore the mechanisms of action of fascia compression bands and METs in DOMS, with attention to the pathophysiological mechanisms underlying symptom persistence. They should use additional experimental groups to compare the therapeutic effects of different interventions on DOMS, identify the approaches that most effectively alleviate symptoms, and provide evidence for a preliminary theoretical framework and treatment protocol.

5. Conclusions

Fascia compression bands combined with METs can effectively alleviate the symptoms caused by delayed onset muscle soreness and reduce the duration of delayed onset muscle soreness, especially showing a more significant improvement in joint range of motion and subjective pain sensation due to delayed onset muscle soreness.

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