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Original research

The effect of acupuncture stimulation on muscle fatigue during the Meridian-Test and Functional Movement Screen

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Abstract

[Objective] The use of medical screening for injury prevention is rising, including the adoption of the Functional Movement Screen or the Meridian-Test for conditioning. However, little information is available on the effect of acupuncture treatment on Functional Movement Screen and Meridian-Test scores. In this study, we investigated the effect of training fatigue and acupuncture treatment on Functional Movement Screen and Meridian-Test scores.
[Methods] Twenty-eight healthy male university students were randomly allocated to an acupuncture treatment group and a control group, each consisting of 14 subjects. On Day 1, both groups took the Meridian-Test followed by Functional Movement Screen measurements. They performed exercises, and 24 hours later members of the acupuncture treatment group received treatment based on the results of the Meridian-Test from Day 1. Both groups then repeated the Meridian-Test and the Functional Movement Screen after 48 hours and 96 hours.
[Results] There were no significant differences between the two groups for any movement of the Functional Movement Screen. In the control group, the Meridian-Test score after 48 hours was significantly higher than the score on Day 1 or after 96 hours. The Meridian-Test score after 48 hours was also significantly higher in the control group than the score in the treatment group.
[Conclusion] When using the Functional Movement Screen to assess stability and muscle exertion, a tool widely used for general evaluation in the sporting world, using the Meridian-Test to concurrently assess the flexibility and mobility of the different parts of the body may be extremely useful in enabling acupuncturists to carry out therapeutic interventions intended to improve movement.

Key words: *Dynamic alignment, Sports acupuncture, Injury prevention, Meridian-Test, Functional Movement Screen*

I. Introduction

The use of acupuncture in sports is well-known, and many acupuncture practitioners are active in this field. An investigation of the types of qualifications or certifications that Athletic Trainers of Japan Sports association (JASA ATs) possess revealed that many are qualified acupuncturists. This suggests that many acupuncturists are involved with the care of professional or recreational athletes and teams. The need for acupuncture is also expanding, with a rising demand not only for the treatment of injury and the alleviation of pain, but also for methods of injury prevention. Amid the increasing demand in sports settings, the use of medical screening for injury prevention is also rising, such as the adoption of the Functional Movement Screen (FMS) or the Meridian-Test (M-Test) for conditioning.

Since the FMS enables the simple evaluation of dynamic alignment and makes the subsequent exercises to improve poor dynamic alignment clear, it has been widely adopted by top-level sport and fitness clubs. It is a method for the composite assessment of the mobility and stability of the parts of the body fundamental to sport-related movement and motor control, and consists of 7 basic movement tests (the deep squat, hurdle step, in-line lunge, shoulder mobility, trunk stability push-up, rotary stability, and active straight leg raise). Subjects are scored on a scale of 0-3 points, based on whether they can perform each movement according to the method indicated. Since using the body inappropriately may cause injury, the FMS is regarded as an effective means of identifying athletes who may develop injuries[1].

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The M-Test[2,3] is based on the concept of meridians and relies on the subjective evaluation of pain or tightening, which occurs as a result of movements that extend the meridians, to identify problems as well as the appropriate type and location of treatment. It is composed of 30 types of movement. As many of these movements are similar to regular orthopedic manual tests or the everyday stretches performed by athletes, the M-Test is simple to perform (Figure 1). Studies have found that the M-Test is useful as a conditioning method for male and female athletes, including specific movement-based conditioning, and that acupuncture treatment based on this test suppresses the build-up of fatigue[4,5]. However, little information is available on the effect of acupuncture treatment on M-Test scores. In this study, we investigated the effect of training and exercise fatigue and the effect of acupuncture treatment (based on M-Test results) on FMS and M-Test scores.

Ⅱ. Material and Methods

1. Subjects

At the start of the study, 28 healthy male university students were randomly allocated to an acupuncture treatment group and a control group consisting of 14 subjects each. Approval of the study was obtained from the Ethics Committee of Teikyo Heisei University (27-066). The study was fully explained and all participants provided informed consent. Five subjects dropped out of the acupuncture treatment group part-way through the study, reducing the total number of subjects in the acupuncture treatment group to 9. The characteristics of the study subjects are shown in Table 1.

2. Outcomes

The outcomes assessed in this study were the M-Test

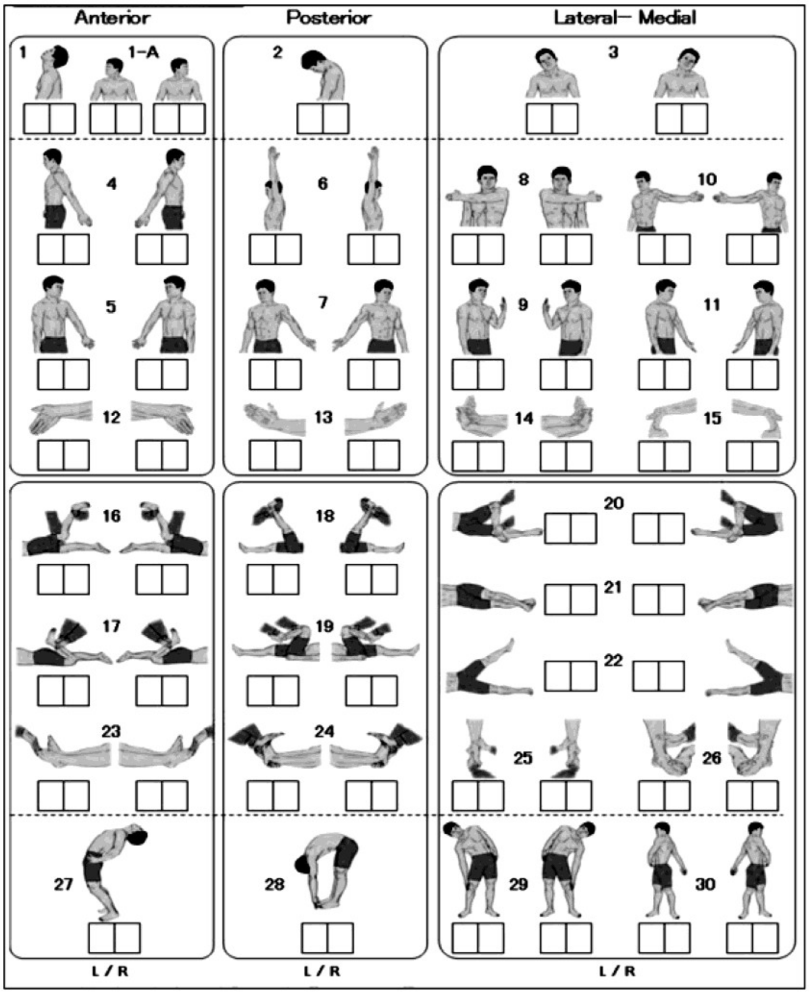

Figure 1. The Meridian Test (M-Test)
Chart of the 30 movements performed as part of the M-Test. Each movement is scored on a visual analog scale.

Table 1. Participant characteristics

	acupuncture treatment group	control group
Age (years)	20.2 ± 1.4	20.0 ± 1.5
Height (cm)	172.7 ± 4.0	170.7 ± 4.5
Weight (kg)	63.3 ± 8.4	63.8 ± 9.6
Average exercise (hours/week)	1.9 ± 1.0	3.3 ± 2.0

and FMS scores. The effect of exercise on these scores, in the form of push-ups and split lunge jumps, was investigated.

3. Measurement protocol

Measurements were carried out over a 5-day period. On Day 1, both groups took the M-Test followed by FMS measurements. They performed exercises, and 24 hours later, members of the acupuncture treatment group received treatment based on the results of the original M-Test. Both groups then repeated the M-Test and the FMS 48 hours and 96 hours after the original tests.

4. Measurement methods

(1) Functional Movement Screen (FMS)

All seven types of movement listed in the FMS manual were performed: the deep squat (DS), hurdle step (HS), in-line lunge (IL), shoulder mobility (SM), trunk stability push-up (TSP), rotary stability (RS), and active straight-leg raise (ASLR). To ensure that the subjects had a common understanding of the FMS movements, the method of movement was explained immediately before the start of the measurement and the subject carried out three practice attempts before the final attempt was measured, for each of the seven movements. Each movement in the FMS was assessed on a 4-point scale (0-3). During the measurements, an EX-ZR200 digital camera (Casio Computer Co., Ltd., Tokyo, Japan) was used to record each movement from the front (coronal plane) and side (sagittal plane). Scoring was carried out on the basis of the video by six evaluators who had been trained in FMS assessment criteria, one week after all of the subjects had completed the measurements. To eliminate any interaction between the evaluators, they refrained from commenting on the movements or their assessments at the time the measurements were made, and scored them later from the video recordings.

(2) M-Test

The M-Test measurements were taken by actively performing all 30 meridian-extending movements twice, in the prescribed order, starting on the left side. To avoid any mistakes, the investigator stood facing the subject from the front and instructed him to perform the same movement, while encouraging him to avoid any compensatory movements.

Assessment was performed using a visual analog scale (VAS) (Figure 2). In this study, if no symptoms occurred as a result of the movement, it was scored as 0, mild stiffness was scored as 1-3, severe stiffness as 4-5, pain as 6-7, severe pain as 8-9, and maximum pain as a 10. Subjects were requested to draw a short vertical line on a 10-cm horizontal line to indicate their subjective response. To minimize error on the part of subjects, these guidelines were placed so that they were constantly in view while the measurements were taking place. To compare the DS movement with the movements of the

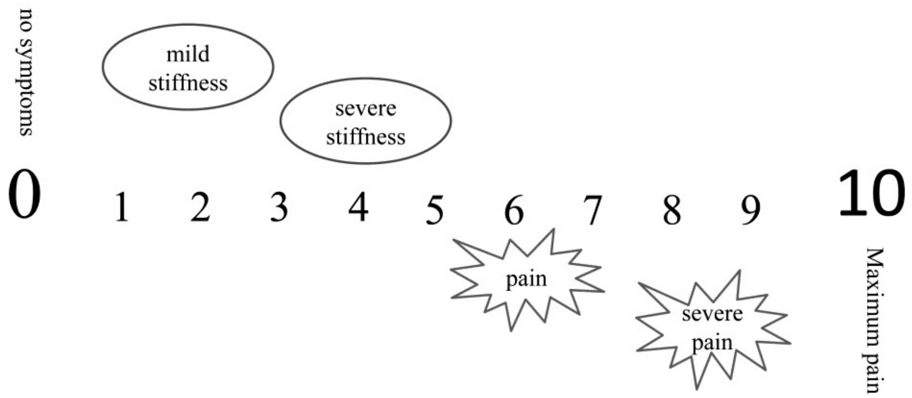

Figure 2. VAS of the M-Test

Graphic representation of the visual analog scale (VAS) used to score the movements of the Meridian Test (M-Test). Symptoms progress from 0 to 10 as severity increases.

Table 2. FMS score results
Abbreviations: FMS, Functional Movement Screen; DS, deep squat; IL, in-line lunge; HS, hurdle step; RS, rotary stability; TSP, trunk stability push-up; ASLR, active straight leg raise; SM, shoulder mobility; SD, standard deviation
*, # significant at $P < 0.05$

	Before Intervention		After 48 hours		After 96 hours	
	Acupuncture	Control	Acupuncture	Control	Acupuncture	Control
Total	14.6	15.0	13.4 *#	13.3 *#	13.9	14.6
	2.1	2.4	2.0	1.8	2.0	2.2
DS	2.0	2.0	1.7 *#	1.7 *#	1.8	2.0
	0.4	0.5	0.3	0.4	0.3	0.5
IL	2.4	2.5	2.2 *#	2.3 *#	2.3	2.4
	0.5	0.4	0.4	0.4	0.5	0.4
HS	2.4	2.3	2.2 *#	2.1 *#	2.2	2.3
	0.4	0.4	0.3	0.4	0.4	0.4
RS	2.0	1.9	1.8	1.8	1.9	1.9
	0.1	0.2	0.3	0.3	0.2	0.2
TSP	2.0	2.1	1.7 *#	1.7 *#	1.7 *	1.8 *
	0.6	0.6	0.7	0.6	0.6	0.7
ASLR	2.1	1.9	2.0	1.8	2.1	1.9
	0.6	0.7	0.5	0.6	0.6	0.7
SM	1.8	2.1	1.8	1.9	1.8	2.1
	0.8	0.9	1.0	0.8	0.8	0.9
			* : vs Before Intervention			mean
			# : vs After 96 hours			SD

M-Test, movements considered to be associated with the DS score (shoulder joint flexion, horizontal shoulder extension, knee joint flexion, hip joint flexion, ankle joint dorsiflexion, and trunk extension) were isolated and the total VAS score for these movements (M-DS movements) was investigated.

(3) Treatment

Treatment priority was given to the movement with the highest VAS score in the pre-treatment M-Test, and was carried out for 30 min with the aim of reducing this score to below half of its previous value. Thumbtack needles of 0.6-mm length (Seirin Corp., Shizuoka, Japan) were used for treatment. Some previous studies have reported the clinical effects of treatment with thumbtack needles on muscle fatigue[2,3]. Conveniently, thumbtack needles can also be used during sports activity. Therefore, we also used thumbtack needles in this study.

(4) Exercise

Exercise was carried out according to the Tabata protocol[6], using two forms of movement (push-ups and split lung jumps) that were performed in sets of 8 for 20 seconds each, with a 10-second rest between each set. Each subject performed the exercise to the point of fatigue, thus total repetitions varied between subjects.

(5) Statistical analysis

Fleiss' Kappa coefficient was calculated according to the method reported by Siegel[7] in order to assess the intra-evaluator reliability of the FMS scores. A two-way analysis of variance (ANOVA) was carried out for the elapsed time and whether or not treatment was performed; if a main effect was identified, an unpaired t-test was used as a post-hoc test to compare the treatment and control groups, and multiple comparisons, with the significance level adjusted by Bonferroni correction, were used to investigate changes over time in each group. If an interaction was identified, the simple main effect was tested. A P-value < 0.05 was regarded as significant. The statistical software packages used were SPSS 22.0 (IBM Corp., Armonk, NY, USA) and R 2.8.1 (R Foundation for Statistical Computing, Vienna, Austria).

Ⅲ. Results

1. Comparison of FMS scores

Fleiss' Kappa coefficient was calculated as 0.62, which was regarded as indicating substantive consistency between the evaluators. The scores for DS, HS, IL, TSP, and the total score all declined significantly after 48 hours in both groups. After 96 hours, the TSP score was also significantly lower than it had been prior to exercise, but DS, HS, and IL scores all recovered from this decline after 96 hours. There was no significant change in the scores for RS, SM, or ASLR, and there were no significant differences between the two groups for any movement (Table 2).

2. Comparison of total scores for all M-Test movements

A comparison of the total VAS scores for all M-Test movements between the treatment and control groups found that there was a significant main effect for time and that the interaction was significant. A test of simple main effects found that the score after 48 hours was significantly higher than the score on Day 1 or after 96 hours in the control group, and that the M-Test score after 48 hours was also significantly higher in the control group than the score in the treatment group (Figure 3).

3. Comparison of the FMS and M-Test

A comparison of the total VAS score for the M-DS movements between the treatment and control groups found that there was a significant main effect for time and that the interaction was significant. A test of simple main effects found that the VAS score after 48 hours was significantly higher in the control group than it was on Day 1, and that the VAS score in the control group after 48 hours was also significantly higher than the score in the treatment group after 48 hours (Figure 4).

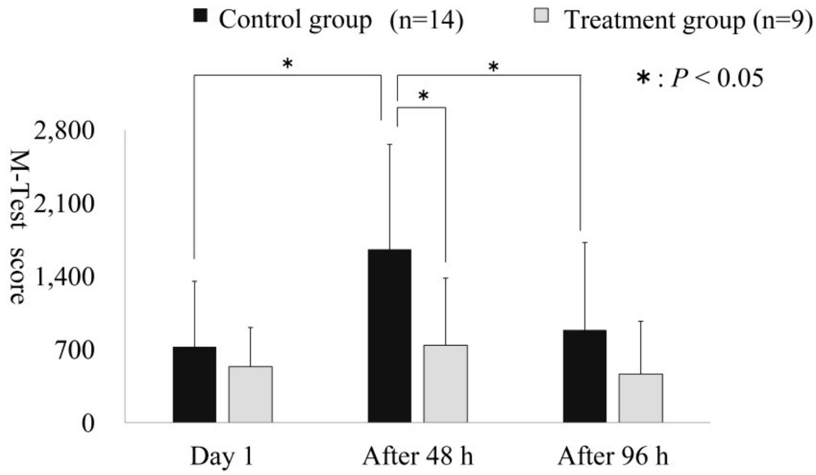

Figure 3. Total scores for all M-Test movements
Bar graph indicating that the scores in the control group were significantly higher after 48 hours than the scores on Day 1 or after 96 hours, and that the Meridian-Test (M-Test) scores in the control group were also significantly higher after 48 hours than the scores in the treatment group.

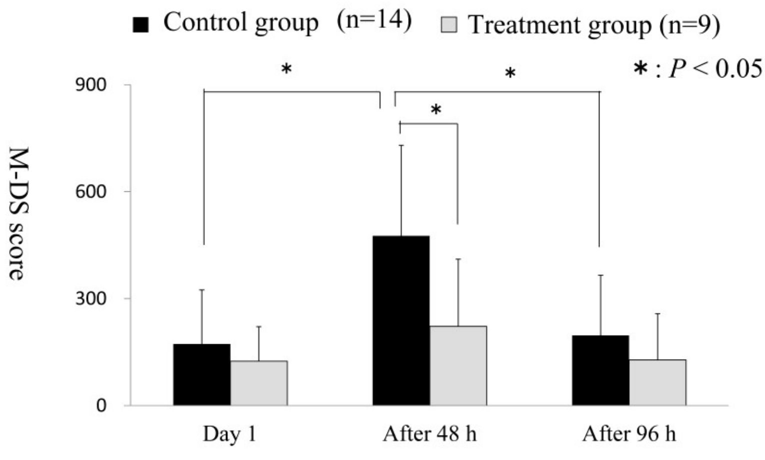

Figure 4. Total VAS score for the M-DS movements
Bar graph indicating that the VAS scores in the control group were significantly higher after 48 hours than the scores on Day 1, and that the VAS scores in the control group after 48 hours were also significantly higher than the scores in the treatment group after 48 hours. The M-DS movements are those that are comparable to the component movements of the deep squat used by the Functional Movement Screen.

Ⅳ. Discussion

The investigation of the inter-evaluator reliability of the FMS scores revealed that they were substantively consistent, confirming the validity of using the mean FMS scores obtained from 6 evaluators for each subject.

The total score declined significantly after 48 hours compared with the measurements taken before the exercises. The FMS is said to enable the evaluation of 7 types of movement. The exercises carried out in this study caused a decline in muscle function[8] and decreased the modulatory action of the motor system[9]. The decline in FMS scores may have been caused by the effect of persistent delayed-onset muscle pain[10] and muscle fatigue[11] on dynamic alignment.

DS, IL, and HS scores obtained 48 hours after exercise were significantly lower than both the initial scores and the scores obtained 96 hours later. According to Cook[1], reasons for a low DS score may include limited range of motion (ROM) of the upper body due to reduced mobility of the shoulder joints and thoracic spine, diminished flexibility of the legs, limited dorsiflexion of the ankle joints, limited flexion of the hip and knee joints, reduced stability, or insufficient motor control. Reasons for a low IL score may include diminished ROM in the ankle, knee, or hip joint of either the front or back leg, inadequate dynamic stability, and limited mobility of the thoracic spine. Reasons for a low HS score include diminished stability of the standing leg, reduced mobility of the stepping leg, and problems in maximally flexing the hip joint of the stepping leg while maintaining extension of the hip joint of the standing leg. Lunge jump movements require muscle activity in the gluteals, vastus lateralis, biceps femoris, and soleus, and Irie et al.[8] have reported an association between muscle fatigue and muscle elasticity. Given the requirements of the exercises, performing split lunge jumps may have caused muscle fatigue in the vastus lateralis and soleus. Exercise-induced muscle fatigue can persist after 48 hours[11], and reduced elasticity may limit ankle joint dorsiflexion and knee and hip joint flexion, thereby reducing the scores for the DS, IL, and HS movements. It may be inferred that both muscle fatigue and muscle elasticity recovered after 96 hours, resulting in improved scores.

The TSP score was significantly lower both 48 and 96 hours after exercise compared with scores obtained before exercise. Reduced upper body strength, diminished scapular stability, decreased mobility of the hip joint and the thoracic spine, and reduced trunk stability may have contributed to this decrease[1]. According to Kanna et al.[12], push-ups involve activity of the triceps brachii, brachioradialis, and deltoid muscles, and fatigue in these muscles may have resulted in diminished upper body muscle strength and a reduced score 48 hours later. It is conceivable that push-ups impose relatively greater stress on the arms than split lunge jumps do on the legs, and that this was the reason that the score was still significantly lower 96 hours after exercise compared with scores prior to exercise.

There was no significant change in SM, RS, or ASLR scores. Possible reasons for a low RS score include the lack of postural reflexes, diminished scapular and hip joint stability, and reduced mobility of the knee and hip joints, spinal column, and shoulder joints. Possible reasons for a low SM score include diminished shoulder girdle stability or mobility of the thoracic spine, functional incompetence of the scapulothoracic joint resulting from these issues, or anterior or rotatory displacement of the scapula due to overdevelopment and contraction of the pectoralis minor, latissimus dorsi, and rectus abdominis. A low ASLR score may be because of insufficient hamstring functional flexibility, inadequate pelvic control, inappropriate mobility of the hip joint on the non-elevated side, and insufficient flexibility associated with limited hip joint extension[1]. These factors may have had no effect on the movements involved in either lunge jumps or pushups.

There was a significant difference in the total VAS score for M-DS movements between the two groups, and this score was improved by acupuncture treatment. Although DS-associated mobility improved, there was no difference between the two groups in terms of DS score on the FMS, which remained low in both groups 48 and 96 hours after exercise. This may have been due to the fact that the FMS also assesses stability and muscle exertion in addition to flexibility and mobility. It is conceivable that although the flexibility of each body part required to perform a DS was improved by acupuncture treatment, no such improvement in stability or muscle exertion was evident.

The subjects in the acupuncture treatment group displayed improvements in muscle fatigue and lower VAS scores. These results were consistent with those of previous studies which found that thumbtack needles are effective for controlling delayed-onset muscle pain[13] and assisting recovery from muscle fatigue[14,15]. Localized acupuncture stimulation with regular acupuncture needles induces axonal reflexes along unmyelinated C-fibers in the afferent pathway, releasing vasodilators such as calcitonin gene-related peptide (CGRP) and increasing muscle perfusion[16-19]. Excitation and firing of C-fiber nociceptors when thumbtack needles are applied has been reported[20], and stimulation of the skin with a resin device with 0.3-mm protuberances has also been found to excite C-fiber nociceptors[21], suggesting that even the minute stimulation of the skin imparted by thumbtack needles excites C-fiber nociceptors and evokes a similar axonal reaction to that of regular acupuncture needles, improving local circulation. These findings suggest that stimulation by thumbtack needles aids recovery from fatigue, which may have led to improved muscle viscoelasticity and better VAS scores.

In terms of the limitations of this study and issues for future research, this study included some parameters for which the FMS score did not change. As only a limited subset of muscles may have been affected by the exercises used, a wider variety of forms of exercise must be investigated. Although the factors potentially affecting VAS and FMS scores include muscle fatigue, internal muscle condition, and muscle elasticity, the influence of these factors remains unclear, and the mechanism of action of the thumbtack needle stimulation used in this study is still in the realm of speculation. Detailed investigations of muscle condition and perfusion will be required in the future. The FMS can be used to evaluate both mobility and stability. However, the FMS is an evaluation tool and does not suggest the optimal way to improve mobility and stability. In contrast, the M-Test can only be used to evaluate mobility by checking the ROM of each joint, although it can suggest methods to improve the limitation. Therefore, using the FMS and M-Test in combination can enable practitioners to suggest appropriate methods for preventing sports injuries.

V. Conclusion

When using the FMS to assess stability and muscle exertion, a tool widely used for general evaluation in the sporting world, using the M-Test to concurrently assess the flexibility and mobility of the different parts of the body may be extremely useful in enabling acupuncturists to carry out therapeutic interventions intended to improve movement.

Conflict of Interest

There is no conflict of interest.

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