Original research

Effects of stimulation with press tack needle acupuncture on muscle fatigue

Okuma Yoshihiro[1,2,3], Yoshida Naruto[1], Miyazaki Shogo[1], Hisajima Tatsuya[1], Takahashi Hidenori[1], Miyakawa Shumpei[2]

1) Faculty of Health Care, Department of Acupuncture and Moxibustion, Teikyo Heisei University
2) Division of Sports Medicine, Graduate School of Comprehensive Human Sciences, University of Tsukuba
3) TOYOTA VERBLIZ, Rugby team

Abstract

[Objective] Acupuncture is a widely used technique for treating pain and osteoarthritis, and is more widely used among athletes than general population. Recently the press tack needle acupuncture method has become more popular. However, information regarding press tack needle acupuncture remains scarce. Muscle fatigue is defined as a reduction in the instantaneous muscle force generation, including a decrease in peak muscle force, a reduction in the maximum velocity of muscle contraction, or a reduction in the maximal capacity to generate power output. In the present study, we aimed to investigate the effects of stimulation by press tack needle acupuncture on the decrease in instantaneous muscle force generation due to muscle fatigue.

[Materials and Methods] We randomly assigned 32 healthy young adult men (mean age, 24.32 ± 2.47 years) to an acupuncture group (n = 16) or a control group (n = 16). Both groups then underwent exhaustive exercise, comprising 30 series of isometric maximum voluntary contractions. The outcome measurements included isometric maximum voluntary knee extensor muscle force, rate of force development, force-time integral and muscle activity (integrated electromyogram and mean power frequency) values. All data were recorded before and after exhaustive exercise.

[Results] Based on result of two-way ANOVA the main effect of intervention and the main effect of intervention × time interaction were found to be significant in the peak muscle force, rate of force development, force-time integral and integrated electromyogram.

[Conclusion] It was suggested that press tack needle acupuncture may prevent exercise-induced muscle fatigue.

Key words: *muscle fatigue, peak muscle force, rate of muscle force, press tack needle*

I. Introduction

Acupuncture has been widely used to treat musculoskeletal pain and is known to ameliorate pain in patients with low back pain and knee osteoarthritis, thus improving the patients' quality of life. Moreover, in the field of sports medicine, acupuncture has been reported to have therapeutic effects on low back pain and rotator cuff tendinitis. At present, acupuncture therapy is more widely used among athletes than general population[1]. However, only few reports have described the effects of acupuncture on conditioning and performance in athletes, and clear evidence of its effects needs to be obtained.

The mechanism of action of acupuncture involves the suppression of pain and increase of blood flow induced by the stimulation of an appropriate acupoint and leading to highly specific effects. With regard to the effects of acupuncture on muscles, local stimulation of the target muscles has underlying mechanisms that differ from those for remote site stimulation. Segmental acupuncture, the technique aimed at stimulating an area supplied by the same spinal segmental nerve as the target muscles, can serve as an example. In remote site stimulation, the somato-autonomic nerve reflex, which involves the efferent pathway of the cholinergic sympathetic vasodilator nerve, may increase muscle blood flow[2,3]. In contrast, local muscle stimulation releases vasodilator substances such as calcitonin gene-related peptide (CGRP) via the axonal reflex through an unmyelinated C fiber as an afferent pathway, resulting in increased

Corresponding author: Okuma Yoshihiro, TOYOTA VERBLIZ, Rugby team, 57-230 Inomukai Homi-cho, Toyota-city, Aichi, 470-0344, Japan

muscle blood flow[4,5]. Studies have shown that stimulation of muscles by acupuncture may result in the suppression of delayed-onset muscle soreness and elevation of muscle force, which may be induced by an increase in muscle blood flow. However, these studies used a relatively strong stimulus, wherein the traditional needle—called "Go-shin"—was inserted into the muscle through the skin, and electric stimulation was additionally performed via the inserted needles in some cases. However, the stimulation with the "Go-shin" needle may result in a feeling of discomfort. Accordingly, the press tack needle acupuncture, which utilizes light stimulation and does not inflict pain, has recently become popular. Press tack needle acupuncture facilitates the convenient insertion of a needle into the skin and its stabilization, and continuous acupuncture stimulation can be applied with adhesive bandage. The length of this needle is very small, ranging from 0.3 to 1.5 mm; therefore, patients can perform exercise following needle placement without any injury. Press tack needle acupuncture also enables the quantification of the amount of acupuncture stimulation applied to the body, which is useful in research. Although several studies have shown that press tack needle acupuncture suppresses delayed onset muscle soreness and facilitates recovery from muscle fatigue, further research on this topic is needed.

Muscle fatigue during exercise is defined as a reduction in instantaneous muscle force generation, including a decrease in peak muscle force, a reduction in the maximum velocity of muscle contraction[6], or a reduction in the maximal capacity to generate power output[7]. In previous studies, peak muscle force and rate of force development (RFD) were used as indices for evaluating instantaneous muscle force. RFD represents the rate of increase of muscle force and is calculated as the ratio of the difference in muscle force achieved within a given time interval to the duration of this time interval: Δ(muscle force)/Δ(time). Thus, the greater is the muscle force and the shorter is the time interval required for its generation, the larger is RFD. Studies have shown that RFD is closely related to jumping performance, such as in a vertical jump test, as well as to peak muscle force; thus, it can serve as an index of instantaneous muscle performance across various sports activities[8]. Force-time integral (FTI) was used as indices for power output under conditions of muscle fatigue[9]. Muscle activity, as measured on an electromyogram (EMG), is another index of muscle fatigue during exercise. Previous studies have shown that muscle fatigue during recurrent exercise under maximum muscle force reduces the integrated EMG value as well as the mean power frequency (MPF)[9].

In the present study, by using the above-mentioned indices, we aimed to investigate the effects of stimulation by press tack needle acupuncture on the decrease in instantaneous muscle force generation due to muscle fatigue.

Ⅱ. Materials and Methods

1. Study design

To assess instantaneous muscle force generation, we used isometric maximum voluntary contraction (IMVC) of the knee extensor muscle measured with an isometric dynamometer, RFD, FTI and muscle activity (integrated EMG and MPF); these indices were assessed before and after exhaustive exercise. To exclude learning effects, this study compared an acupuncture group with a control group. We randomly assigned our study participants to the acupuncture group and the control group; thus, our study was a randomized controlled trial. Moreover, we assessed the immediately response to a single acupuncture session using press tack needles.

2. Subjects

We estimated the appropriate sample size by performing a preliminary experiment. The outcome was muscle

Table 1 Demographic characteristics of the participants

	Acupuncture Group (n = 16)	Control Group (n = 16)
Age (years)	24.00 ± 1.97	24.88 ± 2.90
Height (cm)	174.13 ± 7.03	173.50 ± 4.71
Weight (kg)	70.31 ± 10.06	69.69 ± 9.08
Isometric maximum muscle force (N•m)	227.32 ± 45.86	216.11 ± 58.36
Isometric maximum muscle force normalized to body mass (N•m/kg)	3.24 ± 0.53	3.10 ± 0.61
RFD (N•m/ms)	10.27 ± 3.39	9.13 ± 3.01

Data are presented as means ± standard deviations
RFD rate of force development

peak force, Subjects were 20 healthy young adult men (acupuncture group: 10, control group:10), and the outcome was muscle peak force. The mean value was 214 N·m in the acupuncture group and 174 N•m in the control group, and the standard deviation for both groups was 39 N·m. The associated α error was 0.05, and the β error was 0.20. This yielded the sample size of 16 per group. In total, 32 healthy young adult men (mean age, 24.32 ± 2.47 years) who were recreational athletes and had no injuries. They enrolled voluntarily in the present study. The participants were randomly assigned to the acupuncture group (n = 16) or the control group (n = 16) by using stratified randomization. Demographic data for the participants are provided in Table 1. Prior to participation in the present study, all the participants read and signed a detailed consent form. The study protocol was approved by the ethics committee of Tsukuba University (No. 25-62).

3. Procedure

Fig. 1a shows the flowchart of the experimental protocol. At first, warming-up was performed, wherein subjects were asked to perform bicycle ergometer exercise with a 50-W exercise load for 10 min at 60 rpm and IMVC of the knee extensor muscles involved the quadriceps in a manner similar to the protocol for the instantaneous muscle force generation measurement was performed 3 times, similar to the protocol for instantaneous muscle force generation measurement (Fig. 1b). After the warming-up phase, the first instantaneous muscle force generation value (measurement before exhaustive exercise) was obtained. After the first measurement, press tack needles were placed for 5 min at rest in the acupuncture stimulation group, whereas the participants were asked to remain in a seated position at rest for 5 min, without any needle placement, in the control group. After press tack needle placement or resting in a seated position, the participants in both groups then performed exhaustive exercise, after 2 min the instantaneous muscle force generation value was measured once again (measurement after exhaustive exercise).

4. Procedure for stimulation with acupuncture or resting

In previous studies on the effect of acupuncture on muscle force, the acupuncture needles stimulated the region around the agonist muscle (such as vastus lateralis muscle, rectus femoris muscle, vastus medialis muscle, vastus intermedius muscle) involved in the exercise on the anterior aspect of the thigh. The locations of acupuncture points have been standardized by World Health Organization (WHO). Following these standards, we placed a 0.6-mm press tack needle (Pyonex, Seirin, Shizuoka, Japan) at the SP10 (*Xuehai*) (on the anteromedial aspect of the thigh, on the bulge of the vastus medialis muscle), SP11 (*Jimen*) (on the medial aspect of the thigh, on the sartorius muscle), ST32 (*Futu*) (on the anterolateral aspect of the thigh, on the rectus femoris muscle), and ST34 (*Laingqiu*) (on the anterolateral aspect of the thigh, on the rectus femoris muscle) sites on the skin surface around the right anterior aspect of the quadriceps (Fig. 2), which was used as the agonist muscle. The needles were retained in these sites for 5 min, and the outcome measurements were then performed. After completion of the outcome measurements, the needles were removed.

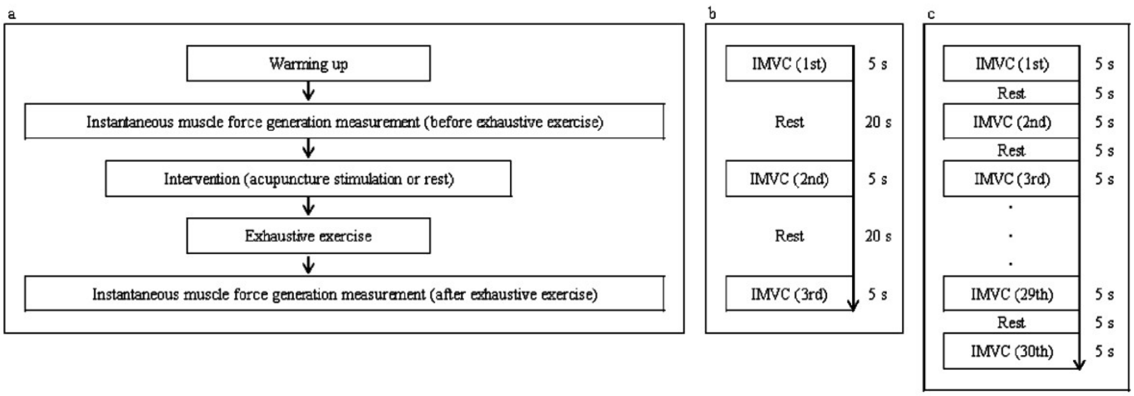

Fig. 1 Experimental protocol and exhaustive exercise procedure. (a) Experimental protocol. During the warming up, subjects were asked to performed bicycle ergometer exercise with a 50-W exercise load for 10 min at 60 rpm, and isometric maximal voluntary contraction (IMVC) was performed 3 times, similar to the protocol for instantaneous muscle force generation measurement. (b) Instantaneous muscle force generation measurement protocol. The participant performed IMVC as soon as the beep sound was heard, and was asked to maintain the contraction throughout the sound-on period (5 s). This was followed by a 20-s rest period. (c) Exhaustive exercise procedure. The participants performed IMVC for a 5-s period, which was followed by rest for a 5-s period. This procedure was repeated 30 times.

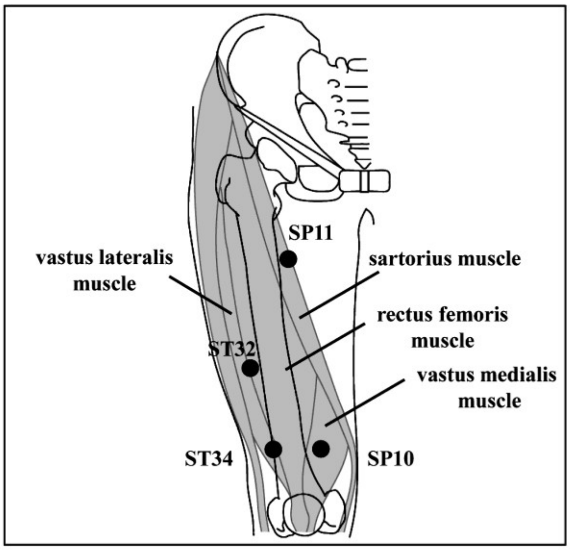

Fig. 2 Locations of acupuncture points where the press tack needles were attached. The 0.6-mm press tack needles were placed at the SP10 (Xuehai) (on the anteromedial aspect of the thigh, on the bulge of the vastus medialis muscls), SP11 (Jimen) (on the medial aspect of the thigh, on the sartorius muscle), ST32 (Futu) (on the anterolateral aspect of the thigh, on the rectus femoris muscle), ST34 (Laingqiu) (on the anterolateral aspect of the thigh, on the rectus femoris muscle) sites on the right anterior skin surface of around the quadriceps muscle.

5. Procedure for exhaustive exercise

The exhaustive exercise that induced muscle fatigue involved 30 series of IMVC, as described in previous studies[10]. Accordingly, the participants performed IMVC for a 5-s period, followed by resting for a 5-s period; this was repeated 30 times (Fig. 1c).

6. Instantaneous muscle force generation measurement

To assess instantaneous muscle force generation, we recorded the isometric maximum voluntary knee extensor muscle force, RFD, FTI and surface EMG (integrated EMG and MPF) values. These indices were measured before and after the exhaustive exercise.

For the measurement of instantaneous muscle force generation, the participant was asked to sit on a high chair, with his back supported, hips flexed at 90°, and knees flexed at 80°, according to the protocols established in previous studies[10]. Straps were placed around the waist, chest, and right ankle of the participant to stabilize the body, and real-time wave of muscle force was examined to prevent counter movement and slams into the dynamometer arm.

A specially designed beep sound generator was placed at a distance of approximately 1.0 m in front of the participant. As per the protocols of previous studies[10], the participant performed IMVC as soon as the sound signal was heard and was asked to maintain the contraction throughout the sound-on period (5 s), followed by a 20-s rest period. The procedure was repeated 3 times per session. Three sessions were conducted before and after exhaustive exercise. During these measurements, the peak muscle force, RFD, FTI and surface EMG (integrated EMG and MPF) were obtained and mean values of 3 repeats were determined in each session.

(1) Peak muscle force measurement

Muscle force signal was recorded at 1000 Hz using a Biodex Dynamometer (Biodex Medical Inc., Shirley, NY). The peak muscle force was measured during the 5-s period of IMVC

(2) Rate of force development (RFD) measurement

The RFD value was measured as the change in the amount of muscle force within a specific length of time: Δ(muscle force)/Δ(time)[8]. In the present study, the muscle force was determined when its value reached 7.5 N•m, based on previous studies[11]. The RFD values were calculated every 20 ms after muscle force onset which was reported reliable method during isometric lower limb extensor assessment[12], and the maximum RFD value was recorded.

(3) Force-time integral (FTI) measurement

Force-time integral was calculated using a Biodex Dynamometer during the 5-s period IMVC (sampling at 1000Hz)[9].

(4) Integrated EMG and Mean Power Frequency (MPF) measurement

EMG signal was recorded at the rectus femoris[13] at 1000 Hz and amplified (1000-fold) using the TRIAS System with a bandpass filter (5–480 Hz). The electrode was placed on the anterior aspect of the thigh in the midpoint between the anterior superior iliac spine and the upper edge of the patella[13]. To evaluate muscle activation for every measurement, integrated EMG and MPF values were calculated during the 5-s period of IMVC using TRIAS System. The MPF was then calculated using fast Fourier transform (FFT) spectrum analysis with the integration window of 5-s (5000 samples, Hamming window).

7. Statistical Analyses

We assessed the rate of variations in the peak muscle force, RFD, FTI and surface EMG (integrated EMG and MPF) from the first measurement. Thereafter, we analyzed the effects of stimulation with press tack needle acupuncture by using the variation rates from the first measurement (i.e., differences in the values from those recorded before exhaustive exercise) and by using a two-way analysis of variance, according to intervention (press tack needle or resting) and time (before exhaustive exercise, after exhaustive exercise). If the analysis of variance showed significant effects, a Bonferroni post-hoc test was performed. Furthermore, we used the t-test for comparisons between groups after exhaustive exercise. The level of significance was set at 5% for all analyses. All statistical analyses were performed using SPSS (version 22.0J for Windows).

Ⅲ. Results

1. Baseline values (difference between both groups in measurement before exhaustive exercise)

No significant difference in any of the values was noted between the groups in measurement before exhaustive exercise (Table. 2).

2. Peak muscle force

Significant main effects of time (F (1.00, 30.00) = 27.74, P = 0.01 < 0.05) and intervention (F (1.00, 30.00) = 5.08, P = 0.03 < 0.05) were noted, and the main effect of intervention × time interaction was also found to be

Table. 2 Results of each measurement and two-way analysis of variance

	before exhaustive exercise		after exhaustive exercise		main effect of time		main effect of intervention		intervention × time interaction	
	Acupuncture Group	Control Group	Acupuncture Group	Control Group	F value	P value	F value	P value	F value	P value
Muscle peak force (N·m)	227.32 ±45.36 (0.00 ±0.00%)	216.01 ±58.36 (0.00 ±0.00%)	214.16 ±51.57 (-5.66 ±13.44%)	184.21 ±45.49 (-14.13 ±6.73%)	27.74*	0.01	5.08*	0.03*	5.08*	0.03*
RFD (N·m / msec)	10.27 ±3.39 (0.00 ±0.00%)	9.13 ±3.01 (0.00 ±0.00%)	9.07 ±3.30 (-7.18 ±27.28%)	6.94 ±2.37 (-23.61 ±9.10%)	18.34*	0.01	5.22*	0.03*	5.22*	0.03*
FTI (N·m×sec)	978.57 ±201.81 (0.00 ±0.00%)	906.12 ±267.49 (0.00 ±0.00%)	921.01 ±225.17 (-5.74 ±12.35%)	781.39 ±234.17 (-13.51 ±8.28%)	26.82*	0.01	4.38*	0.04*	4.38*	0.04*
Integrated EMG (%MVC)	82.11 ±7.03 (0.00 ±0.00%)	84.30 ±9.50 (0.00 ±0.00%)	86.79 ±8.11 (6.31 ±12.68%)	80.69 ±9.67 (-3.80 ±10.73%)	0.36	0.55	5.93*	0.02*	5.93*	0.02*
MPF (Hz)	84.67 ±8.02 (0.00 ±0.00%)	86.42 ±7.31 (0.00 ±0.00%)	82.59 ±9.29 (-2.41 ±7.01%)	85.28 ±9.94 (-1.45 ±6.29%)	2.68	0.11	0.17	0.69	0.17	0.69

The actual value and the rate of variation from the before exhaustive exercise (means ± standard deviations)

* $P < 0.05$, *RFD* rate of force development, *FTI* force-time integral, *EMG* electromyogram, *MPF* mean power frequency

significant (F (1.00, 30.00) = 5.08, P = 0.03 < 0.05) (Table 2). Result of post-hoc test, the peak muscle force after exhaustive exercise decreased significantly compared to that before exhaustive exercise in both groups. Moreover, the peak muscle force after exhaustive exercise in the acupuncture group was significantly greater than that in the control group (Fig. 3).

3. Rate of force development (RFD)

Significant main effects of time (F (1.00, 30.00) = 18.34, P = 0.01 < 0.05) and intervention (F (1.00, 30.00) = 5.22, P = 0.03 < 0.05) were noted, and the main effect of intervention × time interaction was also found to be significant (F (1.00, 30.00) = 5.22, P = 0.03 < 0.05) (Table 2). Result of post-hoc test, the RFD after exhaustive exercise decreased significantly compared to that before exhaustive exercise in both groups. Moreover, the RFD after exhaustive exercise in the acupuncture group was significantly greater than that in the control group (Fig. 4).

4. Force-time integral (FTI)

Significant main effects of time (F (1.00, 30.00) =

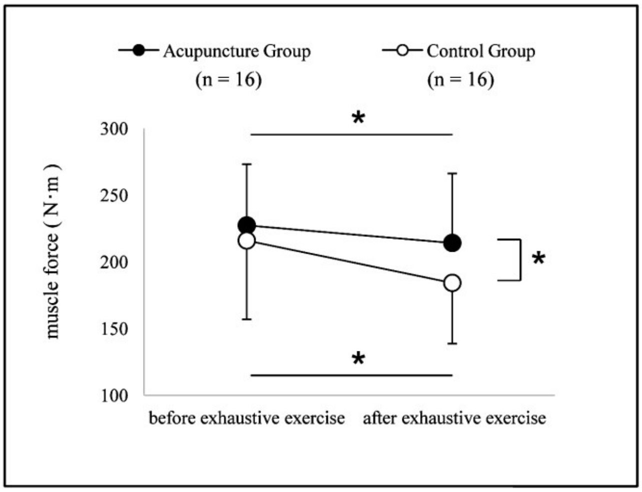

Fig. 3 The variation in the peak muscle force. Significant main effects of time and intervention were noted, and the main effect of intervention × time interaction was also found to be significant. The peak muscle force after exhaustive exercise in the acupuncture group was significantly greater than that in the control group.

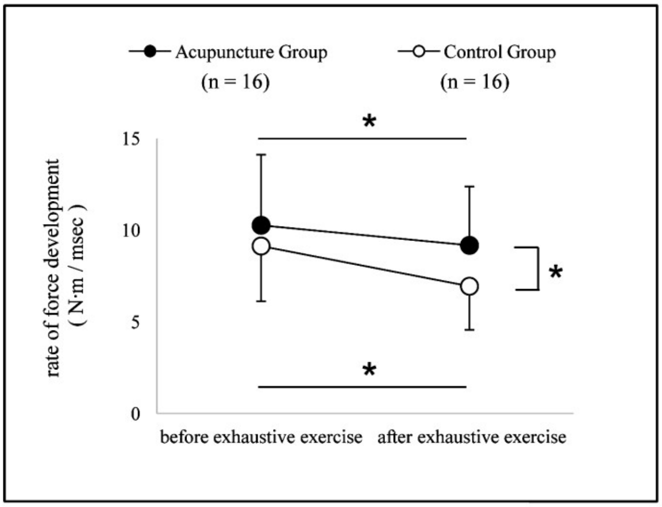

Fig. 4 The variation in the rate of force development (RFD). Significant main effects of time and intervention were noted, and the main effect of intervention × time interaction was also found to be significant. The RFD after exhaustive exercise in the acupuncture group was significantly greater than that in the control group.

26.82, P = 0.01 < 0.05) and intervention (F (1.00, 30.00) = 4.38, P = 0.04 < 0.05) were noted, and the main effect of intervention × time interaction was also found to be significant (F (1.00, 30.00) = 4.38, P = 0.04 < 0.05) (Table 2). Result of post-hoc test, the FTI after exhaustive exercise decreased significantly compared to that before exhaustive exercise in both groups. Moreover, the FTI after exhaustive exercise in the acupuncture group was significantly greater than that in the control group (Fig. 5).

5. Integrated EMG

The main effects of time (F (1.00, 30.00) = 0.36, P = 0.55 n.s.) were not significant, although the main effects of intervention (F (1.00, 30.00) = 5.93, P = 0.02 < 0.05) and intervention × time interaction were found to be significant (F (1.00, 30.00) = 5.93, P = 0.02 < 0.05). Moreover, the integrated EMG after exhaustive exercise in the acupuncture group was significantly greater than that in the control group (Fig. 6).

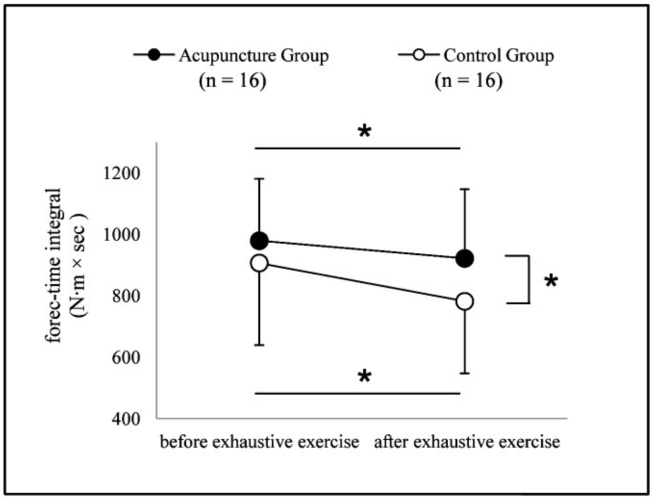

Fig. 5 The variation in the force-time integral (FTI). Significant main effects of time and intervention were noted, and the main effect of intervention × time interaction was also found to be significant. The FTI after exhaustive exercise in the acupuncture group was significantly greater than that in the control group.

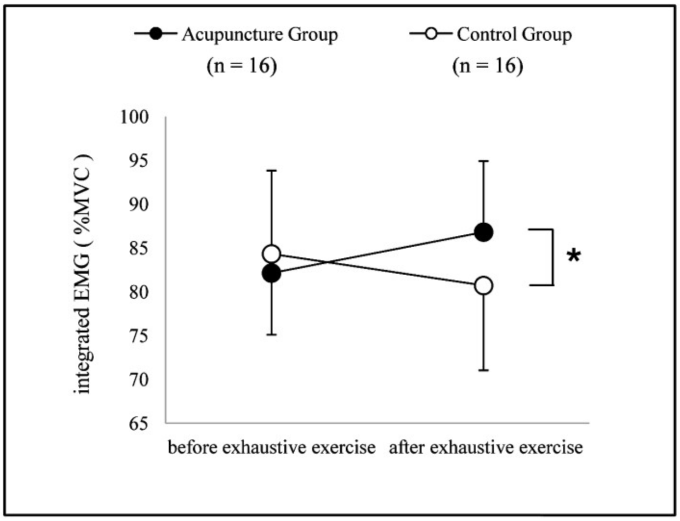

Fig. 6 The variation in the integrated EMG. The main effects of time (F (1.00, 30.00) = 0.36, P = 0.55 n.s.) were not significant, although the main effects of intervention (F (1.00, 30.00) = 5.93, P = 0.02 < 0.05) and intervention × time interaction were found to be significant (F (1.00, 30.00) = 5.93, P = 0.02 < 0.05). Moreover, the integrated EMG after exhaustive exercise in the acupuncture group was significantly greater than that in the control group.

6. Mean Power Frequency (MPF) measurement

The main effects of time (F (1.00, 30.00) = 2.68, p = 0.11 n.s.), intervention (F (1.00, 30.00) = 0.17, p = 0.69 n.s.) and intervention × time interaction were not significant (F (1.00, 30.00) = 0.17, p = 0.69 n.s.) (Table. 2).

Ⅳ. Discussion

In the present study, we evaluated the peak muscle force, RFD, FTI, integrated EMG and MPF values to assess the effects of stimulation by press tack needle acupuncture on the reduction in instantaneous muscle force[6)] or the reduction in the maximal capacity to generate power output[7)] caused by muscle fatigue. The main effect of intervention was found to significantly affect the peak muscle, RFD, FTI and integrated EMG. Moreover, the intervention × time interaction was found to significantly affect the peak muscle force, RFD, FTI and integrated EMG, and the values after exhaustive exercise in the acupuncture group were significantly greater than those in the control group. These results indicated that stimulation by press tack needle acupuncture may prevent exercise-induced reduction in these indices.

The peak muscle force and RFD are known to be influenced by loaded exercise units as well as the firing of motor units[14-16)]. Although it has been reported that both recruitment of motor units and firing frequency contribute to the EMG signal, in the present study the integrated EMG values after exhaustive exercise were significantly lower in the control group than in the acupuncture group, indicating that the prevention of the decrease in peak muscle force and RFD by press tack needle acupuncture was due to the prevention of muscle fatigue-induced motor unit reduction. Therefore, press tack needle acupuncture can prevent a reduction in the motor-unit discharge rate due to muscle fatigue. However, there was no significant effect of on the MPF values, and EMG was recorded in one muscle only. Because the press tack needle acupuncture were placed at vastus medialis muscle and vastus lateralis muscle where placed electrode[13)]. Thus, Further studies may be necessary to obtain more precise information.

Another potential mechanism underlying the effects of acupuncture on muscles involves an increase in the local muscle blood flow. In the present study, we applied the press tack needle acupuncture stimulation at the quadriceps muscle, which was used as the agonist muscle. As stated earlier, the local effects of acupuncture involve the elevation of muscle blood flow through vasodilators such as CGRP, which are released via the axonal reflex through an unmyelinated C fiber as an afferent pathway[4,5)]. Previous studies on this mechanism used “Go-shin” needles, which need to be inserted into the muscle. The effects of acupuncture using the longer “Go-shin” needles may differ from those using the shorter 0.6-mm press tack needles. Only a few studies have investigated the mechanisms underlying the effects of press tack needle acupuncture, wherein the needle remains within the cutaneous tissue. Goto et al.[17)] measured C-fiber nociceptor excitation/discharge activities by microneurography, wherein the “Go-shin” needle tip was inserted only into the cutaneous tissue, and increase of muscle blood flow was also found under an identical condition[18)]. Moreover, a recent study has reported C-fiber nociceptor excitation/discharge activities in cases where press tack needles were placed within the cutaneous tissue[19)]. Furthermore, Hotta et al.[20)] described C-fiber nociceptor excitation with cutaneous stimulation using regularly arranged microcones with a pitch of 0.4 mm. The tip diameter of an individual microcone was 0.037 mm, and each measured 0.3 mm in height. Fine cutaneous stimulation can improve local blood flow via the axonal reflex through C-fiber nociceptor excitation, in a manner similar to that involved in stimulation by the “Go-shin” needle placed into the muscle tissue. The results of the present study may suggest the same mechanism. On the other hand, it has been reported that muscle fatigue caused by high-intensity intermittent exercise similar to the exhaustive exercise in the present study resulted from decreases in the levels of muscle ATP, CP, and glycogen[21)] along with a decrease of pH value caused by accumulation of H^{+}[22,23)]. Sugaya et al.[24)] suggested that the decrease in muscle force induced by high-intensity intermittent exercise was related to regional intramuscular blood circulation and resulted from accumulation of H^{+}, lactate, and ATP degradation products caused by cardiovascular failure during the exercise. The cardiovascular failure was associated with the interruption of muscle blood flow in lower limb that occurred when approximately 70% of the IMVC exercise was completed[25)]. It is likely that our exhaustive exercise constituting 30 repeats of IMVC caused such cardiovascular failure and a pH decrease with a concomitant accumulation of H+, lactate, and ATP degradation products. Moreover, Nelson et al.[23)] reported that low cellular pH led to depressed peak force in all muscle fiber types, with the greatest effect observed in type IIx fibers. Based on these considerations, one of the factors contributing to the effect of press tack needle acupuncture on muscle peak force could be an increase in intramuscular blood circulation, although further studies are necessary to clarify the particular mechanisms.

Our study has certain limitations. First, the IMVC protocol used for exercise loading and instantaneous muscle force measurement differs from actual conditions during sport activities. Second, we did not examine the mechanisms underlying the effects of press tack needle acupuncture by measuring muscle blood flow. Finally, the subjects were not blinded to the intervention type, and the influence of sham acupuncture stimulation was not investigated. Thus, a possible placebo effect cannot be excluded. Future studies are expected to address these concerns.

Ⅴ. Conclusions

The present study results suggest that press tack needle acupuncture can prevent exercise-induced reduction in peak muscle force, RFD, FTI and integrated EMG. Press tack needles may thus help to prevent the decrease in instantaneous muscle force generation or the decrease in the maximal capacity to generate power output caused by muscle fatigue and enhance athletes' performance or facilitate more efficient training in patients who need to improve muscle function after injury. Further studies involving various exercise load protocols and utilizing sham acupuncture as a control are needed, and an assessment of the effects of press tack needle acupuncture on changes in muscle blood flow during exercise would be helpful.

Acknowledgment
The authors thank Prof. Yoshito Mukaino (Fukuoka University) for his assistance in this study.

Conflict of interest
There is no conflict of interest.

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