The Effects of Dry Needling As a Novel Recovery Strategy on Quadriceps Muscle Fatigue: A Pilot Study

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Abstract

Background: Dry Needling (DN) is a procedure to treat neuromusculoskeletal disorders. This study aimed to examine the effects of DN on quadriceps muscle fatigue in healthy young adults.

Methods: Fifteen healthy young subjects (13 male, 2 female; mean±standard deviation 26.1±5.9 years) participated in a pretest-posttest study. Subjects received one session of DN for a total of 3 minutes with one minute each for the vastus medialis, vastus lateralis, and rectus femoris muscles. The Isometric Peak Torque (IPT), Single Leg Hop (SLH) test, and Y Balance Test (YBT) were measured at baseline, immediately after completion of the fatigue protocol, and after DN.

Results: Repeated measures ANOVA demonstrated significant improvements in the IPT, SLH, and YBT scores after DN. Effects sizes were medium for IPT (d =0.61) and SLH test (d=0.57), and large for YBT (d=0.7).

Conclusion: Dry needling had a significant effect on recovery of quadriceps muscle fatigue, functional performance, and dynamic balance. These findings suggest that DN can be utilized as a novel recovery strategy to manage muscle fatigue. Further research is warranted.

Keyword: Dry needling, Exercise, Muscle fatigue, Sports

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Introduction

Muscle fatigue is a common symptom experienced by people and especially athletes at some time during physical exertion. Muscle fatigue is defined as an exercise-induced decrease in maximal voluntary muscle force or power generation following an intensive or prolonged training sessions (1). It is an important, complex phenomenon that can impair function and task performance (2). Muscle fatigue is divided into central and peripheral/muscular fatigue (3). Central fatigue originates from a reduced neural motor drive to the muscles, while peripheral fatigue relates to the impairment in the mechanism of muscle contraction resulting in decrease in muscle force that limits performing physical activities.

Athletic injuries mostly occur in the lower extremities and negatively impact performance and competitiveness. Lower extremity muscle fatigue and, in particular, fatigue of the knee extensors, can have destabilizing effects on postural control and balance (4). Multiple impairments may develop due to muscle fatigue, especially during tournaments when players compete multiple times within a relatively short time period (5). Therefore, recovery from muscle fatigue is important to prevent injuries, to maximize performance, and to accelerate a return to training and competing.

Physiotherapists use a variety of modalities to facilitate recovery from muscular fatigue and maximize the performance of athletes, including massage therapy, contrast water therapy, neuromuscular electrostimulation therapy, whole body vibration, Dry Needling (DN), and active recovery, among others. There is, however, a lack of evidence supporting their effectiveness for improving muscle fatigue (6).

Dry needling is an increasingly popular intervention to treat various neuromusculoskeletal conditions that involves inserting a solid acupuncture-like needle into muscles and fascia (7). Dry needling has been applied most commonly to treat trigger points and their associated symptoms (8). It can be used as a single modality or as an adjunct in combination with other physiotherapy modalities to reduce pain (9), decrease spasticity (10-12), and increase muscle force (13) or flexibility (14).

It appears that there are no studies to assess the effects of DN on muscle recovery after a fatiguing activity. Therefore, the aim of the present study was to determine the effects of a single DN session on muscle recovery after quadriceps muscle fatigue.

Material and Methods

This interventional, pretest-posttest study was approved by the review board, School of Rehabilitation, and the Ethical Committee of Tehran University of Medical Sciences (IR.TUMS.VCR.REC.1397.982).

Healthy young adults recruited from Tehran University of Medical Sciences, between 20-40 years of age, who agreed to participate, were included in the study. The exclusion criteria were: 1) injuries, fractures, pain in lower extremity, or a history of surgery; 2) vestibular/neuromuscular, or cardiovascular diseases; 3) performing intense physical exercises 48 hours before the present study; 4) history of receiving DN in the previous 3 months; 5) contraindications for DN; 6) inability to perform the tests or fatigue protocol; and 7) lack of consent.

Outcome Measures

The outcome measures were Isometric Peak Torque (IPT), Single Leg Hop (SLH) test, and Y Balance Test (YBT).

Procedure

An experienced physiotherapist assessed the patients at baseline and after intervention. The outcome tests and measurements were administered randomly. After recording demographic information and the baseline measurements (T0), the fatigue protocol was performed. Measurements were performed again immediately after completion of the fatigue protocol (T1). Next, DN was performed randomly for 1 minute each on the right Vastus Lateralis (VL), Vastus Medialis (VM), and Rectus Femoris (RF) using a fast in and fast out technique (15). Immediately after DN, all measurements were performed again (T2).

Measurements

Isometric Peak Torque

An Isometric Dynamometer Biodex Multi-Joint Systems (USA) was used to measure the IPT of the quadriceps muscle. The subjects were tested in a seated position with their thighs firmly strapped to the seat of the dynamometer. Tow straps were crossed over the chest to stabilize the trunk. The axis of rotation of the dynamometer lever arm was aligned with the lateral femoral condyle, and the lower leg was attached to the lever arm of the dynamometer at the level of the lateral malleolus. Before the test, subjects warmed up using four isometric contractions. Next, they were asked to perform a maximum voluntary isometric contraction (MVIC) of the quadriceps muscle to extend the knee. The MVIC was measured at 60° knee flexion. Three trials with a 3-second isometric contraction and a rest period of 9 seconds between trials were performed. The best score was recorded in *N/m*.

Single Leg Hop Test

The SLHT for distance was used to assess the functional performance of the lower extremity. To perform the SLHT, subjects were instructed to stand on the right leg, to jump as far forward as possible and land on the same leg without losing their balance or stepping onto the other leg. The test was repeated 3 times with a 9-second rest between jumps. The longest distance in cm was recorded as the test score. The SLHT has good reliability in normal young adults (15).

Y Balance Test

The YBT is a reliable tool to measure the dynamic balance in healthy people (16,17). Subjects were asked to stand on one leg while reaching with the other leg as far as possible in 3 different directions: 1) anterior; 2) posterior-medial; and 3) posterior-lateral. Measurements were taken three times and the best scores for each direction were added in cm and averaged to record the YBT score (6).

Fatigue Protocol

The Wingate Test (WT) was used to induce quadriceps muscle fatigue. A stationary cycle (Monark 884 E Peak Bike, Sweden) was used to perform the WT. Prior to the WT, a one-minute warm up exercise with no resistance was performed, after which the actual test was administered with the fly wheel resistance set at 0.075 *kg per kg* of body weight (18). The subjects were verbally encouraged to pedal as fast as possible for one minute. Upon completion of the test, the subjects performed an active cool down for one minute.

Dry Needling

An expert physical therapist qualified in DN performed the needling procedure of the right quadriceps femoris. While the subject was in supine with the leg in an extended neutral position, points on the VM, VL, and the RF muscles were randomly needled using stainless steel needles with a diameter of 0.3 *mm* and a length of 50 *mm* (DongBang Acupuncture Inc., Boryeoung, Korea) each for one minute using a fast in and fast out technique. The VM point was located at about 25% of the distance of a line from the medial superior border of the patella to the Anterior Superior Iliac Spine (ASIS); the VL point was located at the mid-thigh along a line from the lateral superior border of the patella to the apex of greater trochanter; the RF point was located at the mid-thigh along a line from the superior border of patella to the ASIS (19) (Figure 1).

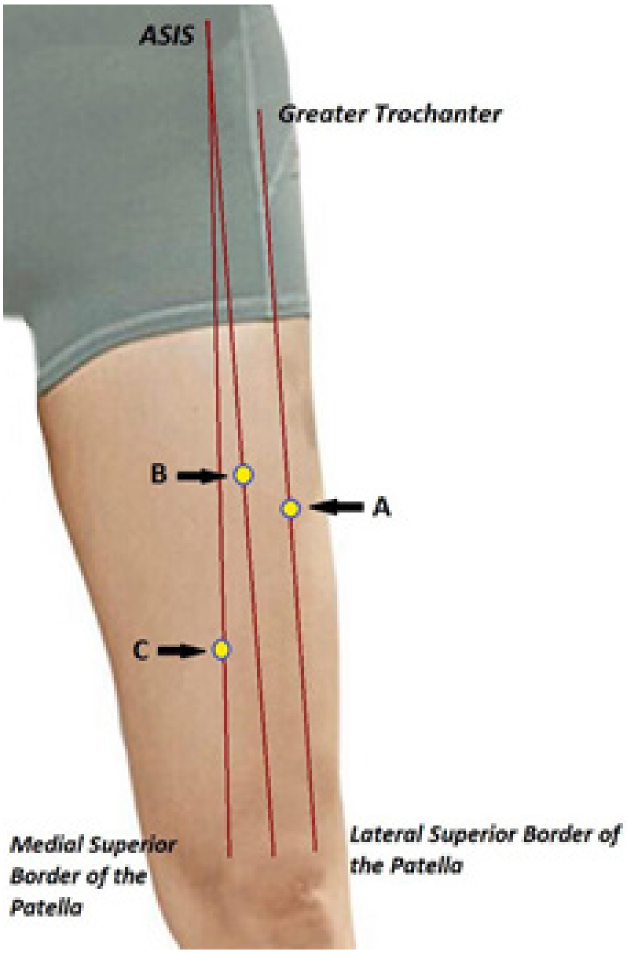

Figure 1. Locations dry needled for quadriceps recovery after fatiguing activity. A: vastus lateralis; B: rectus femoris; C: vastus medialis. ASIS, anterior superior iliac spine.

Statistical Analysis

Statistical analyses were performed using the SPSS 25.0 software (IBM, Inc., Armonk, NY, USA). Descriptive statistics were calculated for all variables. The Kolmogorov-Smirnov test was performed to evaluate the normality of outcome variables. A general linear model, one-way repeated measures (ANOVA) was used to examine the effects of the DN. If the homogeneity of variances was not met using Mauchly's test of sphericity, the Greenhouse-Geisser estimate was used. Post hoc test with Bonferroni adjustment was used to compare the time points within group. Cohen's *d* was calculated to determine the effect sizes of DN. Interpreting the Cohen's *d* values were as follows: negligible (<0.20); small (<0.50); moderate (<0.80); and large (≥0.80).

Results

Fifteen young healthy subjects (13 male, 2 female) with a mean age of 26.13 ± 5.93 years were included in the study. Subjects reported no side effects from the DN. The demographic data are shown in table 1.

Isometric Peak Torque

The mean IPT decreased after the fatiguing activity (p=0.008), improved after DN at T2 (~26%, p<0.001) and reached the previous level before the fatiguing activity (Table 2). Cohen's *d* of effect size was 0.61.

Single Leg Hop Test

The mean score on the SLHT decreased after the fatiguing activity (p=0.02), improved after DN at T2 (~19%, p<0.001) and reached the previous level before the fatiguing activity (Table 2). Cohen's *d* of effect size was 0.57.

Y Balance Test

The mean score on the YBT decreased after the fatiguing activity (p=0.04), improved after DN at T2 compared to T1 (p<0.001) and reached the level of T0 (p=0.004) (Table 2). Cohen's *d* of effect size was 0. 7.

Discussion

Many people, including athletes, commonly experience muscular fatigue which, if not resolved, can restrict their performance and activities potentially leading to various health disorders. Quadriceps muscle fatigue can affect postural control, balance, gait, muscle contractile capacity, and proprioception. This study revealed that in young adults, a single 3-minute session of DN following a quadriceps fatiguing activity improved quadriceps muscle peak torque, single leg hop distance, and total Y balance test score reflecting recovery from fatigue. The results of this pilot study support the use of DN in people with muscle fatigue. As far as we know, this is the first study that evaluated the effects of DN on muscle recovery after muscle fatigue.

Table1. Demographics of study subjects

	Mean	SD*	Minimum	Maximum
Age (year)	26.1	5.9	20.0	40.0
Height (*cm*)	176.7	8.3	161.0	190.0
Weight (*Kg*)	77.7	14.5	55.0	102.0

*: Standard deviation

Table 2. Mean±SD* for outcome measures

	Before fatigue T0	After fatigue T_1	After dry needling T_2	Repeated measures ANOVA
Isometric peak torque, *Nm*	160.9±62.0	131.3±48.5	165.0±61.0	$F_{(2,28)}$ =14.0, p < 0.001
Single leg hop test, *cm*	91.3±25.1	79.7±26.9	94.5±24.8	$F_{(2,28)}$=11.02, p < 0.001
Y balance test, *cm*	89.8±9.1	86.9±11.4	94.7±10.8	$F_{(2,28)}$=25.45, p < 0.001)

* Standard deviation

Isometric Peak Torque

In the present study, IPT recovered after DN and reached the level of pre-fatiguing activity after only a 3-minute DN intervention. The reduction of muscle force after activities and the subsequent muscle fatigue indicates a failure of the contractile mechanisms. The observed drop in torque following the onset of fatigue recovered after DN possibly reflects improvements in the contractile mechanisms (3).

Sufficient blood flow plays an essential role in the maintenance of force output by providing oxygen and energy in the form of Adenosine Triphosphate (ATP) to working muscles. One factor in inducing muscle fatigue is a reduction in blood flow (20) or ischemia, which may lead to hypoxia. Dry needling has been shown to increase the local circulation and restore oxygenation, which in part may explain the recovery of IPT observed in the quadriceps muscles (9). In addition, the improved circulation and oxygenation following DN will modulate concentrations of multiple biochemical associated with fatigue-related hypoxia, which not only contribute to the increase in IPT after DN, but also result in a reduction in pain.

Considering that various peripheral and central neural structures have roles in muscle force output (3), some effects of DN may occur at neural levels, which also may have contributed to an improved IPT. Muscle afferents in groups III/IV have been shown to interact with cardiovascular and respiratory systems that consequently improve muscle blood flow and oxygenation and contribute to the management of muscle fatigue (21). It may be hypothesized that manipulation of the quadriceps muscle by DN could have improved the muscle blood flow and oxygenation through stimulating group III/IV afferents. Subsequently, interactions with cardiovascular and respiratory processes may have contributed to recovery of the quadriceps muscle fatigue. Furthermore, the needle was applied close to motor points of the quadriceps muscle and perhaps, manipulation of the needles stimulated motor nerves and contributed to an increase in quadriceps muscle activity and maximum force of the knee extensors (13,22).

Single Leg Hop Test

The SLHT is an objective functional test allowing quantitatively measuring the strength and power of the leg. It is a dynamic test that challenges the individual control on motor output and movement direction. In the present study, DN significantly and quantitatively recovered the SLHT distances to pre-fatigue levels. It is plausible that a post-DN improvement of IPT provided a mechanism to improve the strength and control of the leg particularly the quadriceps muscle as reflected in the restored SLHT distance. Strength deficits of leg muscles due to fatiguing activities contribute to poor performance and functional mobility thus increase the risk of injury/re-injury. The recovery of the SLHT distance after DN is important as it indicates a full recovery of muscle strength and dynamic leg stability, which allow the individual to return to sports or other activities.

Y Balance Test

Muscle fatigue decreases the ability to produce sufficient force to perform functional tasks and increases the risk of injury. In the current study, the YBT was used as it is a functional test that evaluates dynamic balance and risk of injury. It requires a subject to have sufficient strength, flexibility, stability, joint range of movement, balance, and proprioception (23). Failure to perform the YBT may indicate an impairment in the neuromuscular control system.

In this study, subjects who received DN showed a significant improvement in the YBT. The performance scores on the YBT after DN were significantly higher than the pre-fatigue scores at T0 and the scores measured immediately after the fatigue protocol at T1. Again, the recovery of the IPT after DN may have restored sufficient muscle strength of the quadriceps muscle to correctly perform the YBT. The significant improvement in the YBT scores after DN may be an indicator of a normal neuromuscular system recovered after a fatiguing activity.

The higher performance on the YBT observed after DN suggest that the DN intervention may have normalized the mechanical behavior of the muscle (14) by potentially affecting nearby muscle spindles. This may have increased their excitability and firing rate necessary for accurate proprioceptive signaling and efferent information (24). This neuromechanical coupling might have occurred alongside an increased excitatory drive from the motor cortex to the motor neurons and improved sensorimotor function resulting in a higher performance on the YBT. Future research should include appropriate dependent variables and objective measuring tools to confirm the hypothesized mechanisms.

Limitation

This pilot study included small sample of subjects. There was no control, sham, or placebo group. An important limitation was that the subjects and assessor were not blinded.

Conclusion

This pilot study utilized a single 3-minute DN session after triggering quadriceps muscle fatigue. Significant improvements in IPT and SLS and YBT scores were achieved. The results suggest that DN offers a potential novel recovery strategy for muscle fatigue. Future investigations with a control group and larger samples are needed to verify the findings and elucidate the potential mechanisms.

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Conflict of Interests

Dr. Jan Dommerholt is affiliated with Myopain Seminars, LLC, Bethesda, MD, USA, an organization that promotes the recognition and application of dry needling. Dr. Dommerholt receives royalties from published books.

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