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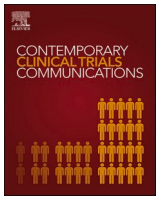

Effect of dry needling on quadriceps muscles fatigue in taekwondo players: A protocol for a triple-blinded randomized controlled trial

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ABSTRACT

Background: A common issue among athletes is muscle fatigue, a brief and transient reduction in the potential of skeletal muscle strength after engaging in muscular activity. A high-quality clinical investigation to evaluate the impact of dry needling (DN) on athletes' muscle fatigue is lacking. Therefore, this study aims to examine the effect of DN on quadriceps muscle fatigue in taekwondo players.

Methods: A triple-blind, randomized, controlled trial will be conducted to measure changes in quadriceps muscle fatigue after DN. Eighty-eight taekwondo players who meet the eligibility criteria will be selected to receive either DN or sham needling to the quadriceps muscle after exercise. Three assessments will be performed before the exercise, after exercise fatigue, and after intervention. The outcomes measured will be isometric peak torque, single-leg hop test, and vertical jump test.

Conclusions: The results of this study will provide preliminary evidence regarding the effectiveness of DN in improving quadriceps muscle fatigue in taekwondo players.

Trial registration: IRCT20210811052141N1.

1. Introduction

Muscle fatigue is a common phenomenon among the general population, especially athletes, and is characterized by a temporary and transient decrease in the potential of skeletal muscle strength following physical exertions that engage muscles [1,2]. Performing prolonged, repetitive, or isometric contraction activities results in muscle fatigue that impairs muscle function and reduces motor units' maximal voluntary muscle force or power generation [1,3]. In addition, oxidative stress caused by strenuous activity with short breaks and the resulting muscle contraction plays an important role in increasing fatigue, leading to skeletal muscle damage and inflammation [4,5]. When left unmanaged, the buildup of fatigue may progress to endocrine disorders, disrupt immune system functioning, and lead to chronic fatigue syndrome [6–8]. Also, skeletal muscle fatigue can adversely affect athletes' professional careers and achievements, especially during tournaments when they compete multiple times within a relatively short period, and recovery from muscle fatigue is critical [8,9]. Muscle fatigue is very common following high-intensity training of taekwondo athletes [10]. This martial art relies primarily on the athlete's leg movements with significant engagement of the quadriceps muscles [11]. Over time, this can adversely impact the performance of these muscles, leading to a destabilizing effect on posture control and balance [12].

There are still no universally accepted recommendations for the recovery of muscle fatigue. However, some nonspecific treatments have been used clinically or experimentally, such as massage therapy, contrast water therapy, consumption of synthetic or natural supplements (such as caffeine, ginseng, vitamins and minerals, and creatine), neuromuscular electrostimulation therapy, and whole body vibration. [8]. Dry needling (DN) is a recently introduced and widely used

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intervention in various neuromusculoskeletal conditions with a rapidly growing clinical and scientific interest [13,14]. DN involves inserting a fine, solid filiform acupuncture-like needle into muscles and fascia to treat trigger points and their associated symptoms [13]. However, its applications extend beyond the treatment of muscular conditions, as DN is also used for a variety of pathological conditions involving ligaments, tendons, scars, and peripheral nerves [15]. DN can be used as a solitary modality or in combination with other physiotherapy modalities to reduce a variety of neuromusculoskeletal pain and fatigue syndromes [13,16,17]. In only one pilot study published in 2019, Ershad et al. investigated the effect of DN on quadriceps muscle fatigue in healthy young adults, in which 15 subjects underwent a session of DN for the vastus lateralis, vastus medialis, and rectus femoris muscles. In this study, a significant improvement in Isometric Peak Torque (IPT), Single Leg Hop Test (SLHT), Y Balance Test (YBT), and Vertical Jump Test (VJT) was shown after the DN procedure. In general, it can be concluded from this study that DN has a significant effect on improving quadriceps muscle fatigue, executive function, and dynamic balance [18]. A previous study has shown that DN of gastrocnemius muscles can enhance performance in vertical jumps among young adults [19]. However, only one case series has evaluated the effects of DN on recovery in athletes. In this study, Brewster et al. found that lower extremities DN can be beneficial for recovery, as measured by the acute recovery stress scale, particularly in physical performance capability, overall stress, overall recovery, and muscle stress domains in hockey players [20].

In brief, there are limited studies that have assessed the effects of DN on muscle fatigue in athletes. Therefore, the aim of this study is to examine the effect of DN on the recovery of quadriceps muscle fatigue in taekwondo athletes.

2. Methods

2.1. Study design

This study will be a triple-blinded, parallel-group, randomized controlled trial (RCT). The study will be conducted at the Physiotherapy Clinic, School of Rehabilitation, Tehran University of Medical Sciences. The study protocol is approved by the Ethics Committee of the Tehran University of Medical Sciences (ethics code: IR.TUMS.NI.REC.1400.029) and is registered at the Iranian Registry of Clinical Trials (IRCT code: IRCT20210811052141N1). The current protocol is reported according to the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) guideline [21].

2.2. Participants & sample size

Taekwondo athletes aged between 18 and 40 years who consent to participate and sign an informed consent form will be included in the study. A taekwondo player is defined as an individual who has participated in a minimum of three taekwondo training sessions per week, each session lasting at least 90 min, over the past six months. Individuals will be excluded from the study if they have lower extremity injuries, fractures, pain, or a history of surgery; a history of cardiovascular or neuromuscular diseases, engagement in intense physical activity within 48 h before the intervention, a history of DN of the quadriceps muscles in the three months prior to the study, contraindications for DN, or an inability to perform the fatigue protocol.

Participants will be recruited via advertisements at taekwondo clubs in Tehran. Those who are interested will be screened for the eligibility criteria and will be enrolled in the study if they meet the criteria. Participation in the study will be voluntary and after explaining the goals and methods of project implementation, people can opt to participate in the research. Participants can withdraw from the research at any stage.

We used G*Power software version 3.1.9.7 to determine the sample size [22,23]. We used the difference between two means two-tailed statistical test for this purpose. Considering $\alpha = 0.05$, power $= 0.8$, effect size $= 0.61$ [18], and allocation ratio 1:1, the required sample size would be 44 in the control and 44 in the intervention group, and in total, 88 participants will be enrolled in the study.

2.3. Intervention

Participants in both the intervention and control groups will initially participate in a 90-min session of high-intensity taekwondo exercise designed to induce fatigue in the quadriceps muscle. After the training, a trained physiotherapist will perform the DN procedures. The participants will be blinded to the intervention.

While the subject is in the supine position with the leg in an extended neutral position, points on the vastus medialis, vastus lateralis, and rectus femoris muscles will be needled by using stainless steel needles with a diameter of 0.3 mm and a length of 50 mm (DongBang Acupuncture Inc., Boryeoung, Korea) each for 1 min. Needling will be performed according to the fast in and fast out technique [18]. The specific point on the vastus medialis muscle for needling is approximately 25 % of the linear distance from the medial upper margin of the patella to the Anterior Superior Iliac Spine (ASIS). The selected point on the vastus lateralis muscle is the midpoint of the line from the upper outer side of the patella to the apex of the greater trochanter. For the rectus femoris muscle, the midpoint of the line from the upper side of the patella to the ASIS will be needled. In the control group, the participants will receive a sham needle on the same points. A sham needle is a type of needle that is gently applied without penetrating the skin, offering no therapeutic effect and causing no pain to the patient. This approach was previously established in a study by Ershad et al. [18].

2.4. Outcomes

The participants will be assessed by a physiotherapist blinded to the intervention three times: before fatiguing training, after fatiguing training, and after receiving the intervention. Participants will first be assessed before the training session. They will then complete the training and be reassessed immediately afterward. Following this, they will receive DN and undergo a final assessment after the intervention. The primary outcome in the study is Isometric Peak Torque (IPT), and the secondary outcomes are the Single-Leg Hop (SLH) test and Vertical Jump Test (VJT). Furthermore, participants' age, gender, weight, height, and body mass index (BMI) will be assessed and recorded at baseline.

2.4.1. Isometric peak torque

A Biodex Multi-Joint Systems Isometric Dynamometer (USA) will be used to measure the IPT of the quadriceps muscle. The participant will be seated with their thighs strapped to the dynamometer seat. Two straps, placed in a cross-over fashion on the chest, will immobilize the trunk. The dynamometer lever arm's rotation axis will align with the lateral condyle of the femur, and the lower leg will be attached to the lever arm at the lateral malleolus level. Before the test, the subject will warm up with four isometric contractions at 50 % of their maximum voluntary contraction. Then, they will be instructed to extend their knee with maximum voluntary isometric contraction (MVIC), and the angle at which the MVIC is observed will be recorded. This test will be repeated three times, with each contraction lasting 3 s and a rest interval of 9 s before the next repetition. The highest recorded value will be reported in Newton-meters (N/m).

2.4.2. Single-leg hop test

The SLH test evaluates the functional performance of lower extremity muscles. Participants will be instructed to stand on their right leg, jump forward as far as they can, and land on the same leg without assistance from the other foot or losing balance. The test will be conducted three times, with a 9-s rest period between each jump. The

furthest distance from the start of the jump to the landing point on the heel is recorded in centimeters and considered the test result. Previous studies have established this test as reliable for healthy young adults [24].

2.4.3. Vertical jump test

The VJT, aimed at assessing leg muscle strength, is frequently used to evaluate post-exercise fatigue [25]. The participants will be asked to raise their right hand and press it against the wall across their body while ensuring their soles are fully in contact with the ground. The location of the fingertips will be marked and recorded as the standing reach height. The subject then will step away from the wall and will use their arms and legs to jump vertically as high as possible, touching the wall at the peak of the jump. The difference in distance between the initial standing reach point and the highest point reached during the jump will be recorded as the test result. After three attempts, the greatest distance achieved will be reported.

2.5. Randomization, allocation concealment, and blinding

Participants will be randomly allocated to either the DN or sham needle group, with the specific treatment unknown to them. The designated interventions will be written on papers (44 for the main DN treatment and 44 for the placebo sham needle treatment) and placed in opaque envelopes. We will utilize a block randomization method, with an equal number of participants in both the intervention and control groups within each block. Each participant will be randomly given one of these envelopes by the researcher, who is also unaware of the treatment type. The participant will then take the envelope to the therapist, who administers either the primary treatment or placebo based on the envelope's contents. Furthermore, assessments will be conducted by a physiotherapist who is also blind to the treatment assignment, and the analyses will be performed by an analyst who will be unaware of the treatments.

2.6. Statistical analysis

We will report the mean and standard deviation (SD) for the continuous variables and the number and percentage for categorical ones. We will use the Kolmogorov-Smirnov test to assess the normal distribution of outcomes and will use parametric and non-parametric tests accordingly to perform within and between-group comparisons. $P < 0.05$ will be considered statistically significant.

3. Discussion

The aim of this study is to evaluate the comparative effects of actual DN versus sham needling on the recovery of taekwondo athletes from quadriceps muscle fatigue. We hypothesize that in treating quadriceps muscular fatigue in taekwondo athletes, DN will significantly differ in effectiveness from the sham needling. Consequently, we expect noticeable differences between the groups in outcomes, including the IPT, SLHT, and VJT. To our knowledge, this is the first study investigating the impact of DN on an athlete's quadriceps muscle fatigue.

DN is selected for treatment as it is a relatively novel option, has immediate positive effects, improves muscle strength [26], is safe and inexpensive [27,28], and its impacts on athletes with quadriceps muscle fatigue are unknown. The high-quality triple-blind RCT design and random participant assignment offered by the protocol employed in this study serve to reduce the possibility of confounding variables and bias in the interpretation of the findings. It assesses the pertinent clinical parameters and potential mechanisms for the effect of DN on the quadriceps muscles. The results of our study will provide evidence of the effects of real DN vs. sham DN on the quadriceps in athletes after muscle fatigue and the possible mechanisms involved. This study is limited by the lack of assessment of the long-term effects of DN. We recognize that a trial emphasizing long-term outcomes would provide more comprehensive data. We intended to start by examining the short-term effects before carrying out trials with longer intervention durations because, as of now, no research has been done that assesses the effects of DN on the quadriceps in the athlete population.

4. Conclusion

The findings from this study are set to offer initial insights into the effectiveness of DN in improving quadriceps muscle fatigue among athletes. These results will serve as a foundational basis, contributing to a better understanding of how DN can be utilized in sports medicine and rehabilitation to enhance muscle recovery. This evidence is particularly important for developing targeted therapeutic interventions aimed at optimizing athletic performance and reducing recovery time after intense physical activity.

CRediT authorship contribution statement

Reyhaneh Aghajani: Writing – review & editing, Writing – original draft, Methodology, Funding acquisition. **Elaheh Dehghani:** Writing – review & editing, Writing – original draft. **Mohammad Saeid Khonji:** Writing – review & editing, Writing – original draft. **Soofia Naghdi:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization. **Noureddin Nakhostin Ansari:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization, **Jan Dommerholt:** Writing – review & editing. **Amin Nakhostin-Ansari:** Supervision, Methodology, Funding acquisition, Conceptualization, Writing – review & editing.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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