The Immediate Effect of Manual Needle Acupuncture and Electro Acupuncture on the Explosive Force Production of Quadriceps on Asymptomatic Subjects: Randomized Controlled Trial

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Abstract

Enhancing explosive force is a priority in both sports performance and rehabilitation. Acupuncture may acutely improve muscle power by facilitating motor unit recruitment and optimizing neuromuscular coordination. This study aimed to directly compare the immediate effects of manual acupuncture (MA) and electro-acupuncture (EA) on quadriceps explosive force in healthy young adults. Sixty-six asymptomatic participants (18–23 years) were randomized to MA (n=22), EA (n=22), or sham acupuncture (n=22). MA and EA targeted ST32, ST34, ST36, and SP10; sham stimulation was applied to non-acupoints adjacent to these sites. All treatments lasted 20 minutes. Quadriceps performance—average maximum torque, average work, average power, and average peak power—was assessed pre- and post-intervention using isokinetic dynamometry. EA produced the largest improvements: +60.17% (torque), +80.39% (work), +70.74% (power), and +54.94% (peak power). MA achieved +45.72%, +65.55%, +51.40%, and +38.03%, respectively. Sham changes were negligible (+2.47–5.22%, $p>0.05$). Both EA and MA outperformed sham ($p<0.001$), and EA surpassed MA across all metrics ($p<0.01$). It could be concluded that a single EA session elicits substantial, immediate gains in quadriceps explosive force, outperforming MA and sham. EA may represent a potent, time-efficient intervention for enhancing lower-limb muscle power in athletic and clinical contexts.

Key words: ***Traditional Chinese Medicine (TCM); Acupoints; Acupuncture; Electro- Acupuncture; Manual acupuncture; Sham acupuncture; De-qi.***

Introduction

Acupoints serve as the basis for research into the mechanism of acupuncture, as well as the primary location for needling treatment and specially selected acupuncture manipulation sites [(1)]. The body has more than 361 mapped acupoints. According to earlier studies, acupoints are complexes of high-density, excitable nerve endings that have both central and peripheral effects [(2)]. About 2,500 years ago, acupuncture was first used in China, and throughout time, it was combined into what is today known as Traditional Chinese Medicine (TCM) [(2)]. To create a physiological impact, a tiny needle must be inserted and moved through the skin at specific acupuncture locations (also known as acupoints) on the body.

Electroacupuncture is a type of acupuncture in which a higher stimulatory effect is achieved by adding an electrical current to the implanted needle. Acupuncture not only has therapeutic benefits but can also improve musculoskeletal rehabilitation, resulting in decreased disability and pain and muscular tension [(2)]. Zusanli (ST 36), an acupuncture point, is commonly recognized in traditional Chinese medicine as a site for strength development [(3)]. Lower extremity paralysis, hemiplegia, and muscle impairment have all been demonstrated to be delayed by points ST-36 and ST-39. SP-9 is said to be useful in treating the muscular system, and GB-34 is best for tendon strength [(4)].

There has been a broader acceptance of acupuncture aimed at enhancing sports performance, Over the past two decades there have been a number of studies that have shown positive results during and following acupuncture stimulation 5-11, The four main areas that acupuncture is utilized in enhancing human performance during or following exercise include improving muscle strength, reducing delayed onset of muscle soreness (DOMS), reducing lactic acid, and heart rate reduction following exercise [(3)].

It can effectively improve the strength of the quadriceps femoris of athletes in sports competitions, which is conducive to improving sports performance and restoring neuromuscular function. Therefore, acupuncture is an alternative therapy useful for improving sports performance and competition results in sports medicine [(12)].

Explosive force refers to the ability to increase contraction torque as quickly as possible from a lower or static level under the nerve drive of the central nervous system and inherent muscle. Acupuncture can increase the recruitment of motor units by stimulating nerve fibers at the acupoints and improves the coordination within and between muscles, thus increasing the ability of muscles to produce maximum power. According to literature there was no any clinical trial reported the immediate effect of manual needle acupuncture and electro acupuncture on the explosive force production of quadriceps on asymptomatic subjects, so this study was conducted to claim this point.

MATERIAL AND METHOD

Study design

This single-blinded (assessor) pre-post randomized controlled study was conducted from March 2024 to April 2024 in the physical therapy clinic of Egyptian Chinese University. The unique ethical number for this trial was (P.T.REC/012/004967) from the Faculty of Physical Therapy, Cairo University's Research Ethics Committee. The other unique number from Clinical Trials Registry was (Registry ID: NCT07037342). Informed consent: Informed consent was signed by all subjects participated in this study.

Participants:

Participants were healthy students. In this study, participants from both genders were included if they were asymptomatic, ages from 18-23 years old, Right leg dominant and Normal daily life activities, Participants were excluded, if they had (1) Needles phobia 3 (2) Under supervision of other heath practitioner 3 (3) Impaired sensation or any neurological/ musculoskeletal disorder 3, 12(4) Pregnant 3 (5) Involved in regular strength training during 6 months prior to the study 12

Sample size

Before the trial started, Specific number of subjects was calculated according to G-power 3.1.9.4., MANOVA, repeated measure, between factor, power =0.8, effect size= 0.28 which resulted in a minimum group size of 66 participants per group. The effect size was calculated from previous published research 12.

Randomization

Sixty-six subjects will be allocated randomly to either manual acupuncture (Group A), electro acupuncture (Group B) or sham acupuncture (Group C). A computer-generated block randomization

method was used to minimize bias and variation between groups (available at http://www.randomization.com/),as shown in **Figure (1)**.

Participants were randomly assigned to blocks with sizes of 3 and 9 using a 1:1 allocation ratio. The randomization was conducted by the first author, who will not be engaged in the recruitment process, collection of data, or therapeutic interventions. Randomization codes will be kept undisclosed in sequentially numbered, sealed, opaque envelopes to guarantee concealed allocation. The second author applies assessment and the third one applies treatment.

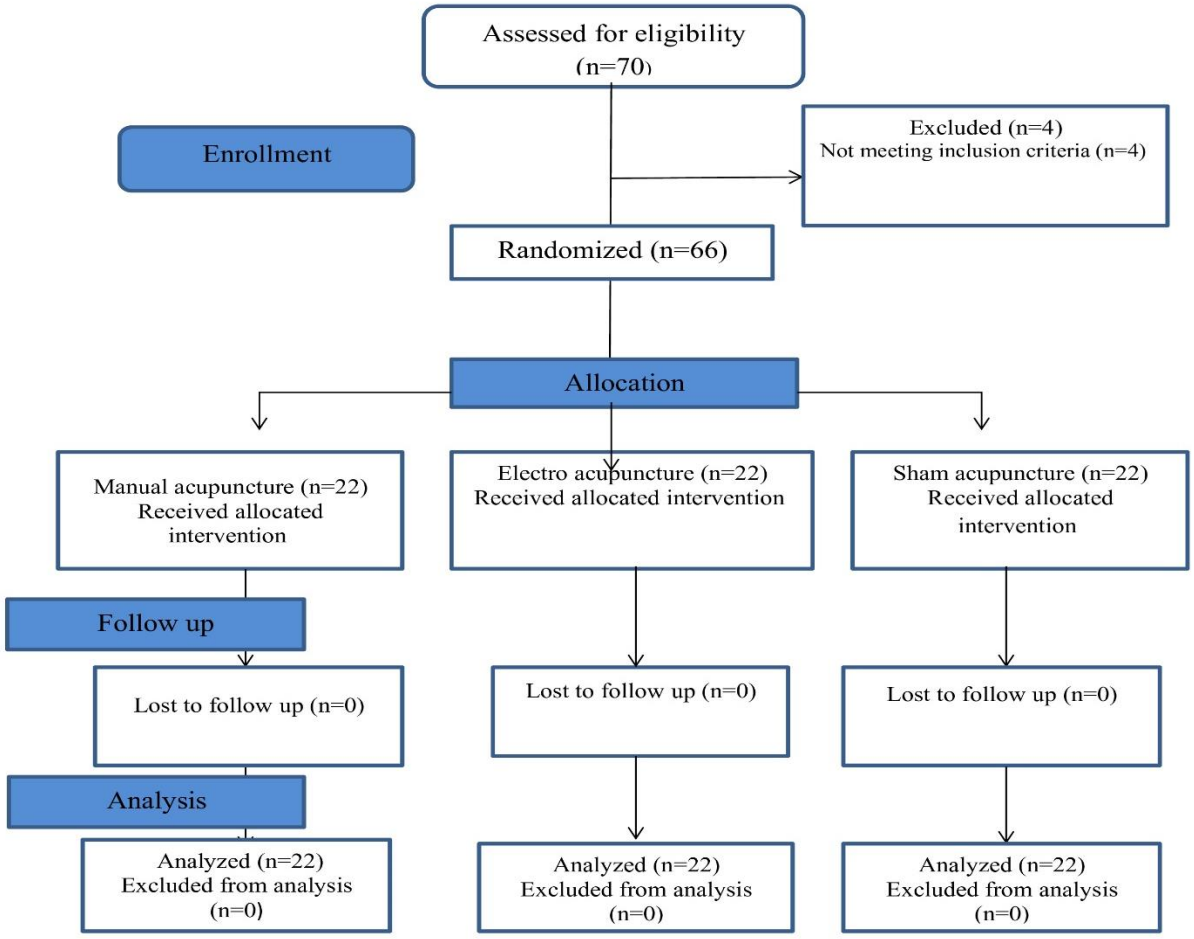

Figure (1): Consort Flow Diagram

Interventions

Group "A" (experimental 1) received a manual acupuncture on acupoint (ST32, ST34, ST36, SP10)11, Group "B" (experimental 2) received electro acupuncture on acupoint (ST32, ST34, ST36, and SP10) Group "C" (control group) received sham acupuncture on point adjacent to (ST32, ST34, ST36, and SP10)12. Each group received the treatment intervention for 20 minutes.

Manual Acupuncture

First, the procedures of Manual Acupuncture were explained to all Participants, where the needles were inserted perpendicularly on acupoint (ST32, ST34, ST36, SP10) to a depth depended on the anatomical location of each point and the physical characteristics of each subject (e.g., skin thickness and subcutaneous fat layer thickness). It varied from 10 to 15 mm and manipulated bidirectionally with rotation until De-Qi arrival [(12)], then were manipulated (bi-directionally rotated) every 5 min for 15 seconds [(3)], as shown in **Figure (2)** and **Figure (3)**.

Figure (2): Removing the needle from accu-point ST32 after the treatment time

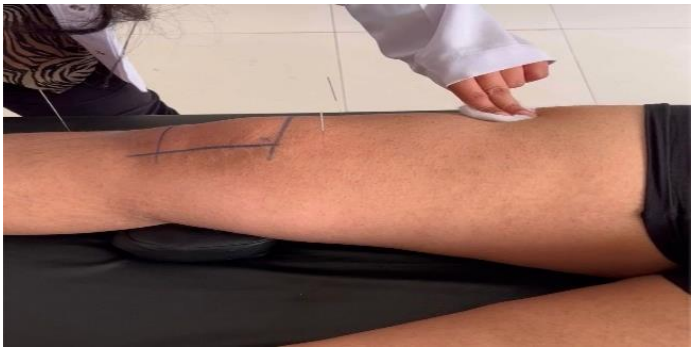

Figure (3): the final procedure of manual acupuncture treatment.

Electro-Acupuncture

First, the procedures of Electro-Acupuncture were explained to all Participants where the needles were inserted perpendicularly on acupoint (ST32, ST34, ST36, SP10) to a depth depended on the anatomical location of each point and the physical characteristics of each subject (e.g., skin thickness and subcutaneous fat layer thickness). It varied from 10 to 15 mm and were manipulated (bidirectionally rotated) until De-Qi arrival, then electrodes from a transcutaneous electrical nerve stimulation (TENS) machine was attached to the needles, delivering a constant current wave form at a frequency of 120 Hz pulsed width 1 ms and the intensity up to the maximum level the subject could tolerate for 20 mins. Participants were instructed not to voluntarily contract the muscle in either limb during session [(3)], as shown in **Figure (4)**.

Figure (4): the needles inserted on the chosen acupoint and attached to electrodes

Sham acupuncture

First, the procedures of Sham Acupuncture were explained to all Participants where the needles were inserted acupuncture on body locations not recognized as true acupoints or meridians for needling (sham acupuncture) were used, a point adjacent to (ST32, ST34, ST36, and SP10) for 20 min15.

Outcome measures

Outcome measures were Explosive force performance that was measured by HUMAC Norm Isokinetic dynamometer, Past studies have shown that torque, work, power, and speed can be used as measures of explosive force [(14)], accordingly the average max torque/kg (Nm/kg), the average work/kg (J/kg), the average power/kg (W/kg), the average peak power/kg (W/kg)[(12)] were chosen to assess the changes in the explosive forces generated by quadriceps.

HUMAC Norm Isokinetic dynamometer

Isokinetic dynamometry is considered a valid and reliable device used to determine the force, or torque, generated by a muscle group for a specific action, having good-to-excellent reliability [(16)] and it is often used as a reference standard for other strength assessments [(17)], an isokinetic dynamometer allows to assess muscle function with an accommodating resistance, at a constant angular velocity, thereby enabling maximum force production throughout a prescribed range of motion (ROM)18. Habets, et al assessed the intra-rater reliability of two HUMAC NORM isokinetic devices in the assessment of concentric and eccentric strength measurements of the knee extensors and flexors, and the shoulder rotators. This was a test–retest study, with an interval between the first and second test of 1–2 weeks. This was considered sufficient to minimize the influence of muscular fatigue, but also sufficiently short to ensure no actual change in strength. The first test was performed at Papendal Sports Medical Center (Arnhem, The Netherlands), and the re-test was performed at HAN University of Applied Sciences (Nijmegen, The Netherlands). All tests were conducted by two physiotherapy students, of which one performed the actual test, and the other checked all settings prior to commencement of the test. This was the first study to assess intrarater reliability for knee and shoulder tests performed on two different HUMAC NORM isokinetic dynamometers. The study found good to excellent reliability, with ICC values ranging from 0.74 to 0.89 for knee tests and from 0.72 to 0.94 for shoulder tests [(19)].

- Isokinetic dynamometer strengthening assessment

- Subjects secured by body straps and seated comfortably in the dynamometer chair with an angle of <110° between the alignment of the spine and the femur, and the knee and hip flexed at 90°. The axis of rotation of the device aligned with the anatomical axis of the knee and the right leg secured with an inelastic band. The seating position, knee, and hip joint angles all recorded during the familiarization session and used before and after the intervention to eliminate differences in strength output due to the seating position.

- Each subject performed five repetitive isokinetic Knee Extension on the right knee at 240° s^{-1}. Participants instructed to extend their knee "as fast and hard as possible" for 1 s upon hearing an auditory signal, with the emphasis on "fast". All isokinetic assessments started at knee angles of 90° and ~ 180° (full extension). As the arm of the dynamometer moved up from 90° to 180°, subjects encouraged to perform maximally for each contraction throughout the full range of motion. The participants verbally instructed to "push" or "pull" "as fast as possible". The subjects asked to be relaxed as the dynamometer arm move back to 90° (the passive phase of the contraction cycle) [12], as shown in **Figure (5)**.

Figure (5): The student was sitting on the isokinetic chair while performing the assessment test

Statistical analysis

Subject characteristics were compared between groups by ANOVA test. Chi- squared test was used for comparison of sex distribution between groups. Normal distribution of data was checked using the Shapiro-Wilk test. Levene's test for homogeneity of variances was conducted to test the homogeneity between groups. Mixed MANOVA was performed to compare within and between groups effects on quadriceps average max torque, average work, average power and average peak power. Post-hoc tests using the Bonferroni correction were carried out for subsequent multiple comparison. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through the Statistical Package for Social Sciences (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

RESULTS

- Subject characteristics:

Table (1) shows the subject characteristics of group A, B and C. There was no significant difference between groups in age and sex distribution ($p > 0.05$)

Effect of acupuncture on quadriceps average max torque, average work, average power and average peak power:

Mixed MANOVA revealed that there was a significant interaction of acupuncture and time ($F = 55.16$, $p = 0.001$, Partial Eta Squared = 0.79). There was a significant main effect of time ($F = 647.62$, $p = 0.001$, Partial Eta Squared = 0.98). There was a significant main effect of acupuncture ($F = 2.77$, $p = 0.008$, Partial Eta Squared = 0.16).

Within group comparison

There was a significant increase in quadriceps average max torque, average work, average power, and average peak power in group A and group B post acupuncture compared with pre acupuncture ($p < 0.001$).

Group B showed the highest percentage of increase across all variables, with increases of 60.17% in average max torque, 80.39% in average work, 70.74% in average power, and 54.94% in average peak power. In group A the percentage of increase was 45.72%, 65.55%, 51.40%, and 38.03% in the respective parameters. In contrast, group C showed no significant changes, with minimal percentage increases ranging from 2.47% to 5.22% ($p > 0.05$). (Table 2).

Between group comparison

Post acupuncture there was a significant increase in average max torque, average work, average power, and average peak power in group A and B compared with that of group C ($p < 0.001$). Additionally, group B showed a significant increase than group A in all outcomes ($p < 0.01$). (Table 2).

Table 1. Basic characteristics of participants.

Variables	Group A	Group B	Group C	p-value
	mean ± SD	mean ± SD	mean ± SD	
Age (years)	21.73 ± 0.77	21.36 ± 0.85	21.32 ± 0.89	0.21
Weight (kg)	67.41 ± 5.81	68.73 ± 5.72	70.27 ± 7.69	0.87
Height (cm)	169.82 ± 5.75	169.68 ± 6.33	170.32 ± 7.00	0.58
BMI (kg/m²)	23.41 ± 2.07	23.87 ± 1.54	24.14 ± 1.14	0.92
Sex, n (%)				
Females	9 (41%)	10 (45.5%)	11 (50%)	0.83
Males	13 (59%)	12 (54.5%)	11 (50%)	

SD, standard deviation; p-value, level of significance

Table 2. Mean quadriceps average max torque, average work, average power and average peak power pre and post acupuncture of group A, B and C:

Outcomes	Group A	Group B	Group C
	mean ± SD	mean ± SD	mean ± SD
Average max torque (Nm/kg)			
Pre acupuncture	30.23 ± 9.66	33.09 ± 7.08	31.14 ± 9.97
Post acupuncture	44.05 ± 10.19	53.00 ± 7.28	31.91 ± 9.47
MD	-13.82	-19.91	-0.77
% of change	45.72	60.17	2.47
p-value	p = 0.001	p = 0.001	p = 0.13
Average work (J/kg)			
Pre acupuncture	11.64 ± 4.18	12.95 ± 3.87	12.27 ± 5.24
Post acupuncture	19.27 ± 4.39	23.36 ± 4.55	12.91 ± 5.08
MD	-7.63	-10.41	-0.64
% of change	65.55	80.39	5.22
p-value	p = 0.001	p = 0.001	p = 0.11
Average power (W/kg)			
Pre acupuncture	16.09 ± 5.23	17.36 ± 4.74	16.41 ± 6.25
Post acupuncture	24.36 ± 5.23	29.64 ± 5.58	17.14 ± 6.72
MD	-8.27	-12.28	-0.73
% of change	51.40	70.74	4.45
p-value	p = 0.001	p = 0.001	p = 0.12
Average peak power (W/kg)			
Pre acupuncture	22.59 ± 6.62	23.50 ± 6.57	22.45 ± 6.35
Post acupuncture	31.18 ± 6.32	36.41 ± 5.65	23.05 ± 6.28
MD	-8.59	-12.91	-0.60
% of change	38.03	54.94	2.67
p-value	p = 0.001	p = 0.001	p = 0.27

SD, Standard deviation; MD, Mean difference; p-value, Probability value

Table 3. Comparison of quadriceps average max torque, average work, average power and average peak power between group A, B and C post acupuncture.

Outcomes	Group A vs B	p value	Group A vs C	p value	Group B vs C	p value	η^2
	MD (95% CI)		MD (95% CI)		MD (95% CI)		
Average max torque (Nm/kg)	-8.95 (-15.51: -2.40)	0.005	12.14 (5.58: 18.70)	0.001	21.09 (14.53: 27.65)	0.001	0.48
Average work (J/kg)	-4.09 (-7.48: -0.70)	0.01	6.36 (2.97: 9.75)	0.001	10.45 (7.07: 13.84)	0.001	0.46
Average power (W/kg)	-5.28 (-9.53: -1.02)	0.01	7.22 (2.97: 11.48)	0.001	12.50 (8.25: 16.75)	0.001	0.44
Average peak power (W/kg)	-8.13 (-9.64: -0.82)	0.01	13.36 (3.73: 12.55)	0.001	0.14 (8.95: 17.77)	0.001	0.46

MD, mean difference; CI, Confidence interval; p value, Probability value; η^2, Partial Eta Squared.

DISCUSSION:

This study evaluated the immediate effects of manual acupuncture (MA) and electro-acupuncture (EA) on quadriceps explosive force production in healthy adults. Both interventions produced statistically significant post-intervention improvements in average maximum torque, average work, average power, and average peak power compared with pre-intervention values ($p < 0.001$). The EA group exhibited the greatest relative improvement across all parameters. Intergroup comparisons confirmed significant differences between all study groups, with EA yielding superior outcomes ($p < 0.001$).

The observed improvements following MA at ST32, ST34, ST36, and SP10 (20 minutes) may be explained by several neurophysiological mechanisms. Acupuncture is known to enhance muscle fiber conduction velocity by stimulating afferent nerves, leading to increased recruitment of motor units and elevated firing frequencies [20]. These neural adaptations can augment muscle contraction strength and conduction velocity, ultimately increasing torque generation [12].

A plausible contributing factor is "post-activation potentiation (PAP)", a neuromuscular phenomenon in which prior stimulation facilitates recruitment of high-threshold motor neurons [21] and accelerates force development via myosin regulatory light chain phosphorylation [22]. In the present study, acupuncture-induced muscle contractions may have triggered PAP, thereby enhancing explosive force output [12].

The increases in average work, power, and peak power may also be related to the selection of acupoints, particularly Zusanli (ST36), which is reported to elicit the "De-Qi" sensation. De-Qi activates multiple nerve fiber types and modulates motor cortex excitability, improving knee extensor and flexor strength [23-25]. It has also been associated with improved pain control, enhanced motor function in knee osteoarthritis, and increased torque and power in athletes, thereby contributing to improved rapid lower-limb strength [26,27].

Muscle strength generation is dependent on the nervous system's capacity to recruit motor units effectively, a process regulated via spinal cord inputs [28]. Evidence indicates that acupuncture activates multiple supraspinal centers [29] and increases spinal motor neuron excitability, as demonstrated by H-reflex facilitation [30]. The present results suggest that these central and spinal adaptations may underlie the increases in knee joint work and power observed post-intervention.

Our findings are consistent with Wang et al. (2021), who reported significant improvements in quadriceps explosive force and joint stiffness following true acupuncture compared to sham in healthy males [12]. Similar effects have been documented in the shoulder joint, where PAP was proposed as a contributing factor; however, these effects diminished approximately 10 minutes post-treatment [31]. Studies in the forearm [32] and in volleyball athletes33 have further supported the capacity of acupuncture to enhance explosive force.

Not all studies have reported performance gains. Silva et al. (2024) found no significant improvements in lower-limb performance in physically active young women following a single acupuncture session, with vertical jump height decreasing in both sham and acupuncture groups [34]. Such discrepancies may stem from differences in participant characteristics, acupoint selection, intervention protocols, and outcome measures.

The superior improvements observed with EA may result from the combined effects of mechanical needle stimulation and controlled electrical input. EA delivers consistent, modulated impulses that preferentially activate motor nerve fibers owing to their lower activation threshold compared with muscle fibers [(3)] thereby increasing neuromuscular responsiveness. In addition, EA may promote neuroplastic changes, reduce inflammation, and sustain muscle activation patterns [(35)].

Evidence from clinical and experimental studies supports these mechanisms. Xing et al. (2024) demonstrated that EA combined with extensor training improved quadriceps contraction strength and knee function in osteoarthritis patients more than training alone, with benefits persisting up to six months [(36)]. Similarly, Huang et al. (2013) reported a 92% likelihood of strength improvement in athletes receiving four weeks of EA compared with controls [(37)].

However, EA does not consistently yield strength gains in all settings. Kim et al. (2020) observed that both EA and MA improved hip flexion range of motion but transiently reduced quadriceps strength immediately post-treatment, suggesting possible acute inhibitory neural or metabolic effects [(38)].

Limitations and Implications

While the present results strongly support the use of acupuncture - particularly EA - for immediate enhancement of quadriceps explosive force, variability across studies highlights the need for standardized protocols. Future investigations should examine optimal stimulation parameters, intervention duration, and post-treatment time windows to maximize performance gains and clarify the underlying neurophysiological mechanisms.

Conclusion

Manual needle acupuncture and electro acupuncture are both effective interventions for explosive force production of quadriceps in healthy subjects with electro acupuncture being superior.

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References

1. **Li F, He T, Xu Q, Lin LT, Li H, Liu Y, Liu CZ. (2015).** What is the Acupoint? A preliminary review of Acupoints. Pain Medicine, 16(10), 1905-1915.
2. **Micalos, PS, Pak SC, Jesulola E, Cannon J, Hale M, Koo BS (2021).** Does Acupuncture Enhance Muscle Strength and Performance?. Strength & Conditioning Journal, 43(2), 116-120.
3. **Payton SS, Bailey SD (2017).** The effect of manual acupuncture and electroacupuncture on lower limb muscle strength:. Journal of Acupuncture and Tuina Science.
4. **Bailey, S (2022).** Effects of Acupuncture on Enhancing Muscle Strength: A Systematic Review. International Journal of Sports and Exercise Medicine. 8. 10.23937/2469-5718/1510221.

5. **Gentil D, Assumpcao J, Yamamura Y, Neto TB (2005).** The effect of acupuncture and moxibustion on physical performance by sedentary subjects submitted to ergospirometric test on the treadmill. Journal of sports medicine and physical fitness, 45(1), 134.

6. **Cheung, LCT, Jones AYM. (2007).** Effect of Acu-TENS on recovery heart rate after treadmill running exercise in subjects with normal health. Complementary Therapies in Medicine, 15(2), 109-114.

7. **Huang LP, Zhou S, Lu Z, Tian Q, Li X, Cao LJ, Wang H (2007).** Bilateral effect of unilateral electroacupuncture on muscle strength. The Journal of Alternative and Complementary Medicine, 13(5), 539-546.

8. **Itoh K, Ochi H, Kitakoji H. (2008).** Effects of tender point acupuncture on delayed onset muscle soreness (DOMS)–a pragmatic trial. Chinese Medicine, 3, 1-5.

9. **Hübscher M, Vogt L, Bernhörster M, Rosenhagen A, Banzer W. (2008).** Effects of acupuncture on symptoms and muscle function in delayed-onset muscle soreness. The Journal of Alternative and Complementary Medicine, 14(8), 1011-1016.

10. **Lin ZP, Lan LW, He TY, Lin SP, Lin JG, Jang TR, Ho TJ (2009).** Effects of acupuncture stimulation on recovery ability of male elite basketball athletes. The American journal of Chinese medicine, 37(03), 471-481.

11. **Hübscher M, Vogt L, Ziebart T, Banzer W. (2010).** Immediate effects of acupuncture on strength performance: a randomized, controlled crossover trial. European journal of applied physiology, 110, 353-358.

12. **Wang J, Wang IL, Hu R, Yao S, Su Y, Zhou S, Chen CH. (2021).** Immediate effects of acupuncture on explosive force production and stiffness in male knee joint. International Journal of Environmental Research and Public Health, 18(18), 9518.

13. **Tsimachidis C, Patikas D, Galazoulas C, Bassa E, Kotzamanidis C (2013).** The post-activation potentiation effect on sprint performance after combined resistance/sprint training in junior basketball players. Journal of sports sciences, 31(10), 1117-1124.

14. **Wang IL, Chen YM, Wang J, Hu R, Zhang KK, Ho CS. (2020).** Effects of acupuncture on explosive force production by the healthy female shoulder joint. Evidence-Based Complementary and Alternative Medicine, 2020.

15. **Assefi NP; Sherman KJ; Jacobsen C; Goldberg J; Smith WR; Buchwald D (2005).** A randomized clinical trial of acupuncture compared with sham acupuncture in fibromyalgia. Ann. Intern. Med. 143, 10–19

16. **Moussa AZB, Zouita SBSF, Salah FB, Behm DG, Chaouachi A (2020).** Isokinetic trunk strength, validity, reliability, normative data and relation to physical performance and low back pain: A review of the literature. International journal of sports physical therapy, 15(1), 160.

17. **Stark T, Walker B, Phillips JK, Fejer R, Beck R. (2011).** Hand-held dynamometry correlation with the gold standard isokinetic dynamometry: a systematic review. PM&R, 3(5), 472-479.

18. **Perrin DH. (1994).** Open chain isokinetic assessment and exercise of the knee. Journal of sport rehabilitation, 3(3), 245-254.

19. **Habets B, Staal JB, Tijssen M, van Cingel R.(2018)** Intrarater reliability of the HUMAC NORM isokinetic dynamometer for strength measurements of the knee and shoulder muscles. BMC Res Notes. 10;11(1):15. doi: 10.1186/s13104-018-3128-9. PMID: 29321059; PMCID: PMC5764011.

20. **Connelly DM; Vandervoort AA (2000).** Effects of isokinetic strength training on concentric and eccentric torque development in the ankle dorsiflexors of older adults. J. Gerontol. Ser. A: Biol. Sci. Med Sci. 55, B465–B472.

21. **Hodgson M; Docherty D; Robbins D. (2005).** Post-activation potentiation. Sports Med. 35, 585–595.

22. **Farup J; Sørensen HJTJ.; Research C. (2010).** Postactivation potentiation: upper body force development changes after maximal force intervention. J. Strength Cond. Res. 2010, 24, 1874–1879.

23. **Ozerkan KN; Bayraktar B; Sahinkaya T; Goksu OC; Yucesir I; Yildiz S. (2007).** Comparison of the effectiveness of the traditional acupuncture point, ST. 36 and Omura's ST. 36 Point (True ST. 36) needling on the isokinetic knee extension & flexion strength of young soccer players. Acupuncture & electro-therapeutics research, 32, 71–79

24. **Zhu SP; Luo L; Zhang L; Shen SX; Ren XX; Guo MW; Yang JM; Shen XY; Xu YS; Ji B.; (2013).** Acupuncture De-qi: From Characterization to Underlying Mechanism. Evid. Based Complementary Altern. Med., 518784, doi:10.1155/2013/518784.

25. **Sun ZG; Pi YL; Zhang J; Wang M; Zou J; Wu W (2019).** Effect of acupuncture at ST36 on motor cortical excitation and inhibition. Brain Behav. 9, e01370.

26. **Ahmedov SJTJ; Research C. (2010).** Ergogenic effect of acupuncture in sport and exercise: a brief review. J. Strength Cond. Res. 24, 1421–1427.

27. **Spaeth RB; Camhi S; Hashmi JA; Vangel M; Wasan AD; Edwards RR; Gollub RL; Kong J. (2013).** A longitudinal study of the reliability of acupuncture deqi sensations in knee osteoarthritis. Evid. Based Complementary Altern. Med. 12.

28. **Scaglioni G; Ferri A; Minetti AE; Martin A; Van Hoecke J; Capodaglio P; Sartorio A; Narici MV (2002).** Plantar flexor activation capacity and H reflex in older adults: adaptations to strength training. J. Appl. Physiol. 92, 2292–2302.

29. **Napadow V; Makris N; Liu J; Kettner NW; Kwong KK; Hui KK (2005).** Effects of electroacupuncture versus manual acupuncture on the human brain as measured by fMRI. Hum Brain Mapp. 24, 193–205.

30. **Fink M; Rollnik JD; Bijak M; Borstädt C; Däuper J; Guergueltcheva V; Dengler R; Karst M (2004).** Needle acupuncture in chronic poststroke leg spasticity. Arch Phys Med Rehabil, 85, 667–672.

31. **Wang IL; Wang J Chen Yi-M, Hu R, Su Y, Yao S, Ho CS. (2021).** Effect of Acupuncture on the Timeliness of Explosive Forces Generated by the Male Shoulder Joint. Evidence-Based Complementary and Alternative Medicine. 1-9. 10.1155/2021/5585605.

32. **Zhou S; Wang, I-Lin; Chen, Yi-Ming; Hu, Rui; Su, Yu; Shen, Jia-Yu; Wang, Jun. (2021).** Effects of Traditional Chinese Acupuncture Compared with Sham Acupuncture on the Explosive Force Production by the Forearm Muscles in Female: A Randomized Controlled Trial. Evidence-Based Complementary and Alternative Medicine. 10.1155/2021/1992753.

33. **Cruz, Flávio Rodolfo Gonçalves (2019).** The Effect of Acupuncture on the Performance of the Volleyball Player. 2019. University of Porto, Master's thesis. Repositório Científico de Acesso Aberto de Portugal, https://hdl.handle.net/10216/125151.

34. **Silva MAA, de Souza BJ, Oliveira AA. (2024).** Systemic acupuncture application does not change

muscle performance parameters in women: A randomized, controlled, double-blind pilot study. Journal of Bodywork and Movement Therapies. https://doi.org/10.1016/j.jbmt.2024.01.008

35. **Jang DJ, Shin WC, Cheon C, Cho JH, Chung WS, Song MY, Kim, H. (2024).** A systematic review and meta-analysis of electroacupuncture in enhancing lower limb function for post-stroke hemiplegia. SSRN. https://doi.org/10.2139/ssrn.5224611

36. **Xing B, Liu Y, Zhou X, He G, Pei W, Liang Z, Ruan J, Duan Y (2025).** Electroacupuncture with extensor exercise improves the contraction elastic density of quadriceps in short and long term for knee osteoarthritis. Clin Rheumatol. Jan;44(1):443-452. doi: 10.1007/s10067-024-07243-5.

37. **Huang Q, Li M, Zhang W, Zhang H, Zhao W. (2013).** Effect of electroacupuncture on muscle strength of ankle dorsiflexion and plantar flexion in athletes. Chinese Journal of Rehabilitation Medicine, 28(6), 530–533.

38. **Kim D, Jang S, Park J. (2020).** Electroacupuncture and Manual Acupuncture Increase Joint Flexibility but Reduce Muscle Strength. Healthcare (Basel, Switzerland), 8(4), 414. https://doi.org/10.3390/healthcare8040414.