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ORIGINAL RESEARCH

The effect of strain counterstrain (SCS) on forearm strength compared to sham positioning☆

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Osteopathic manipulative treatment;
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Abstract *Objective:* Determine the effect of strain counterstrain (SCS) techniques on forearm pronation and supination muscle strength compared to passive sham positioning.
Design: Randomized, blinded, sham-controlled study.
Subjects: 12 healthy right-handed subjects (4 men, 8 women) with 19 included forearms (6 right, 13 left). Each forearm was individually and randomly assigned to the SCS or control group (9 SCS, 10 control).
Methods: Subjects attended 3 sessions within 3 weeks. Initial forearm pronation and supination strength was assessed at the first session. Forearm muscle strength was assessed in a stable seated position using a hydraulic dynamometer with doorknob-shaped handle. Pre- and post-treatment strength was assessed during the second session, with the SCS group receiving 1 SCS treatment to the pronator and supinator muscles and the control group receiving passive sham positioning between assessments. The third session consisted of a 1-week follow-up forearm strength.
Results: At baseline, the SCS and control groups were comparable with respect to age, gender, height, weight, hand dominance, and initial pronator and supinator strength ($p > 0.05$). After treatment, control group strength remained unchanged ($p > 0.05$) while the SCS group increased pronation strength by 8.3% ($p = 0.009$) and supination strength by 11.9% ($p = 0.046$) from pre-treatment to follow-up 1 week later. SCS group strength increased more compared to the control group for pronation ($p = 0.045$) and supination ($p = 0.059$).

☆ The Institutional Review Board of the Touro College School of Health Sciences, New York, NY, approved this study.
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Conclusions: Forearm strength increased after SCS in a healthy population with muscle tenderness, with greater strength increase apparent than after passive sham positioning.

Introduction

Osteopathic manipulative therapy includes a wide range of 'direct' and 'indirect' techniques.[1] A body of multidisciplinary evidence is growing to support direct manipulation techniques such as high velocity low amplitude thrust when applied to both the spine[2–6] and extremities.[7–10] Indirect techniques such as strain counterstrain (SCS) are used less often than direct techniques[11] and the evidence to document SCS has only begun to emerge.

Since Jones described SCS as a passive positional release technique in 1964,[12] others have expanded on the applications for SCS.[13–15] A number of case studies then followed documenting the use of SCS for chronic myofascial pain,[16] low back pain,[17] iliotibial band friction syndrome,[18] and complex regional pain syndrome.[19] Two studies have used SCS within protocols that combined both direct and indirect techniques and demonstrated decreased pain and increased range-of-motion and strength for those with tennis elbow[20] and decreased length of stay for patients with pancreatitis.[21]

Within the last decade, a number of studies have examined the specific effects of SCS on measurable outcomes such as pain, range-of-motion, and strength. In a randomized controlled study of healthy subjects with painful hip tender points, palpation pain was reduced after SCS, with or without exercise, compared to after exercise alone. However, the 'jump sign' sometimes used to assess tender points had low reliability and weak validity compared to a visual analog scale.[22] In a randomized controlled trial of people with mechanical neck pain, SCS resulted in immediate decrease in upper trapezius pain, as measured with a visual analog scale, compared to a control group that received no treatment.[23] Similar findings were reported by Ibanez-Garcia et al. for subjects with masseter trigger points; SCS decreased pain as measured with a visual analog scale as much as after 'neuromuscular massage'.[24] In subjects with Achilles tendonitis, ratings of soreness and stiffness also reduced after SCS.[25]

While pain upon palpation has been demonstrated to immediately decrease after SCS treatment, the effect of SCS on range-of-motion has been contradictory. Ibanez-Garcia et al. found that for subjects with masseter trigger points, jaw opening range-of-motion increased after SCS or massage by 4 mm compared to a control group that received no treatment.[24] In another randomized controlled study by Blanco et al., however, muscle energy technique was found to be more effective in increasing jaw opening than SCS, which was comparable to a control of no treatment.[26] Treatment with SCS also had no effect on hamstring length measured as knee extension in the sitting position compared to sham positioning in a randomized controlled crossover study of healthy subjects with hamstring tightness.[27]

The effect of SCS on strength was reported by Wong and Schauer-Alvarez in a randomized controlled study of the 98 lower limbs of 49 healthy individuals with hip tender points.[28] After the second exercise session, control group strength increased by 11.4–14.5%, with a significant increase in strength at the follow up of 22.0–40.4% ($p < 0.001$). With and without exercise, strength significantly increased ($p < 0.001$) by 21.4–47.2% immediately after the first SCS treatment, by 41.0–60.7% after the second SCS treatment, and by 50.4–72.5% after the 2–4 week follow-up period. There was no significant difference between the SCS with and without exercise groups. While the authors suggested that increased strength might have resulted from enhanced muscle recruitment produced by neuromuscular facilitation or decreased inhibition, the mechanisms to explain how SCS affected strength requires further study.[28]

None of the studies examining the effect of SCS on pain, range-of-motion, or strength have documented effects of SCS on the upper extremity. The only previous study that used a sham involving human touch demonstrated no difference in effect on range-of-motion between SCS and sham.[27] Without the use of sham touch in research of manual therapy techniques, it is difficult to separate the effect of treatment from that of simple human touch.[29] The aim of this study was to determine the effect of SCS compared to a sham consisting of touch and passive positioning on palpation pain and strength of the forearm pronator and supinator muscles.

Materials and methods

Subjects

A convenience sample of 19 healthy subjects was recruited from a School of Health Science campus in 2007. Sample size was based on a priori power analysis performed using the results after one SCS treatment of a prior study.[28] To detect significant difference with an expected difference of 6.0 kg and common standard deviation of 4.0 at the alpha = 0.05 and 80% power level, at least 5 subjects were required to detect within group change and 8 subjects per group required to detect between groups difference. Subjects were excluded if they experienced any upper extremity, neck, or back pain; had a history of arthritis, tendonitis, fracture, or other upper extremity pathology; or had cardiovascular, pulmonary, or neurologic disorder. Subjects were included if their age was between 20 and 50 years old, of either gender, and met the inclusion criteria of tenderness upon manual palpation of both the teres pronator (PRO) and supinator (SUP) muscles on the anterior surface of the proximal forearm. All subjects gave informed consent prior to participating in this study, which was approved by the Institutional Review Board of Touro College School of Health Sciences, New York, NY. Each forearm was then randomly assigned separately by the research coordinator, using a random number table, to either the control or strain counterstrain (SCS) group. Subjects and evaluators were blinded to group assignments. Due to scheduling issues, 7 subjects could not complete the study within the 3-week timeline and never underwent treatment and thus were excluded from analysis following intent to treat guidelines.[30] The remaining 12 subjects (8 women; 4 men) were right-handed, aged 21–33 years, and provided 19 forearms (6 right; 13 left) that met the study inclusion criteria.

Of the 12 subjects, 5 had one forearm and 7 had both forearms included in the study. Although each forearm was considered a separate entity, the 7 subjects with both arms entered into the study had both arms assigned to the same group. The control group consisted of 3 men with 4 forearms and 3 women with 6 forearms; the SCS group consisted of 1 male with 2 forearms and 5 women with 7 forearms. There were 3 right and 7 left forearms in the control group; the SCS group had 3 right and 6 left forearms (Table 1).

Table 1 Initial subject comparison.

	Control	SCS
Forearms (right; left)	10 (3;7)	9 (3;6)
Gender: female; male	6;4	7;2
Average age (years)	25.9 ± 4.1	24.8 ± 1.5
Height (centimeters)	163.8 ± 7.3	166.4 ± 5.0
Weight (kilograms)	73.7 ± 18.2	64.0 ± 17.1

Note: Values are mean ± SD.

Design

A randomized blinded sham-controlled two-group pre-test post-test research design was used, with all treatments performed by one practitioner.

Procedures

Subjects attended 3 sessions over a 3-week period. Initial PRO and SUP strengths were assessed at the first session. The second session included, pre- and post-treatment strength assessments, with the SCS or sham treatment performed between assessments. Follow-up strength was assessed on the third session a week after the treatment.

Forearm PRO and SUP strengths were measured using a Baseline Hydraulic Dynamometer (BHD) affixed to a platform and outfitted with a doorknob handle to simulate a common functional activity (Fig. 1). The BHD set up in this manner has been

Fig. 1 Strength assessment with Hydraulic Dynamometer. The hydraulic dynamometer instrument with doorknob-shaped handle was affixed to a wooden platform and set up on a table. Note that subject's forearm position was stabilized using a strap and cradle.

shown to have excellent test-retest reliability with $ICC_{3,1}$ values ranging from 0.92 to 0.96.[31] Compared to forearm strength testing using the CYBEX 6000 with a vertical bar handle, the BHD assessment with doorknob handle demonstrated criterion validity with moderate correlation for pronation strength ($r = 0.57-0.66$) and good correlation for supination strength ($r = 0.75$) with the difference between the measures attributed in part to the different grips used to grasp the different handle shapes.[31]

Forearm PRO and SUP strengths were assessed with the subject in a stable seated position with shoulder flexed to 45° and abducted 0°, and the elbow flexed to 135°. The forearm was stabilized with a strap and placed in neutral to avoid the variations in PRO and SUP strengths observed at the end ranges of pronation and supination.[32,33] The elbow and forearm position was chosen to lessen the effect of the biceps brachii on supination, which is strongest when the elbow is flexed to 90° and the forearm is pronated.[33] The wrist was positioned in slight extension and ulnar deviation. All joint positions were measured using a standard goniometer. After one practice trial to familiarize themselves with the task, subjects exerted an isometric force as they attempted to turn the doorknob three times in each direction, with a 30-s rest between repetitions. The starting direction was predetermined randomly. In a level tone of voice, the blinded evaluator gave consistent instructions to "turn as hard as you can to the left/right" before the subject began each set of strength tests. After a 1-min rest, the subject then repeated the procedure in the opposite direction. The procedure was then repeated with the alternate arm with the same 30-s rest period between assessments.

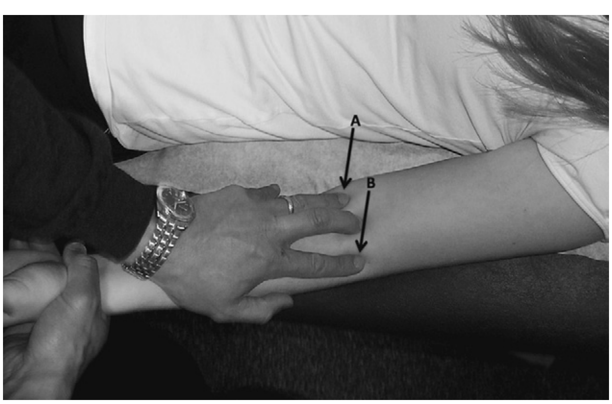

Fig. 2 Palpation of forearm tender points. The top arrow points (A) in the direction of palpation for the pronator (PRO) and the bottom arrow points (B) in the direction of palpation for the supinator (SUP).

One licensed physical therapist trained in SCS provided the SCS and sham positioning treatment for both groups in a private space separate from the strength evaluator to preserve the blinded environment. For both treatments, subjects lay supine, arms passively positioned for 90 s, after palpation of each muscle just distal to the elbow on the anterior surface (Fig. 2). The SCS group received SCS directed to the PRO muscle (Fig. 3) and SUP muscle (Fig. 4).[34] The sham group received passive positioning in 45° elbow flexion and neutral forearm position held for 90 s with forearm palpation designed to mimic real SCS treatment (Fig. 5). The positioning of the sham treatment was chosen because the angulations were in the midrange between the PRO and SUP SCS positions and were not previously described as SCS positions.[34,35]

All statistical analyses were performed with SPSS 16.0 statistical package (SPSS-UK Ltd, Surrey, United Kingdom). Data were analyzed using Mann Whitney *U* test and 2-tailed independent *t*-tests to identify any differences between the groups prior

Fig. 3 Strain counterstrain position for pronator muscle. The elbow was flexed to approximately 90°, the forearm was pronated, and the position was fine-tuned with slight shoulder internal rotation.

Fig. 4 Strain counterstrain position for supinator muscle. The elbow was extended to approximately 0°, the forearm was supinated, and the position was fine-tuned with slight elbow abduction.

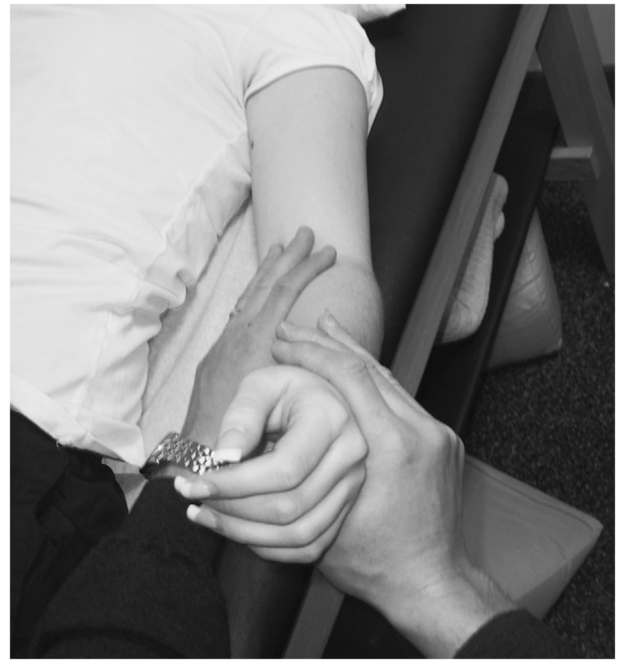

Fig. 5 Sham positioning and forearm palpation. The elbow was flexed to approximately 45°, the forearm and shoulder were held in neutral rotation, and the palpating hand rested on the proximal anterior forearm.

to treatment. Pre-treatment strength data fell within the normal distribution (Shapiro–Wilk, $p > 0.05$), thus despite the small sample size were analyzed using parametric statistical tests. Paired 1-tailed t-tests were used because past findings suggested that strength would increase and not decrease after treatment[28,36]; between-group comparisons of strength changes were analyzed with 1-tailed independent t-test. Significance was set at $p < 0.05$.

Results

The SCS and control groups were comparable at baseline with respect to age, gender, height, weight, and hand dominance ($p > 0.05$). There were no significant differences between the SCS and control groups in initial pre-treatment PRO and SUP strengths ($p > 0.05$) (Table 2).

Within the SCS group, both PRO ($p = 0.009$) and SUP ($p = 0.046$) strengths increased significantly from pre-treatment to the 1-week follow-up measure. After passive sham positioning, the control group had not experienced any significant change in strength in either PRO or SUP during the study ($p > 0.05$) (Table 3). Between-group comparison at follow-up demonstrated that the SCS group had a significantly greater increase in PRO strength compared to the control group ($p = 0.045$). SCS group increase in SUP strength compared to the control group did not reach significance ($p = 0.059$) (Table 3). No other analyses were performed. No adverse events were reported.

Discussion

This study of healthy subjects with forearm tenderness has shown that a 90s passive indirect osteopathic manipulation treatment increased forearm strength. A week after treatment, a strength increase of 8.3% for PRO and 11.9% for SUP was observed in the SCS group, while no strength increase was observed in the control group. Effect sizes for between group differences, from pre-treatment to follow-up ranged from $d = 0.76$ to 0.83, which can be interpreted as large by Cohen's suggested interpretation.[36] (Table 3) The strength increase for both PRO and SUP in the SCS group exceeded the 6 kg used in the

Table 2 Forearm strength group means during the study.

		Pre-tx strength	Post-tx strength	Follow-up strength
Pronation	Control	118.5 ± 32.3	119.2 ± 30.2	118.6 ± 31.7
	SCS	105.0 ± 30.9	99.9 ± 26.2	113.7 ± 34.1
Supination	Control	106.6 ± 20.7	110.8 ± 19.3	105.3 ± 8.8
	SCS	110.3 ± 44.6	114.1 ± 36.7	123.4 ± 36.4

Notes: Values are mean ± SD; SCS = Strain Counterstrain; Pre-tx strength is the measure immediately before the treatment; Post-tx strength is the same-day measurement immediately after the treatment; Follow-up strength is the measure one week after the treatment. Strength is measured in kg.

preliminary power analysis and reported as the minimum to detect "genuine clinical change" for grip strength in a sample of healthy and disabled women.[37] Although grip strength assessment is different than the strength assessment in the current study, the comparison may be useful since grasping the doorknob handle of the dynamometer to assess PRO and SUP strengths do require similar muscle function and no comparable data is available for pronation and supination dynamometry. The statistical significance, effect size, and strength change that exceeded the minimum to detect clinical change in a related strength measure, suggest that forearm strength increase after SCS observed in this study was clinically meaningful.

Increased strength after SCS was consistent with a previous study that documented 41.7–72.5% increase in hip strength after SCS treatment.[28] Wong and Schauer-Alvarez did not report effect sizes for hip strength changes, which ranged from 8.1 to 11.5 kg after SCS treatment.[28] Calculations based on the published results, however, yield effect sizes between groups at follow-up ranging from $d = 0.64$ to 1.16,[28] which were medium to large, as in the current study. The smaller increase in percent strength observed in the current study may exist for several reasons. First, the current study included only one SCS treatment session while the previous study included two SCS sessions.[28] Second, percent changes may reflect differences in how the upper and lower extremities respond to SCS. Finally, difference in the magnitude of the treatment effect may have been influenced by the method of strength assessment. Hip strength assessed with a hand held dynamometer in sidelying position reflects the strength beyond that required to maintain the weight of the lower limb against gravity, which is a minimal issue in forearm strength testing. The sidelying testing position also exposed strength assessment of one hip to the strength or treatment effect of the other hip.[28] The current study involved more rigorous extremity stabilization and standardization of subject position.

In the current study, no instructions were given to subjects after treatment for subjects to follow during the follow-up period. It is unknown whether subjects exercised or engaged in other behavior that may have affected strength during the 1-week follow-up period. Interestingly, the SCS group appeared to experience increased muscle strength after treatment at least until the follow-up assessment compared to the control group whose strength remained fairly constant. Further strength increase observed at follow-up was consistent with the prior study, which showed a further increase of strength after at least 2-weeks in both hip adduction and abduction.[28]

The current study showed increased forearm strength after SCS compared to passive sham positioning received by the control group that was comparable to hip strength increases after SCS compared to exercise in the earlier study.[28] For research investigating manual therapy techniques, control treatments that involve sham touch are critical to differentiate the effects of manual therapy from that of the potential positive influence of simple human touch.[29] The passive sham positioning in the current study involved manual holding of the forearm in the sham position and did not appear to have any effect on strength suggesting that the increased muscle strength observed after SCS can be attributed to the specific SCS positioning rather than simple human touch.

Muscle strength is most commonly increased with exercise, which causes hypertrophy of muscle tissues and increased muscle activation through the facilitation or decreased inhibition of the neuromotor system.[38] Muscle hypertrophy typically requires progressive resistance exercise over periods of at least 8 weeks.[38] Strength gained within two weeks has predominantly been attributed to increased muscle activation[38] due to enhanced recruitment, motor learning, or other mechanism.[39–41]

In the present study, no change in strength was apparent prior to treatment. Significant strength gains were achieved only after the passive indirect

Table 3 Within group changes and between group differences in forearm strength.

	Change pre to post	Within group change	Between group difference & effect size	Change post to follow-up	Within group change	Between group difference & effect size	Change pre to follow-up	Within group change	Between group difference & effect size
	Mean ± SD;	*P*	*P*	Mean ± SD;	*P*	*P*	Mean ± SD;	*P*	*P*
	95% CI		Cohen's *d*	95% CI		Cohen's *d*	95% CI		Cohen's *d*
Pronation control	0.7 ± 9.8;	0.410		−0.6 ± 11.1;	0.566		0.1 ± 11.9;	0.487	
	−6.3 to 7.8			−8.5 to 7.3			−8.4 to 8.6		
Pronation SCS	−5.1 ± 7.6;	0.959	.916	13.7 ± 11.5;	0.004	.007	8.7 ± 8.6;	0.009	.045
	−10.9 to 0.8		−.66	4.9 to 22.6		1.27	2.0 to 15.3		.83
Supination control	4.2 ± 7.8;	0.062		−5.4 ± 15.2;	0.856		−1.2 ± 17.0;	0.588	
	−1.4 to 9.8			−16.3 to 5.5			−13.4 to 10.9		
Supination SCS	3.8 ± 10.9;	0.162	.534	9.3 ± 15.1;	0.051	.025	13.1 ± 20.5;	0.046	.059
	−4.5 to 12.2		−.04	−2.3 to 20.9		.98	−2.7 to 28.9		.76

Notes: CI = confidence interval; SCS = Strain Counterstrain; SD = standard deviation; Pre-tx strength is the measure immediately before treatment; Post-tx strength is the measurement immediately after treatment; Follow-up strength is the measure one week after treatment. Strength is measured in kg.

osteopathic manipulation SCS treatment within a 3-week time span without any exercise, suggesting that the observed strength gain did not result from hypertrophy but rather enhanced muscle activation. Since the control group did not experience any strength change after the sham positioning treatment, the observed changes within and between the groups appear to be the outcome of the SCS treatment.

The explanation for the observed increase in strength achieved through the use of SCS remains unclear. Past authors have suggested three theories by which SCS may affect change: 1) pain reduction, 2) correction of neuromuscular imbalance, or 3) relief of local circulatory dysfunction.[34,35]

Subjects in the current study were asymptomatic and had tenderness only upon palpation. There was no assessment of changes in pain during the study, thus a potential pain reducing effect on pain in this study cannot be addressed. Similar healthy subjects with hip tenderness did demonstrate increased strength and decreased pain in a prior study.[28] However, the changes in strength and pain in subjects receiving SCS were not correlated while the subjects performing only exercise did demonstrate a weak correlation between decreasing pain and increasing strength.[28] Though the results from that study do not support the theory that SCS may increase strength by reducing pain in the related muscle, results may be different in future studies of symptomatic patients.

Neuromuscular imbalance between agonist and antagonist muscles around a joint may persist long after injury[42] and might affect the muscle length—tension relationships and limit muscle performance. However, no consistent correlation was apparent between decreased pain in a muscle agonist and increased strength in its antagonist.[28]

Recent evidence has suggested that SCS may affect neuromuscular function. In a randomized controlled crossover study of patients with plantar fasciitis, SCS applied to the foot and ankle resulted in increased gastroc-soleus generated plantarflexion torque and time to reach peak torque of both the stretch and H-reflex.[43] It is possible that reflex changes and the symptomatic relief of the plantar fascia, with which the gastroc-soleus complex plays a synergistic role, resulted from correction of neuromuscular imbalance around the foot and ankle.[43] Similar results were not achieved in a cohort controlled study of Achilles tendonitis patients.[25] The effect of SCS on the torque of voluntary gastroc-soleus contraction is unknown.

It has been suggested that SCS may affect local circulation[35,44] and thus may affect muscle function. A cadaver study demonstrated that humeral head pressure on the rotator cuff can cause areas of decreased vascularity that can be relieved by placing the tendons in shortened positions[45] similar to the positions used in treating the rotator cuff muscles with SCS.[46] Alternately, since joint effusion has been shown to inhibit muscle function,[47] increased local circulation may reduce swelling leading to increased strength. New evidence has emerged to suggest that SCS may affect local circulation through the inhibition of pro-inflammatory interleukins. For fibroblasts in vitro, indirect osteopathic manipulative treatment decreased pro-inflammatory interleukins potentially suggesting improved healing,[48] though how this would affect muscle strength is unclear. Essentially, there is no evidence to suggest that the healthy subjects with forearm tenderness in the current study experienced increased strength due to circulatory effects.

An emerging theory to explain how indirect osteopathic manipulation technique may alter muscle activation and affect related muscle performance through the potential action of SCS on ligaments has been suggested.[49] Ligaments may function as sensory organs that activate or inhibit synergistic muscle function through a ligamentomuscular reflex to protect the ligaments and assist joint stability, both directly and indirectly connected to the specific ligament.[50] Joint malposition may cause aberrant ligamentous tension that may in turn alter related muscular response, thus a correction of such malposition may relieve ligamentous tension and result in restoration of normal muscle function, potentially observed as strength increase. Such a mechanism may explain the observed phenomenon of strength increases in related muscle function after both direct[51,52] and indirect osteopathic manipulative treatment,[28] such as that observed in the current study.

More research is needed to explore the mechanism by which SCS can increase muscle strength. The results of this study should not be generalized as the findings are limited by the small sample size and selection of asymptomatic subjects. Strain counterstrain treatment has typically been applied to those with musculoskeletal dysfunction with reported clinical benefits that include decreased pain, and increased range-of-motion and strength. The current study included subjects who had tenderness at the tender points related to PRO and SUP, but otherwise had no dysfunction. The benefit of SCS treatment for these subjects may be more limited than for people with specific musculoskeletal dysfunctions such as epicondylitis. Future studies should employ larger samples that include symptomatic populations in order to generalize findings to a wider clinical population. This study could also have been strengthened by use of a pressure gauge to standardize palpation force during screening and assessments and evaluation of the blinding method. To provide information more relevant to clinical decision-making, further research should include clinical populations with functional outcomes and longer-term follow up.

Conclusion

Forearm strength increased after SCS treatment in a healthy population with tenderness of the PRO and SUP muscles, consistent with a past report of gains in hip strength.[28] Compared to a sham treatment of manual passive positioning, forearm strength increased in the SCS group. While the mechanism through which SCS acts remain unknown, results of this study suggest that SCS may be useful in the treatment of forearm weakness. The role of SCS to increase strength and function in symptomatic samples should be investigated.

Author contribution statement

CKW conceived the idea for the study. All authors contributed to the design and planning as well as the data collection of the research. CKW analyzed the data and together with NM wrote the first draft of the manuscript. All authors edited and approved the final version of the manuscript.

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Conflict of interest

The authors have no conflicts of interest that could influence this work.

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