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The effect of bidirectional rotation of an acupuncture needle at LI10 on acupuncture needle sensation and experimentally induced contact heat pain in healthy human volunteers

Authors:

Alex Benham^{1,2,3} (Ph.D)

Mark I Johnson^{1,3} (Ph.D)

Affiliations:

1. Faculty of Health and Social Sciences, Leeds Metropolitan University
2. Bradford Institute of Health Research, Bradford Royal Infirmary
3. Leeds Pallium Research Group, www.leeds.ac.uk/pallium

Address for correspondence:

Professor Mark I. Johnson

Faculty of Health and Social Sciences

Leeds Metropolitan University

Civic Quarter

Leeds LS1 3HE

United Kingdom

Telephone: (UK) @0113 2832600

Fax: 0113 2833124.

e-mail M.Johnson@Leedsmet.ac.uk

ABSTRACT

Introduction: There is insufficient evidence of a relationship between acupuncture needle sensations (deqi), and hypoalgesia. The aim of this study was to investigate the effects of bidirectional needle rotation at LI10 on acupuncture needle sensations and heat pain thresholds.

Methods: Twenty-two human participants received one acupuncture needle at LI10 with bidirectional rotation of the needle in one experimental session and one acupuncture needle at LI10 with mock rotation in a separate session, in a randomised order. Measurements of heat pain thresholds were taken before needle insertion, during needle retention and 15 minutes after needle removal. At each measurement time point, participants rated needle sensations using the Massachusetts Acupuncture Sensation Scale (MASS) and a visual analogue scale (VAS) of overall intensity of needle sensation.

Results: Bidirectional needle rotation produced significantly higher scores for VAS, MASStotal, MASSpain and MASSsensation compared with mock rotation (all $P < 0.001$). There were significantly higher pain thresholds relative to pre-intervention baseline during ($p = 0.014$) and post ($p < 0.001$) bidirectional needle rotation but not during ($p = 0.1$) or post ($p = 0.62$) mock bidirectional needle rotation. Bidirectional needle rotation elevated pain threshold relative to baseline 15 minutes after needles were removed ($p = 0.009$). A significant, yet low, correlation between needle sensation and change in pain threshold post-needling was only found when data from mock and rotation interventions were combined.

Conclusion: Needle rotation increased the magnitude of hypoalgesia. There was tentative evidence that needle sensation may be associated with the amount of change in pain threshold.

Keywords:

Acupuncture, pain, hypoalgesia, acupuncture needle sensation, de qi, experimental pain

INTRODUCTION

Manipulation of acupuncture needles is used to increase the intensity of stimulation to improve hypoalgesia. It has been suggested this may be due to coupling between the needle and sensory receptors and/or their axons and that this phenomenon may be reflected in acupuncture needle sensations, sometimes referred to as de qi (1-3). Research on the topic is sparse (4), although White and colleagues (5) found that the intensity of needle sensation was not correlated with pain relief in patients with osteoarthritis of the hip and knee. Recently, Park et al (6) concluded that there was insufficient research to determine whether there was a relationship between treatment effect and acupuncture needle sensations.

Studies investigating the effects of needle manipulation on experimental pain have been conflicting with studies failing to detect superior effects for manual acupuncture compared with controls (7). Bidirectional rotation of a needle inserted at Large Intestine 10 (LI10) has been shown to generate more intense needle sensations than mock bidirectional rotation (4, 8). Needle sensations were both painful and non-painful. Brain imaging studies have found that painful needle sensations were associated with activation in areas of the brain involved in pain processing and may reflect poor needling technique, whereas non-painful acupuncture needle sensations have been found to deactivate areas of the brain involved in pain processing, suggestive of hypoalgesia (9-13).

Kong et al (14) reported that manual acupuncture reduced experimentally induced thermal pain in 11 healthy participants and that this was related to needle sensations of numbness and soreness, but not stabbing, throbbing, tingling, burning, heaviness, fullness, or aching. Recently, Choi et al (15) reported that deep needling with manipulation significantly increased pressure pain thresholds compared with superficial needling and deep needling. Also, deep needling did not increase pain thresholds compared with superficial needling.

The aim of the present study was to investigate the effects of bidirectional rotation of a needle inserted into 'deep' tissue at LI10 on acupuncture needle sensations and experimentally induced contact heat pain.

METHODS

A cross-over design was used where all participants received both deep acupuncture with bidirectional rotation of the needle in one experimental session, and deep needling without

stimulation (mock rotation) in the other session. The order of interventions was randomised for each participant to control for order effects.

Recruitment and Selection

Twenty two, unpaid, healthy human volunteers aged over 18 were recruited from staff and students at Leeds Metropolitan University using announcements in lectures. Individuals expressing an interest in the study were invited to attend a familiarisation session where they were given a participant information pack. During the familiarisation session, volunteers were screened and excluded if they had a chronic medical condition, a fear of needles causing severe anxiety or any skin disorders in the area surrounding the LI10 acupuncture point. They were given an opportunity to experience the experimental pain procedure and to have an acupuncture needle inserted into the Large Intestine 4 (LI4) point which was away from the point used in the experiment (all volunteers took up this offer). Volunteers were then invited to take part in the experiments and were given a minimum of 48 hours to consider whether they wished to participate. Institutional ethical approval was obtained and volunteers were enrolled by providing written consent. Participants were informed that they could withdraw consent at any time and without reason.

Procedures

Participants took part in two identical experimental sessions. They received acupuncture with bidirectional rotation of the needle in one session and acupuncture with mock bidirectional rotation of the needle in the other. They were told that needling may produce sensations and that these may or may not cause some discomfort. Computerised block randomisation was used to determine the order of the rotated and mock rotated interventions. A wash out period of at least 72 hours was used between interventions to allow any minor bruising from needling in the first experimental session to subside. If tenderness in the area was reported at the second visit then it was planned that the second experimental session would be postponed to a later date. This did not happen for any participant. Participants lay on a plinth with their head elevated and their non-dominant hand supported on a table to the side of the plinth. A screen was used to conceal the acupuncture procedures. The acupuncture intervention was administered by the principal investigator (AB) who is an acupuncture trained physiotherapist and was not blind to the intervention allocation but was blind to the responses given to all of the assessment measures.

Experimental sessions lasted 30 minutes and consisted of a baseline measurement of pain threshold followed by a 15 minute acupuncture intervention. During acupuncture, needles were inserted and the acupuncturist performed either deep needling with rotation or deep

needling with mock needle rotation for 10 minutes. Measures of acupuncture needle sensation and heat pain threshold were taken in the remaining 5 minutes with the needle in situ. Needles were then removed and needle sensation and pain threshold measures were taken for a further 15 minutes (Fig 1).

[Insert Figure 1 here]

Interventions

In both sessions, one single use, sterile, disposable acupuncture needle (C&G, UK, 40mmx0.25mm) was inserted at LI10 of the non-dominant forearm using a guide tube.

Bidirectional Needle Rotation

The rotated intervention consisted of a needle being placed directly into the deep, soft tissues of the forearm to a depth of approximately 15mm-25mm determined by inserting the 40mm needle to approximately half of its length. The needle was rotated approximately 360° clockwise followed by 360° anticlockwise at approximately two rotations per second (i.e. 2Hz) for 30 seconds followed by 30 seconds of no rotation. This procedure was carried out every minute for 10 minutes.

Mock Bidirectional Needle Rotation (Control)

An identical procedure was used for inserting and removing the needle during the mock rotation intervention, except the investigator did not touch the needle after it had been inserted. Bidirectional rotation was imitated behind a screen placed over the arm out of view of the participant. Mock rotation was performed by rotating an empty guide tube between the thumb and index finger clockwise and anticlockwise at a frequency of 2Hz for 30 seconds followed by 30 seconds of no rotation for a total of 10 minutes. The guide tube did not touch the participant's skin and the investigator's arm remained behind the screen and out of view of the participant.

Outcome measures

Acupuncture Needle Sensations

Participants were asked to quantify the overall intensity of acupuncture needle sensation on a 100mm visual analogue scale (VAS) that stated "During acupuncture, I felt a sensation at the acupuncture point as ..." (0mm="not at all", 100mm="very strong"). In addition, participants completed the Massachusetts Acupuncture Sensation Scale (MASS) which uses twelve, 100mm VAS to quantify the intensity of overall needle sensations (MASSTotal) with ten sub scales for non-painful sensations (soreness, aching, deep pressure, heaviness,

fullness/distension, tingling, numbness, warmth, cold and throbbing, “MASSsensation”) and two painful sensations (dull pain and sharp pain “MASSpain”). Participants completed these out of view of the investigator.

Heat Pain Threshold

A TSA-II Neurosensory Analyser (Medoc Ltd, Israel) was used to administer heat stimuli across onto the skin of the dorso-lateral aspect of the forearm. Heat stimuli were administered using a 30x30mm thermode placed on to the surface of the skin approximately 5cm distal to the location of the needle and secured for the duration of the experiment via a Velcro strap. Heat pain threshold was determined using the method of ascending limits with temperature starting at 32°C and rising at a rate of 1°C/s until the participant experienced the first pain sensation, at which point they pressed a response button which stopped the stimulus. Standardised instructions were read at the start of each set of four pain measurements and the mean of these were used for analysis.

Data Analysis

A sample size was calculated using data from a previous study using contact heat pain which found that 21 participants would be needed to detect a difference of 3°C with a standard deviation of 3.3, an α of 0.05 and a β of 0.8 (20). To allow for 5% attrition a target sample of 22 participants were used.

A within-subject, 3x2 factorial repeated measures ANOVA was performed on heat pain threshold. Factors were Time (three levels; baseline, during needling [at 15 minutes] and post needling [at 30 minutes]) and Intervention (two levels; rotation and mock rotation intervention). The order (sequence) of receiving rotation or mock rotation was used as a between-subject factor (two levels; rotation and mock rotation). If Mauchly's test showed Sphericity could not be assumed then a Greenhouse-Geisser correction was used. Alpha was set at 0.05, beta at 0.2 (i.e. power of 0.8) and adjustment were made for multiple comparisons using the Bonferroni correction.

RESULTS

Twenty two volunteers expressed interest in taking part in the study. All took part in the familiarisation session and completed both experimental sessions (11 male, mean age (SD) 25.05 (4.32) years).

Intensity of Needle Sensation

There were significantly higher scores for VAS ($P<0.001$), MASStotal ($P<0.001$), MASSpain ($P<0.001$) and MASSsensation ($P<0.001$) for the bidirectional needle rotation intervention compared with mock bidirectional rotation (Table 1).

Table 1: The mean (SD) scores for each of the 4 measures of needle sensation for both of the interventions. (Numbers in bold indicate statistically significant findings).

| | VAS | MASStotal | MASSsensation | MASSpain |
|----------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| Mock rotation group | 25.09 (15.24) | 174.86 (104.87) | 149.77 (86.94) | 25.09 (22.54) |
| Rotation group | 55.86 (13.88) | 300.90 (136.39) | 252.6818 (117.44) | 48.22 (28.02) |
| Significance | $p<0.001$ | $p<0.001$ | $p<0.001$ | $p<0.001$ |

Heat Pain Threshold

Mauchley's test showed that Sphericity of the heat pain measures could not be assumed and so Greenhouse Geisser corrections were used. There were no between subject effects for the order (sequence) in which the participants received the interventions ($F(1, 20) 1.14$, $p=0.298$). Significant effects were detected for Time ($F(1.52, 30.42) 17.62$, $p<0.001$) but not Intervention ($F(1, 20) 0.46$, $p=0.505$). Significant effects were detected for Time by Intervention interaction ($F(1.37, 27.30) 6.17$, $p=0.012$).

There were no significant differences in pain threshold between bidirectional needle rotation and mock bidirectional needle rotation interventions at baseline ($p=0.98$) or during needling ($p=0.830$). Fifteen minutes after the removal of needles pain threshold was higher in the bidirectional needle rotation intervention compared with the mock bidirectional needle rotation intervention (post needling, $p=0.009$) (Table 2). Pairwise comparisons found that pain threshold relative to pre-intervention baseline was significantly higher during ($p=0.014$) and post ($p<0.001$) bidirectional needle rotation but not during ($p=0.1$) or post ($p=0.62$) mock bidirectional needle rotation (Table 2, Figure 2).

[Insert Fig 2 here]

Table 2: Post-test statistical comparisons of the change in pain threshold from baseline and the difference between the two groups throughout the experiment (Numbers in bold indicate statistically significant findings.)

| | Baseline | Mean (SD) change in pain threshold during needling °C | Significance value of change in pain threshold from baseline during needle retention | Mean (SD) change in pain threshold from baseline post needling °C | Significance value of change in pain threshold from baseline post needling |
|--------------------------------------|--------------|-------------------------------------------------------|--------------------------------------------------------------------------------------|-------------------------------------------------------------------|----------------------------------------------------------------------------|
| Deep with rotation intervention | 44.18 (1.44) | 0.79 (1.14) | p=0.014 | 2.43 (1.94) | p<0.001 |
| Deep with mock rotation intervention | 44.81 (2.14) | 0.27 (1.42) | p=0.1 | 0.46 (1.65) | p=0.62 |
| Comparison between interventions | P=0.098 | p=0.83 | | p=0.009 | |

Relationship between the Intensity of Needle Sensation and Hypoalgesia

There were no significant correlations between pain threshold relative to baseline post needling and overall intensity of needle sensation (VAS) for bidirectional needle rotation ($r=0.41$ $p=0.857$) or mock bidirectional needle rotation ($r=-0.41$ $p=0.85$). A significant correlation was found between the change in pain threshold relative to baseline and the intensity of needle sensation when data from both real and mock bidirectional needle rotation were combined (VAS, $r=0.36$ $p=.014$). This relationship can be seen in Fig 3.

[Insert Figure 3]

DISCUSSION

The findings of this study showed that a single acupuncture needle inserted at LI10 with bidirectional rotation increased heat pain threshold 15 minutes after removing the needle when compared with mock rotation. The mock bidirectional needle rotation intervention controlled for non-specific effects associated with receiving an intervention and enabled us to isolate effects attributable to the bidirectional needle rotation per se. Therefore, we are confident that the elevation in pain threshold after receiving bidirectional rotation was due to a specific physiological action. Our study failed to detect a correlation between the intensity of needle sensation and the change in pain threshold relative to baseline post needling when the two interventions were analysed separately. Further analysis found that when both interventions were combined there was a significant, yet low, correlation between needle sensation intensity and change in pain thresholds from baseline.

In our study, rotation of the needle was attributed to an elevation of heat pain threshold and supports the view that needles should be manipulated to elicit hypoalgesia (1,16). Choi et al (15) investigated the relationship between acupuncture needle sensation and pressure pain threshold during superficial needling (0.3 cm), deep needling (2 cm) and needling with bidirectional rotation on 53 healthy volunteers. They found that bidirectional rotation produced the largest increase in pressure pain threshold and the highest “total acupuncture sensation”, followed by deep needling and superficial needling. Our study included a mock bidirectional needle rotation intervention in order to isolate effects attributable to the bidirectional needle rotation and are were consistent with Choi et al (15). This adds further evidence that bidirectional rotation has an important role in hypoalgesia.

Divergence of hypoalgesia between real and mock needle rotation increased across the time course of our experiment and was most apparent post needling, suggesting a delay in the development of hypoalgesic effects over and above that seen by mock rotation. This is of interest as the difference from baseline was not significantly different between interventions during needle retention but was sufficient to reach statistical significance 15 minutes after needles had been removed (post needling). This delay suggests that a centrally mediated endogenous analgesic mechanism (e.g. activation of descending inhibitory pain pathways) may be elicited by needling rather than a local, stimulation specific analgesic mechanism. It would have been interesting to see if the difference in pain thresholds between the real and mock rotation may have increased further if the experiment was continued for a longer period of time.

White et al (17) suggested that at least four needles, inserted for at least 20 minutes, and eliciting needle sensation is a pre-requisite for an adequate dose of acupuncture. The intervention applied in this study was specifically intended to provide fewer needles, for less time and with the minimum manipulation required to provide a strong needle sensation so that the individual contribution of needle sensation could be isolated as much as possible. Overall acupuncture needle sensation intensity was similar between this study (55.86 (13.88) mm (mean (SD))) and that of Choi et al (15) who reported approximate intensities of 50mm. We used one needle that was rotated for 10 minutes followed by 5 minutes of no rotation, whereas Choi et al (15) administered acupuncture using 4 needles (Spleen 6 (SP6), Spleen 9 (SP9), Stomach 36 (ST36) and Gallbladder 39 (GB39)), although the interventions only lasted 5 minutes. Whether there were differences in the area of distribution of the needle sensations between the studies is not known. An interesting and testable hypothesis for future studies could be that greater numbers of needles generate larger areas of needle sensation and whether this is related to the area of hypoalgesia.

At present there is insufficient evidence to determine whether acupuncture needle sensation is related to pain relief in clinical practice (18). Recently, Spaeth et al (19) found that acupuncture generated stronger needle sensations (de qi) and better clinical outcomes in patients with chronic pain from knee osteoarthritis than sham acupuncture. White et al (5) conducted a secondary analysis of data from a single-blind, randomised controlled trial and found that the presence and intensity of needle sensations (de qi) did not influence osteoarthritic knee pain. Therefore, further clinical studies are warranted to support the increasing number of healthy human studies characterising needle sensation, investigating the physiological basis of the phenomenon and evaluating the relationship with hypoalgesia.

The mean (SD) magnitude of change at post needling in the rotation intervention was 2.43°C (1.94) which is less than the 3°C that our study was powered to detect. This suggests that our study may have been underpowered or that the power calculation was insufficient for the intended study design and so results must be interpreted accordingly. The intended change used in the power calculation was chosen from previous studies that have reported meaningful changes in heat pain thresholds. Differences in pain threshold between real and mock rotation were diverging at the termination of the experiment and therefore a larger magnitude of difference may have been apparent if a longer duration experiment had been conducted. Methodological challenges in quantifying needle sensation experience have been described by other investigators and this may have contributed to redundancy in the higher scale-end of needle sensation scales (5, 14). It is also possible that needle sensation

has no role in a therapeutic response or pain relief and more studies on healthy humans are needed.

The weak association between needle sensation intensity and change in pain threshold post needling suggests that needle sensation intensity may be indicative of hypoalgesic effects. However, the exploratory nature of this analysis means that no firm conclusions can be drawn. This is an area that warrants further research.

In conclusion, bidirectional rotation of an acupuncture needle inserted to a depth of 15-25mm at LI10 increased heat pain thresholds when compared with mock bidirectional rotation suggesting that needle rotation increases the magnitude of hypoalgesia. A weak positive correlation was detected between needle sensation intensity elicited during bidirectional rotation and the magnitude of change of pain threshold. Assay sensitivity and inadequate length of post needling measures may have contributed to this weak relationship. Further studies using more needles that are rotated and left in situ for longer periods of time with extended duration of the measurement phase are planned.

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Legends to Figures

Figure 1

Timeline of experimental procedures at each time point across the experiment

Figure 2

Mean (mm) heat pain threshold for each intervention across all experimental time points

Figure 3

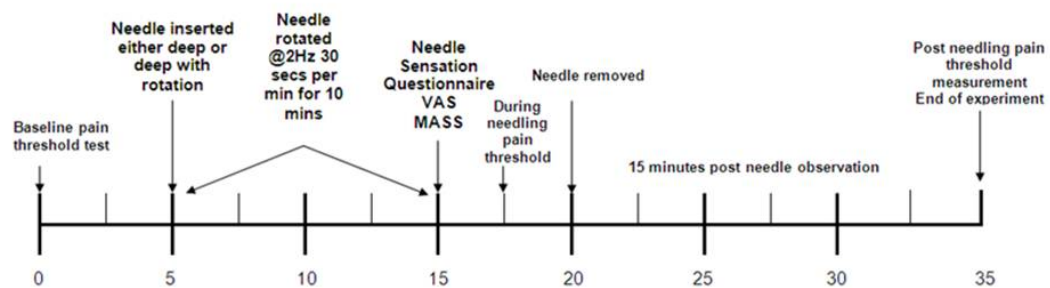
Scatter plot of the association between needle sensation intensity (mm) and change in pain threshold ($^{\circ}\text{C}$) at the final experimental time point

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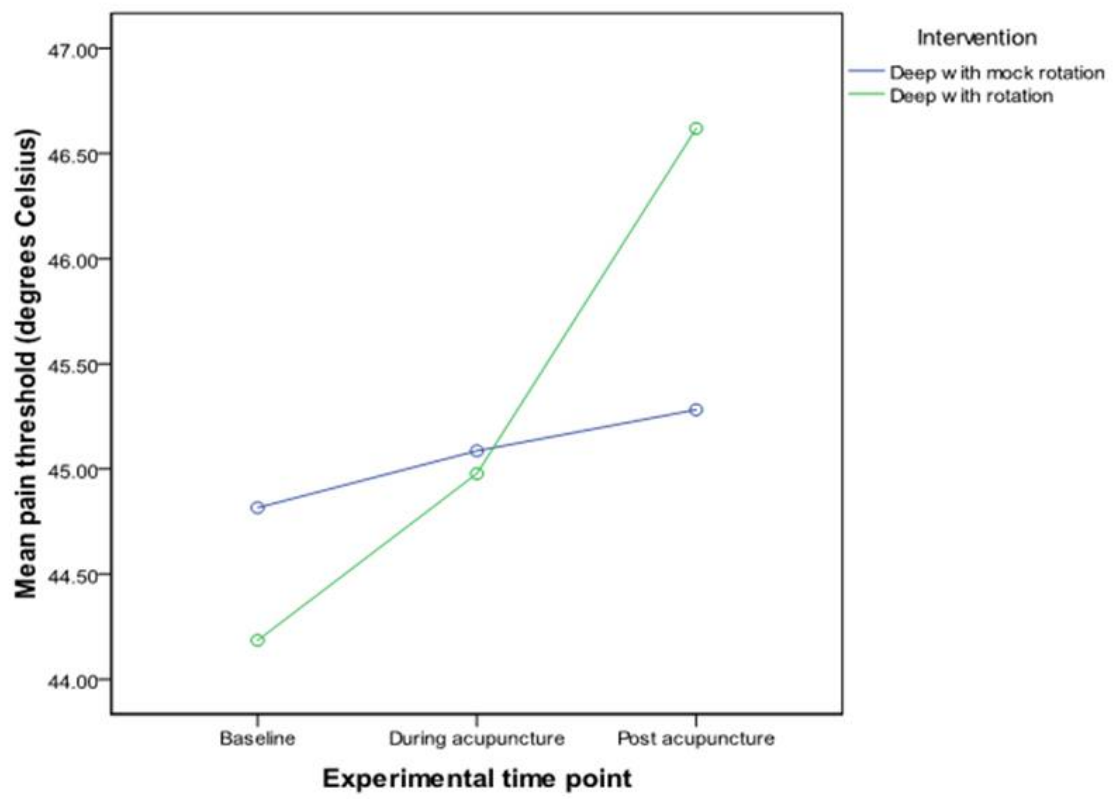
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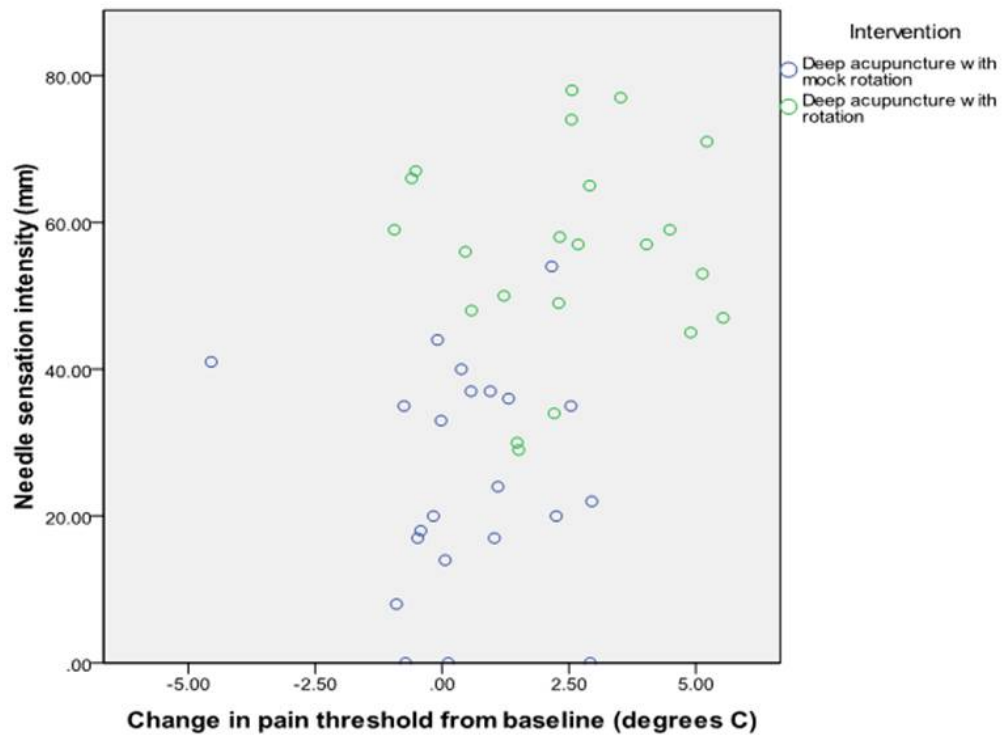
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