Journal of Bodywork & Movement Therapies 24 (2020) 271–279

Contents lists available at ScienceDirect

Journal of Bodywork & Movement Therapies

journal homepage: www.elsevier.com/jbmt

Myofascial Pain and Treatment

# Short term relief of multisite chronicpain with Bowen Therapy: A double-blind, randomized controlled trial

Kiho Lee [a], Gwyn N. Lewis [b, *]

[a] Otago Bowen Therapy, Dunedin, New Zealand
[b] Health and Rehabilitation Research Institute, Auckland University of Technology, Auckland, New Zealand

ARTICLE INFO

*Article history:*
Received 15 May 2019
Received in revised form
27 February 2020
Accepted 7 June 2020

*Keywords:*
Bowen therapy
Chronic pain
Quantitative sensory testing
Autonomic nervous system

ABSTRACT

*Introduction:* Bowen Therapy, a form of soft tissue manipulation, is commonly used to treat musculoskeletal conditions; yet, there is little evidence for its efficacy. The goal of the study was to investigate the impact of Bowen Therapy on pain and function in people with chronic pain in multiple locations. Additionally, we examined the mechanisms of effect through monitoring the nociceptive and autonomic nervous systems.

*Method:* The study was a double-blind, randomized controlled trial involving 31 people with chronic pain. Participants were randomized into real and sham therapy groups. Each group received 6 sessions of therapy over 8 weeks. The primary outcome measures of pain and function were assessed using standard questionnaires. Quantitative sensory testing was used to assess the nociceptive system, while recordings of heart rate variability and skin conductance were used to assess the autonomic nervous system. Outcome measures were assessed at baseline and at 1- and 6-weeks following completion of the intervention.

*Results:* The real therapy group had a significantly lower pain score 1-week following the intervention compared to the sham group. There were no differences between groups at the final follow-up or in the function measures. There was no significant change in the nociceptive measures but there was evidence of increased activation of the sympathetic nervous system.

*Discussion:* Bowen Therapy gave rise to a short-term reduction in pain that was not evident in a sham therapy group. The mechanisms of action of Bowen Therapy remain uncertain but may involve sympathoexcitation.



## 1. Introduction

Bowen Therapy (also known as Bowen Technique and Bowenwork®) is a type of manual therapy that entails a unique manner of soft tissue manipulation. It is named after Thomas Bowen, a manual therapist who practiced in Victoria, Australia from 1959 to 1982. The technique of Bowen Therapy is based on accounts of Bowen's practice by people who observed his work, and the name was not coined until after his death. Bowen did not leave any notes on his practice and not all of the interpretations of Bowen's work are congruent, thus there are different Bowen Therapy approaches in use today (Pennington, 2012). In a Bowen Therapy session, a series of precise, gentle pressure moves, called Bowen moves, are applied with the thumbs and fingers onto specific points of muscles, tendons, ligaments, and myofascial tissue. The moves are interspersed with pauses of 2–5 min to allow time for the body to respond. The most common use of Bowen Therapy is for musculoskeletal conditions, but it has also been indicated for respiratory, gastrointestinal, and endocrine disorders (Long et al., 2001).

Studies regarding the clinical efficacy of Bowen Therapy are sparse (Hansen and Taylor-Piliae, 2011). To date, there have been no high-quality trials examining the effects of Bowen Therapy in clinical populations. A non-controlled experimental study in breast cancer survivors showed improvements in mental health and range of movement following treatment, although physical health and pain were unaffected (Argenbright et al., 2016). A similar non-controlled study in people with frozen shoulder found some benefits in pain and range of movement, but there were no group statistics presented (Carter, 2001). Finally, a case series involving

* Corresponding author. , Health and Rehabilitation Research Institute, Auckland University of Technology Private Bag 92006, Auckland, 1142, New Zealand.
*E-mail address:* gwyn.lewis@aut.ac.nz (G.N. Lewis).

https://doi.org/10.1016/j.jbmt.2020.06.025
1360-8592/

people with chronic stroke reported improved motor function and quality of life after 13 sessions of Bowen Therapy, but, again, there was no control group (Duncan et al., 2011). In a healthy population, one randomized controlled trial has shown an improvement in hamstrings flexibility following a single session of Bowen Therapy (Marr et al., 2011).

There is even less data on the physiological effects of Bowen Therapy. There are largely unsubstantiated claims that it acts through effects on fascia, muscle, and cutaneous sensory receptors that give rise to a rebalancing of autonomic nervous system (ANS) activity, muscle relaxation, altered myofibroblast activity, and changes in the type of collagen (Hansen and Taylor-Piliae, 2011; Wilks, 2013). These hypotheses have not been investigated in healthy or clinical populations.

Given the lack of high quality studies investigating the therapeutic effect of Bowen Therapy or any investigations of the mechanisms of any such effects, the goal of the present study was to determine the effect of an 8-week Bowen Therapy intervention on pain and function in people with chronic pain. The majority of people with chronic pain report pain at more than one location (Buchman et al., 2010; Cho et al., 2012; Patel et al., 2013), and this is associated with a greater impact on function (Buchman et al., 2010; Patel et al., 2013). To reflect this important clinical feature of the chronic pain population, the study involved people who reported pain in multiple locations. We additionally measured the function of the nociceptive system using quantitative sensory testing (QST) and the ANS through recordings of heart rate and skin conductance. Studies using QST have shown previously that populations with chronic pain are more likely to have a nociceptive system that is pro-nociceptive (Staud et al., 2001; Maier et al., 2010; Arendt-Nielsen et al., 2015); that is, there is an enhanced facilitation and/or reduced inhibition of nociceptive signals, and that this may normalize following treatment (Graven-Nielsen et al 2000, 2012; Volz et al., 2016). Additionally, a disruption in ANS function is evident in many chronic pain conditions, including widespread pain, where there is excessive activation of the sympathetic nervous system in comparison to the parasympathetic nervous system (Tracy et al., 2016). We hypothesised that improvements in pain and function following Bowen Therapy would be accompanied by reduced pro-nociception and facilitated parasympathetic nervous system activity.

## 2. Methods

The study was a double-blinded, randomized controlled trial with sham and real therapy groups. It was undertaken in a university setting. The participants and the investigators obtaining the outcome measures were blinded to group allocation until after the final assessment session. The trial was registered on the Australian New Zealand Clinical Trials Registry (#12615000364572; http://www.anzctr.org.au). After the initial recruitment drive, a third arm involving usual care was removed from the design due to low participant recruitment. Ethical approval for the study was obtained from the Health and Disability Ethics Committee (#15CEN59AM02) with local approval from the Auckland University of Technology Ethics Committee (#16/38). Participants provided informed written consent prior to involvement in the study.

### 2.1. Participants

Participants were 31 people who experienced chronic pain. Sample size was based on the detection of a 30% reduction in pain, deemed a meaningful change (Dworkin et al., 2005). Based on previous studies involving chronic pain conditions (Fregni et al., 2006; Soler et al., 2010; Wrigley et al., 2013), this would represent an approximate change in pain rating of 2 on a 0–10 scale and correspond to an effect size of 1. Using this effect size with $\alpha = 0.05$ and $\beta = 0.2$, a sample size of 28 participants (14 per group) was determined. Sample size was increased to 15 per group to allow for participant drop out over the study.

Participants were required to be 18–85 years of age, have stable pain for the preceding 3 months, be taking consistent analgesic medication, report a pain score $\geq$3/10 on most days, and have pain in multiple locations. Pain in multiple locations was defined as pain in the upper limbs or neck as well as pain in the lower limbs or back. Participants were excluded if they had severe or unstable medical or psychiatric conditions, were incapable of mounting and dismounting the therapy table without significant assistance, or were unable to provide informed consent.

Participants were recruited from advertisements in local papers and flyers placed around a university campus. Recruitment was undertaken from November 2016–July 2017. Forty-eight people expressed interest in the study, of which seven were excluded and 10 declined to participate (Fig. 1). Before beginning the study, we required at least 2-weeks free from any other physical treatments. Participants were asked to stay on their normal analgesic medication during the treatment period and to not begin any new pain treatments for the duration of the study.

During the study, the term “Bowen Therapy” was not used with participants and was instead referred to as “a type of manual therapy”. Participants were provided with a list of 11 different types of physical therapies, which included Bowen Therapy, and were asked to indicate which therapies they had received previously. Participants who had indicated they had previously received Bowen Therapy were excluded from the study.

### 2.2. Interventions

Participants were randomized into two groups (real, sham) using a random number generator (Excel) by an experimenter not involved in participant recruitment.

Participants in both groups received six sessions of therapy. The initial three sessions were weekly and the final three sessions were fortnightly, with each session lasting 45–60 min. Both interventions were delivered by two Bowen Therapy practitioners with 12- and 18-years’ clinical experience. The therapists were trained together in the sham therapy technique and both therapists delivered both interventions. Each participant was randomly allocated to one of the practitioners who delivered all of the 6 Bowen or 6 sham therapy sessions. Of the two therapists involved in the study, one provided treatment to 8 participants (50%) in the real therapy group and to 9 in the sham group (60%), while the other provided treatment to 8 participants (50%) in the real therapy group and 6 in the sham group (40%).

Both real and sham therapy sessions were delivered in a temperature-controlled room (21 $\pm$ 1 °C) at a university campus. All sessions followed an individually tailored protocol to reflect the way that Bowen Therapy is delivered in real-life practice. The Bowen or sham moves were applied to both the left and right sides of the body as a pair with a 2–5 min pause between a set of moves. Each set was composed of 2–8 Bowen or sham procedures (Bowen Therapy Academy of Australia, 2013). Longer pauses were utilized when the body of the participant was still reacting to the procedures applied. The Bowen moves consisted of four steps of patterned manoeuvre (Fig. 2) and were performed over light clothing or directly on the skin surface. Initially, the fingers were located onto the starting point with minimum pressure, and then the skin was engaged laterally or medially. Following this, downward pressure was applied to sink the tissue and held for 3–4 s to challenge the target tissue. Finally, the fingers were moved across

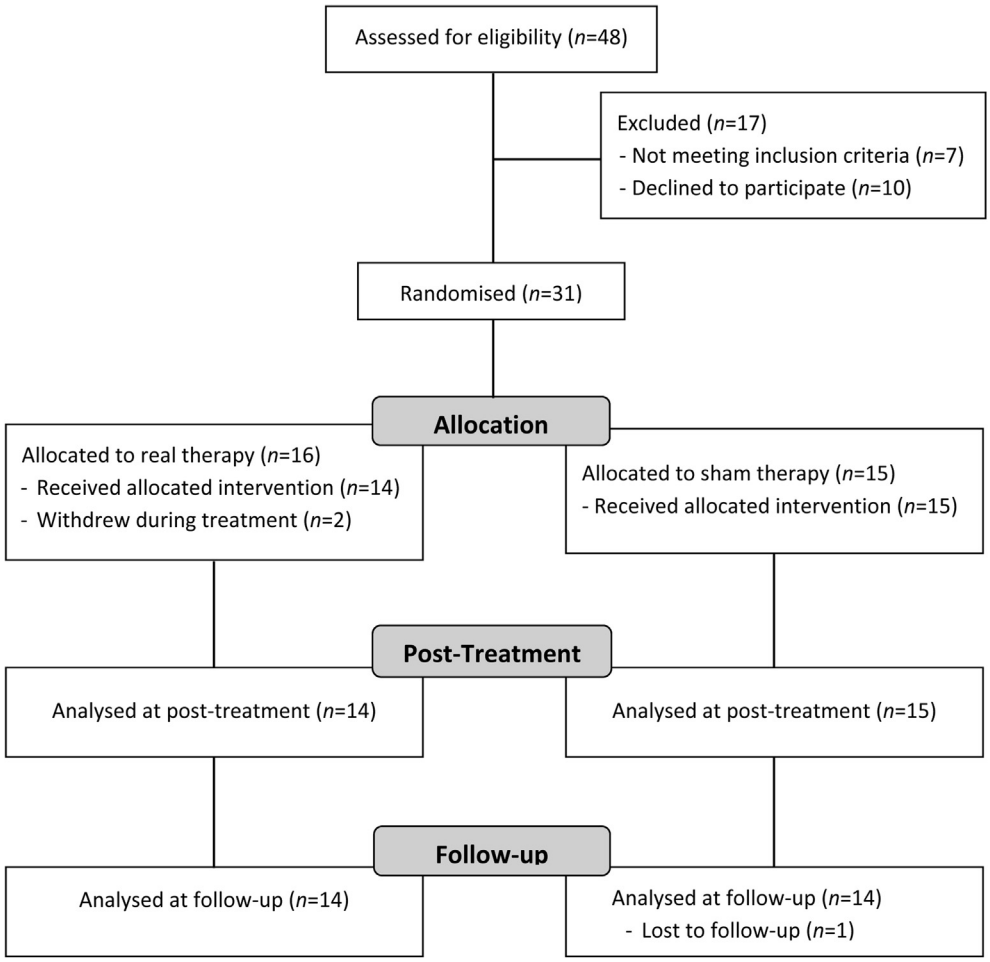


**Fig. 1.** Participant flow during the study.

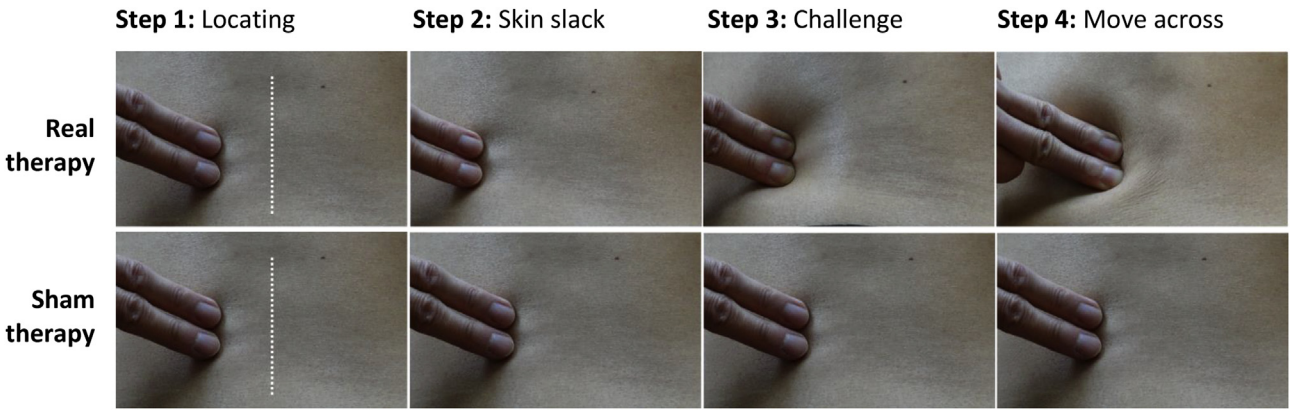


**Fig. 2.** The four steps of the Bowen move. The sham therapy group did not progress further than Step 1.

the target tissue while maintaining pressure to disturb the underlying tissues. In the group receiving sham therapy, the fingers were held in position for 5–10 s without progressing to the later steps of the Bowen move.

The basic relaxation procedures (BRM 1, 2, 3) were applied in each session as a common baseline treatment. Additional procedures were chosen from the following, based on the presenting symptoms of the participant on the day: temporomandibular joint, coccyx, pelvic, sacral, psoas, knee, ankle, hamstring, shoulder, infraspinatus, elbow, wrist, chest, respiratory, sternal, navel, colon, and abdominal procedure. The treatment protocol of each session was tailored for the individual participant. The combination, sequence and number of the procedures, length of break times, and total session duration were decided in consideration of the presenting clinical conditions and how these evolved across the treatment session. Standardized instructions were given to the participants before and following each session. Participants were encouraged to walk, drink plenty of fluids, and avoid strenuous resistance exercise after the treatment. Hot sauna or spas up to 24 h before and after treatment were discouraged.

### 2.3. Outcome measures

The outcome measures were obtained by a blinded assessor immediately prior to the first treatment session (baseline), approximately 7 days following the last treatment session (post-treatment; mean 6.3 ± 2.5 days), and at 6-weeks following the last treatment session (follow-up).

The primary outcome measures assessed pain and function. Pain was assessed using a numerical rating scale (NRS) from 0 (no pain) to 10 (worst pain imaginable) and the Short-Form McGill Pain Questionnaire II (SFMPQ-II). For the NRS, participants were asked to focus on their most painful area and provide an average pain rating over the last week. Function was assessed separately for the upper and lower limbs using the Disabilities of the Arm, Shoulder and Hand (DASH) and the Lower Limb Tasks Questionnaire – Activities of Daily Living section (LLTQ), respectively. Both are valid, reliable, and responsive self-report questionnaires designed to measure physical function (Beaton et al., 2001; McNair et al., 2007).

Secondary outcome measures assessed the nociceptive system using QST and the ANS using heart rate variability and skin conductance. Mechanical pain threshold and temporal summation of pain were assessed in an area of primary pain and at a distant, non-painful site to evaluate both local and widespread nociceptive system function. The sites were individually chosen from eight standardized locations (scapula, toe, lower back, hand, shin, knee, abdomen, forearm) and kept consistent for each individual across the test sessions. To assess mechanical pain threshold, pressure was applied at a constant rate (30 kP/s) using a handheld pressure transducer with a 1 $cm^2$ rounded probe until the participant indicated the sensation of pain. The average of two recordings was taken at each location. To assess temporal summation of mechanical pain, ten standardized punctuate stimuli were applied using a 225.1 g Von Frey filament at a frequency of 1 Hz to the skin overlying the sites. Participants were asked to rate the pain intensity of the first and last stimuli on a 0–100 verbal numerical pain rating scale, with the difference in pain rating between the last and first stimuli determined as the amount of temporal summation (Weissman-Fogel et al., 2009). This was repeated once following a 2 min break and the average determined. Participants with a positive score were deemed as having temporal summation.

Heat pain threshold and temporal summation of heat pain also were assessed at the site of primary pain and at the non-painful site. A MSA Thermal Stimulator (Somedic, Sweden) with a 25 × 50 mm probe were used to apply thermal stimuli. Heat pain threshold was determined by applying the probe at an initial temperature of 32 °C and then increasing temperature at 1 °C/s. Participants pressed a button when the heat sensation became painful. The average of three recordings was taken as heat pain threshold. To assess temporal summation of heat pain, a train of 10 phasic noxious heat stimuli were applied over the painful and non-painful sites. The temperature was increased from 2 °C below the individual heat pain threshold to 2 °C above heat pain threshold at 5 °C/s with a 2 s interval between applications. Participants were asked to report pain scores immediately after the first and last stimuli using the 0–100 scale. The difference in pain rating between the last and first stimuli was determined as the magnitude of temporal summation (Weissman-Fogel et al., 2009). This was repeated once following a 2 min break and the average determined. Participants with a positive score were deemed as having temporal summation.

Heart rate variability (HRV) and electrodermal activity (skin conductance) were used as measures of ANS function. For these recordings, participants were seated in a semi-reclined posture in a temperature-controlled room set at 21 ± 1 °C. They rested for approximately 5 min before ANS recordings were taken. Heart rate and electrodermal activity were recorded for 6 min using a NeXus-10 MKII and BioTrace + software (Mind Media, Netherlands) while the participant relaxed in a quiet environment. Resting blood volume pulse was recorded at 128 Hz using a photoplethysmograph placed over the left index finger and was used to determine heart rate. Inter-beat-interval data were analysed over the final 5 min of recording. The data were screened and extraneous intervals removed before mean heart rate, standard deviation of R-R interval (STDRR), root mean square of successive R-R differences (RMSSD), and the normalized peak power of high frequency HRV (HF power) were determined using Kubios software. Heart rate and STDRR represent the overall level and variability of sympathetic and parasympathetic inputs, while the RMSSD and HF power are strongly associated with parasympathetic input only (Electrophysiology, 1996).

Electrodermal activity was recorded at 32 Hz by placing a pair of electrodes on the palmar tips of the index and middle fingers of the right hand. Recordings involving movement of the participant were removed prior to analysis. The mean electrodermal activity was determined over the final 5 s of each minute for the final 5 min of recording. Thus, five 5 s recordings were averaged. Non-specific electrodermal responses were evaluated over the final 5 min of recording. The signals were filtered using a high pass Butterworth filter with a cut-off of 0.05 Hz (Braithwaite et al., 2013). Fluctuations in the signal greater than 0.03 μS were identified as non-specific responses and used to determine non-specific response rate per minute. Skin conductance level and fluctuations are both direct measures of sympathetic activity (Boucsein et al., 2012).

### 2.4. Efficacy of blinding

At the end of the final assessment session, participants were asked if they thought they received real or sham therapy, and to rate their confidence in this decision from 0 to 100%.

### 2.5. Statistical analysis

Baseline characteristics of the two groups were compared using Student's *T*-tests and Chi-square tests for continuous and categorical variables, respectively. The primary dependent variables, QST pressure pain and heat pain threshold data, and heart rate variability data were analysed using separate two-way repeated measures ANOVAs with the factors of group (real therapy, sham therapy) and time (baseline, post-treatment, follow-up). A Huynh-Fedlt adjustment was used when Epsilon <1. Significant main and interaction effects were followed up using Student's *T*-tests. The number of participants with temporal summation of mechanical and heat pain were compared between groups using a Fisher Exact test.

Due to the non-normal distribution of the electrodermal activity measures (skin conductance level, non-specific response rate), data were compared over time within each group using a Friedman test, and between groups at each time period using Mann-Whitney *U* tests.

For the primary outcome measure of pain NRS, an individual responder analysis was undertaken in addition to the group statistics. The number of participants who had a reduction in pain NRS of ≥30% and ≥50% at post-treatment and follow-up were identified in each group and compared using a Fisher Exact test.

A complete case analysis was undertaken; for each outcome measure, only participants with full data sets were included in the analyses. A level of significance of $\alpha = 0.05$ was used for all statistical tests.

## 3. Results

Baseline characteristics of the two groups are shown in Tables 1 and 2. There were no significant differences in any baseline characteristics (all $P > 0.2$). Two participants in the real therapy group withdrew from the study prior to the completion of the therapy sessions. One withdrew after the first session as they did not wish to continue with the treatment. The second withdrew after the second session as they were diagnosed with an endocrine disorder that required treatment. One participant in the sham group missed the final treatment session and withdrew before the final assessment. All remaining treatment sessions were undertaken as planned in both groups.

One participant in the real therapy group had the final follow-up assessment at 4.5 weeks following treatment (rather than 6) as they were travelling overseas. ANS data from one participant in the sham group was missing at post-treatment and from one participant at follow-up due to equipment problems, while QST and ANS data from one participant in the real therapy group was missing at the final follow-up as they were overseas. Additionally, HRV data from one participant in the real therapy group was removed due to the disclosure of a heart condition after acceptance into the study, and HRV data of one participant in the real therapy group was removed at post-treatment due to the presence of anomalous beats.

### 3.1. Primary outcome measures

Group data for the primary outcome measures are shown in Fig. 3. For the pain NRS data, there was a significant main effect of group ($F_{1,26} = 4.7$; $P = 0.04$) and a significant group and time interaction ($F_{2,52} = 4.2$; $P = 0.03$). While the pain NRS scores were not significantly different between the two groups at baseline ($P = 0.5$), the real therapy group had a significantly lower pain NRS at post-treatment ($P = 0.002$). This difference was not maintained at the 6-week follow-up ($P = 0.1$).

Results of the individual responder analysis are shown in Table 3. There were significantly more participants in the real therapy group who had a >30% reduction in pain at post-treatment compared to sham therapy. There were no other significant differences between groups.

For the SFMPQ-II data, the main effect of time ($F_{2,50} = 4.0$; $P = 0.03$) and the time and group interaction ($F_{2,52} = 4.5$; $P = 0.02$) were significant. Paired *T*-tests indicated the SFMPQ-II score in the real therapy group was significantly reduced from baseline at post-treatment ($P = 0.003$) but not at follow-up ($P = 0.06$). In contrast, there were no changes in the SFMPQ-II score in the sham therapy group from baseline to post-treatment ($P = 0.2$) or to follow-up ($P = 0.3$).

For the DASH, there was a significant main effect of time ($F_{2,52} = 4.7$; $P = 0.02$). The DASH scores were significantly lower than baseline at post-treatment ($P = 0.02$) and follow-up ($P = 0.03$) across both groups. Both the main effect of group ($F_{1,26} = 0.5$; $P = 0.5$) and the time and group interaction ($F_{2,52} = 0.2$; $P = 0.7$) were not significant.

For the LLTQ, the main effects of time ($F_{2,52} = 1.0$; $P = 0.4$) and group ($F_{1,26} = 0.0$; $P = 1.0$), as well as the time and group interaction ($F_{2,52} = 2.8$; $P = 0.08$) were not significant.

### 3.2. Secondary outcome measures

Group QST data are shown in Table 4. The ANOVAs revealed no significant main effects of time, group, or time and group interactions for pressure pain threshold at the pain or control sites, or for heat pain threshold at the control site (all $P \geq 0.1$). For heat pain threshold at the pain site, threshold was significantly higher in the sham group overall ($F_{1,25} = 5.5$; $P = 0.03$) but the effect of time ($F_{2,50} = 1.3$; $P = 0.3$) and the time and group interaction ($F_{2,50} = 0.4$; $P = 0.7$) were not significant. The number of participants with temporal summation of mechanical or heat stimuli at the pain and control sites was not different between the two groups at any of the time periods (all $P > 0.05$).

Group ANS data are shown in Table 5. There were no significant main effects of time or group for any of the HRV variables (all $P > 0.15$). The interaction between time and group also was not significant for RMSSD, STDRR, or HF-HRV (all $P > 0.15$), but the interaction was significant for heart rate ($F_{2,42} = 4.0$; $P = 0.03$). Further analysis revealed a significant increase in heart rate from baseline to post-treatment ($P = 0.02$) in the real therapy group but not the sham group ($P = 0.3$).

For the electrodermal activity data, the Friedman test was significant for skin conductance level in the real therapy group ($P = 0.05$). Wilcoxon Signed Rank tests indicated that skin conductance level was higher than baseline at post-treatment ($P = 0.03$) and follow-up ($P = 0.02$) in this group. The Friedman test for skin conductance level was not significant in the sham therapy group ($P = 0.1$), and there were no significant findings for non-specific skin conductance responses in either group (both $P > 0.08$).

### 3.3. Efficacy of blinding

In the real therapy group, 8/14 (57%) participants who completed the therapy believed they received a real treatment. In the sham therapy group, 7/15 (47%) participants who completed the therapy believed they received a real treatment. These values were not significantly different between two groups ($P = 0.6$).

## 4. Discussion

This is the first randomized controlled trial investigating the effects of Bowen Therapy in a chronic pain population. By applying a control protocol that lacked further engagement of the skin and manipulation of the myofascial tissues, we were able to provide an effective sham therapy, which meant that the study was also double-blinded. The results provide evidence that Bowen Therapy can produce a short-term reduction in pain, although this was not

**Table 1**
Baseline characteristics of participants in the two groups. Values are mean ± standard deviation unless otherwise indicated.

| | Real therapy ($n = 16$) | Sham therapy ($n = 15$) | *P*-value |
|---|---|---|---|
| Gender (female, *n*) | 11 (69%) | 10 (67%) | 0.9 |
| Age (years) | 54 ± 19 | 47 ± 13 | 0.2 |
| Body mass index | 29.0 ± 4.8 | 27.9 ± 6.9 | 0.6 |
| Duration of pain (years) | 13.5 ± 10.9 | 10.6 ± 9.9 | 0.5 |
| Pain NRS | 6.5 ± 1.9 | 7.0 ± 1.4 | 0.5 |
| SFMPQ-II | 81 ± 43 | 80 ± 46 | 0.9 |
| DASH | 35 ± 18 | 30 ± 12 | 0.4 |
| LLTQ | 27 ± 8 | 28 ± 7 | 0.6 |

NRS = numerical rating scale; SFMPQ-II = Short-form McGill Pain Questionnaire-II; DASH = Disorders of Arm, Should and Hand; LLTQ = Lower Limb Tasks Questionnaire.

**Table 2**
Primary pain diagnoses of participants in each group.

| Primary diagnosis | Real therapy ($n = 16$) | Sham therapy ($n = 15$) |
|---|---|---|
| Chronic low back pain | 1 (6%) | 5 (33%) |
| Chronic neck/shoulder pain | 4 (25%) | 1 (7%) |
| Chronic musculoskeletal pain in other locations | 3 (19%) | 3 (20%) |
| Fibromyalgia/widespread pain | 3 (19%) | 2 (13%) |
| Postsurgical pain | 1 (6%) | 2 (13%) |
| Osteoarthritis/rheumatoid arthritis | 2 (13%) | 0 (0%) |
| Other | 2 (13%) | 2 (13%) |

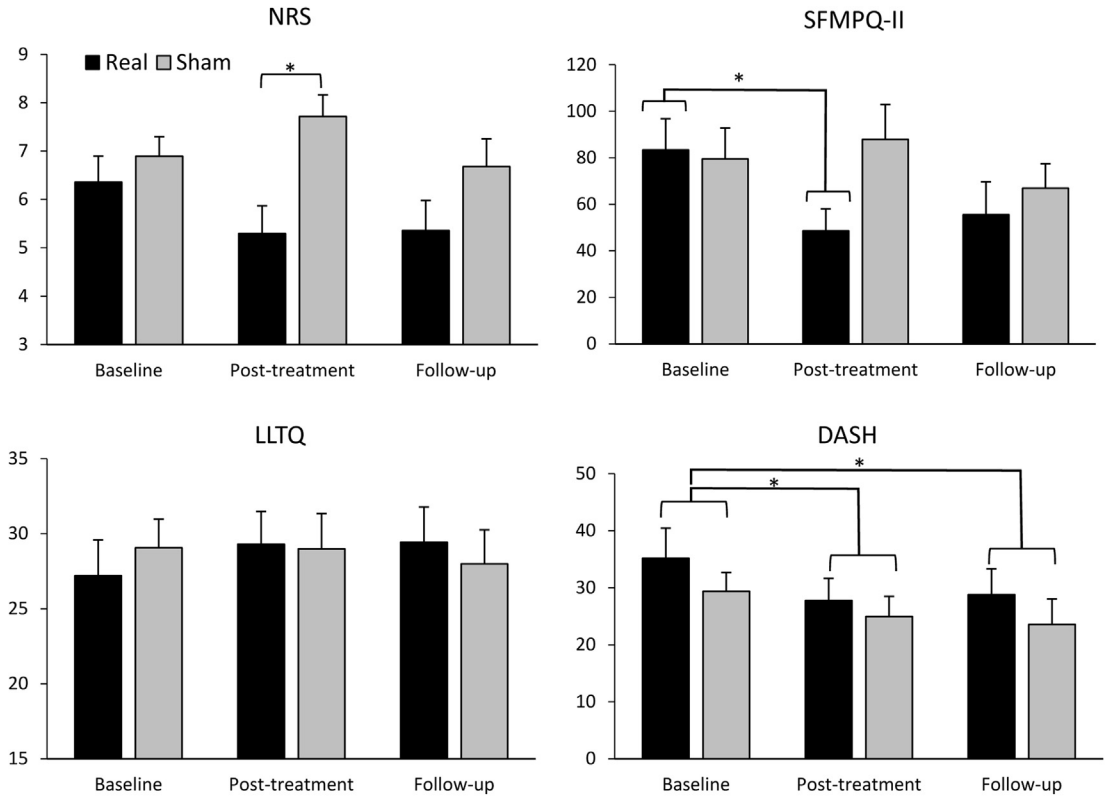


**Fig. 3.** Group averages for the pain numerical rating scale (NRS), Short-Form McGill Pain Questionnaire-II (SFMPQ-II), Lower-Limb Tasks Questionnaire (LLTQ), and Disorders of the Arm, Should and Hand Questionnaire (DASH) data. Error bars are 1 standard error of the mean. * = $P < 0.05$.

**Table 3**
Results of the individual responder analysis. Findings are based on changes in the pain numerical rating scale (NRS) outcome measure. * = significant difference between groups.

| Individual responders | Real therapy ($n = 14$) | Sham therapy ($n = 15$) | *P*-value |
|---|---|---|---|
| Post-treatment | | | |
| >30% reduction | 6 (43%) | 0 (0%) | 0.006* |
| >50% reduction | 2 (14%) | 0 (0%) | 0.22 |
| 6-week follow-up | | | |
| >30% reduction | 5 (36%) | 2 (14%) | 0.21 |
| >50% reduction | 0 (0%) | 1 (7%) | 1 |

associated with changes in function of the upper or lower limbs and did not persist to the follow-up period. There was also no clear evidence of an effect of Bowen Therapy on the nociceptive system, but there was a significant increase in some measures of the sympathetic nervous system.

### *4.1. Effect of Bowen Therapy on pain and function*

Both of the primary outcome measures assessing pain showed significant beneficial effects in the real Bowen Therapy group. The effect sizes of the change from baseline to post-treatment for the NRS and SFMPQ-II were 0.55 and 0.78, respectively, considered moderate-large (Cohen, 1988). The SFMPQ-II evaluates pain more globally than the NRS and captures both the sensory and emotional components of pain, potentially contributing to the larger effect size in this outcome measure. While the follow-up NRS and SFMPQ-II data were not significantly different from baseline in the real therapy group, there was a trend to a persistent reduction in pain, and the individual responder analysis indicated that more than 1/3rd of the participants in the real therapy group had a reduction in pain of >30% at 6-weeks following treatment. Notably, all these participants also had a >30% reduction in pain NRS at the

**Table 4**
Quantitative sensory testing outcome measures. Data are mean ± standard deviation unless indicated otherwise.

| | Baseline | | Post-treatment | | Follow-up | |
|---|---|---|---|---|---|---|
| | Real ($n = 13$) | Sham ($n = 14$) | Real ($n = 13$) | Sham ($n = 14$) | Real ($n = 13$) | Sham ($n = 14$) |
| $PPT_{pain}$ (kPa) | 263 ± 132 | 276 ± 162 | 238 ± 140 | 240 ± 126 | 215 ± 129 | 288 ± 209 |
| $PPT_{control}$ (kPa) | 284 ± 135 | 294 ± 118 | 240 ± 133 | 306 ± 193 | 256 ± 166 | 290 ± 181 |
| Mechanical $TS_{pain}$ ($n$) | 13 (81%) | 10 (67%) | 7 (50%) | 13 (87%) | 10 (77%) | 9 (64%) |
| Mechanical $TS_{control}$ (n) | 10 (63%) | 10 (67%) | 10 (71%) | 9 (60%) | 10 (77%) | 9 (64%) |
| $HPT_{pain}$ (°C) | 42.2 ± 4.6 | 45.4 ± 3.9 | 40.9 ± 5.2 | 44.7 ± 4.4 | 41.1 ± 5.1 | 45.3 ± 3.9 |
| $HPT_{control}$ (°C) | 44.9 ± 6.4 | 47.4 ± 2.9 | 45.9 ± 3.1 | 48.1 ± 3.6 | 45.8 ± 2.3 | 47.1 ± 3.6 |
| Heat $TS_{pain}$ ($n$) | 10 (63%) | 5 (33%) | 6 (43%) | 8 (53%) | 6 (46%) | 7 (50%) |
| Heat $TS_{control}$ ($n$) | 6 (38%) | 8 (53%) | 7 (50%) | 11 (73%) | 11 (85%) | 10 (71%) |

PPT = pressure pain threshold; TS = temporal summation; HPT = heat pain threshold.

**Table 5**
Autonomic nervous system outcome measures. Data are mean ± standard deviation.

| | Baseline | | Post-treatment | | Follow-up | |
|---|---|---|---|---|---|---|
| | Real ($n = 11$) | Sham ($n = 12$) | Real ($n = 11$) | Sham ($n = 12$) | Real ($n = 11$) | Sham ($n = 12$) |
| Heart rate (beats/min) | 72 ± 10 | 77 ± 10 | 78 ± 14* | 71 ± 8 | 76 ± 13 | 74 ± 8 |
| RMSSD (ms) | 21 ± 11 | 29 ± 21 | 25 ± 17 | 33 ± 17 | 23 ± 12 | 27 ± 12 |
| STDRR (ms) | 21 ± 8 | 27 ± 14 | 25 ± 11 | 33 ± 14 | 23 ± 11 | 26 ± 10 |
| HF power (nu) | 47 ± 22 | 48 ± 23 | 51 ± 23 | 41 ± 25 | 47 ± 17 | 49 ± 23 |
| SC level (μS) | 2.2 ± 1.9 | 3.7 ± 3.1 | 2.9 ± 0.9* | 1.8 ± 0.7 | 2.7 ± 1.4* | 2.0 ± 0.9 |
| NS-SCR (responses/min) | 1.3 ± 2.7 | 2.3 ± 3.0 | 0.9 ± 1.5 | 0.5 ± 0.8 | 0.9 ± 1.5 | 1.0 ± 2.1 |

RMSSD = root-mean square differences of successive R-R intervals; STDRR = mean of the standard deviations for all R-R intervals; HF = high frequency; nu = normalized units; SC = skin conductance; NS-SCR = non-specific skin conductance responses. * = significant difference from baseline ($P < 0.05$).

first post-treatment assessment, suggesting almost all of those who responded to the real treatment had a sustained effect.

The findings of a positive, short-term effect of Bowen Therapy on pain support observations from a case series involving people with frozen shoulder (Carter, 2001). Although only a pilot study, it provided some evidence of a reduction in pain with up to five sessions of Bowen Therapy. In contrast, a non-controlled study of symptom management in breast cancer survivors (Argenbright et al., 2016) found that four sessions of Bowen Therapy improved quality of life and mental health, but had no effect on physical health or pain. The majority of participants in our study had chronic musculoskeletal pain, and it may be that Bowen Therapy is more effective for treating this type of pain rather than neuropathic pain associated with breast cancer and its treatment.

Although pain reduced in the real therapy group only, there was a significant improvement in upper limb function across both treatment groups. The baseline DASH scores indicate that participants in both groups were largely outside normal values for the general population (Hunsaker et al., 2002; Aasheim and Finsen, 2014) and were commensurate with scores in people with neck and upper limb disorders (Huisstede et al., 2009). Bowen Therapy itself and the improvement in pain in the real therapy group cannot explain the improvement in upper limb function alone, given that the DASH scores improved in both groups. Potentially, manual touch itself experienced by both groups over the treatment time may have been sufficient to facilitate an improvement in upper limb function.

In contrast to the DASH scores, there were no significant changes in the LLTQ over time. The change in pain in the real therapy group may not have been sufficient to facilitate improvements in lower limb function. Alternatively, the LLTQ may have been limited in its ability to capture improvements in lower limb function. The baseline scores in both groups are higher than other studies involving people with lower limb conditions (McKay et al., 2013; Barnhoorn et al., 2015), allowing a smaller scope for change. Other studies have also shown that the LLTQ may not be responsive to changes in function captured by other outcome measures (McKay et al., 2013).

### 4.2. Mechanisms of Bowen Therapy

Our study found some evidence of an effect of Bowen Therapy on the ANS. An increase of resting heart rate, evident only in those who received real Bowen Therapy, can arise either through decreased parasympathetic or increased sympathetic nervous system activity, as heart rate is determined by the net balance of drive from these two inputs. The lack of significant change in HF-HRV, a reliable assessor of parasympathetic tone, indicates that the increase in resting heart rate more likely arises through sympathoexcitation. The increase of dermal conductivity, which is strongly associated with the sympathetic nervous system, supports the idea of sympathoexcitation following Bowen Therapy. Thus, these findings are in contradiction to our hypothesis of enhanced parasympathetic drive.

Our HRV (Pellissier et al., 2010; Reyes Del Paso et al., 2010; Kulshreshtha et al., 2012; Terkelsen et al., 2012) and electrodermal activity (Carr et al., 1985; Bonnet and Naveteur, 2004; Thieme and Turk, 2005; Kalezic et al., 2007; Spetalen et al., 2008) data are comparable to those published in the literature for similar chronic pain populations. Although we did not have a control group, previous studies using HRV measures have relatively consistently shown an imbalance of ANS function in chronic pain populations with greater sympathetic nervous system activity (Tracy et al., 2016); however, studies using recordings of electrodermal activity have been more mixed. There have been a number of reports of a higher skin conductance level or more non-specific skin conduction responses in people with chronic pain compared to pain-free controls (Bonnet and Naveteur, 2004; Kalezic et al., 2007; Thieme et al., 2016), reflecting greater sympathetic activity, but others have not found any differences between groups (Flor et al., 1992; Thieme and Turk, 2005; Spetalen et al., 2008; Phillips et al., 2014).

Through recordings of HRV and skin conductance, a number of studies have reported evidence of greater parasympathetic drive following treatment for chronic pain (Hassett et al., 2007; Hallman et al., 2011; Matsubara et al., 2011; Thieme et al., 2016). This contrasts with our findings of sympathoexcitation. Evidence of sympathoexcitation has been found immediately after spinal

manipulation in those with chronic low back and spinal pain (Sterling et al., 2001; Perry et al., 2015), craniofacial pain (La Touche et al., 2013), and lateral epicondylagia (Vicenzino et al., 1998), although none of the studies looked at longer term effects beyond the immediate treatment session. It is speculated that the increased sympathetic drive following manual therapy reflects activation of the periaqueductal gray, a key area in the modulation of nociception, and subsequent activation of descending inhibitory pathways (Wright, 1995; Bialosky et al., 2009). However, we found no significant changes in pressure pain threshold, heat pain threshold, or temporal summation of pain in our participants, despite the reduction in pain in the real therapy group. Felix et al. (Félix et al., 2017) also reported that Bowen Therapy had little effect on pressure pain threshold, although the study involved healthy participants and consisted of a single session of treatment. These findings suggest that Bowen Therapy does not have a direct impact on nociceptive processing. This contrasts with previous studies that have shown reduced pro-nociception following interventions that have improved chronic pain (Graven-Nielsen et al., 2012; Petersen et al., 2015; Volz et al., 2016; Khedr et al., 2017), although others have shown similar findings to the current study (Kosek et al., 2013). Using a variety of locations for obtaining the QST measures may have introduced some variability into our findings; however, the individual locations were specifically selected to represent painful and non-painful body sites and remained consistent within a participant.

### 4.3. Strengths and limitations

The study strengths included the randomized and controlled design of the study, and the effective sham therapy that meant blinding of both participants and the people obtaining the outcome measures was possible. The outcome measures used were valid and reliable, and the drop-out rate was low overall. The participants had pain conditions and presented with pain and disability levels that are common across the chronic pain population, making the findings widely applicable.

There were also some limitations. Not all of the participants had function limitations in both the upper and lower limbs, despite the requirement of pain in multiple locations, so there may have been floor effects in the individual DASH and LLTQ scores. We did not collect psychosocial or quality of life outcome measures so we may not have captured all of the possible effects of the interventions, or been able to determine how these measures influenced the efficacy of the intervention. HRV data was determined using recordings from photoplethysmography rather than electrocardiography (ECG). However, Weinschenk et al., (2016) showed good agreement between photoplethysmography and ECG data for most HRV outcome measures obtained from 5 min recordings. The missing data for ANS outcome measures meant that there were reduced participant numbers for these analyses, which reduced study power to detect potential differences over time or between groups.

## 5. Conclusions

Bowen Therapy is able to provide a short-term reduction in pain in people with chronic pain in multiple locations. The mechanisms of this effect remain uncertain, as Bowen Therapy did not appear to impact nociceptive processing but there was some evidence of sympathoexcitation. Future studies should investigate if longer or tapered courses of Bowen Therapy are able to provide a longer therapeutic effect, and investigate possible changes in psychological function and quality of life.

### 5.1. Clinical relevance

- Bowen Therapy can provide short-term pain relief in people with chronic pain
- Not everyone responds to Bowen Therapy, but in some people it can have a clinically meaningful effect
- A longer course of treatment (more than 6 sessions) may be needed to generate a more persistent treatment effect or improvements in function.

## CRediT authorship contribution statement

**Kiho Lee:** Conceptualization, Methodology, Writing - review & editing, Funding acquisition. **Gwyn N. Lewis:** Methodology, Formal analysis, Investigation, Resources, Writing - original draft, Project administration, Funding acquisition.

## Declaration of competing interest

The study was funded by the Bowen Association of Australia (OBT-RC-2015). KL is a practicing Bowen Therapist. GL has no conflicts to report.

## Acknowledgements

The study was funded by the Bowen Association of Australia (OBT-RC-2015). We would like to acknowledge the assistance of Rosalind Parker and Sarah Stewart in participant recruitment and data collection, and of Inga von Benzon and Sally Barrett for providing the real and sham therapy interventions.

## References

Aasheim, T., Finsen, V., 2014. The DASH and the QuickDASH instruments. Normative values in the general population in Norway. J. Hand Surg. 39 (2), 140–144.
Arendt-Nielsen, L., Egsgaard, L.L., Petersen, K.K., Eskehave, T.N., Graven-Nielsen, T., Hoeck, H.C., Simonsen, O., 2015. A mechanism-based pain sensitivity index to characterize knee osteoarthritis patients with different disease stages and pain levels. Eur. J. Pain 19 (10), 1406–1417.
Argenbright, C.A., Taylor-Piliae, R.E., Loescher, L.J., 2016. Bowenwork for symptom management of women breast cancer survivors with lymphedema: a pilot study. Compl. Ther. Clin. Pract. 25 (Suppl. C), 142–149.
Barnhoorn, K.J., van de Meent, H., van Dongen, R.T.M., Klomp, F.P., Groenewoud, H., Samwel, H., Nijhuis-van der Sanden, M.W.G., Frölke, J.P.M., Staal, J.B., 2015. Pain exposure physical therapy (PEPT) compared to conventional treatment in complex regional pain syndrome type 1: a randomised controlled trial. BMJ Open 5 (12).
Beaton, D.E., Katz, J.N., Fossel, A.H., Wright, J.G., Tarasuk, V., Bombardier, C., 2001. Measuring the whole or the parts? Validity, reliability, and responsiveness of the disabilities of the arm, shoulder and hand outcome measure in different regions of the upper extremity. J. Hand Ther. 14 (2), 128–142.
Bialosky, J.E., Bishop, M.D., Price, D.D., Robinson, M.E., George, S.Z., 2009. The mechanisms of manual therapy in the treatment of musculoskeletal pain: a comprehensive model. Man. Ther. 14 (5), 531–538.
Bonnet, A., Naveteur, J., 2004. Electrodermal activity in low back pain patients with and without co-morbid depression. Int. J. Psychophysiol. 53 (1), 37–44.
Boucsein, W., Fowles, D.C., Grimnes, S., Ben-Shakhar, G., Roth, W.T., Dawson, M.E., Filion, D.L., 2012. Publication recommendations for electrodermal measurements. Psychophysiology 49 (8), 1017–1034.
Bowen Therapy Academy of Australia, 2013. Bowtech Manual. Bowtech Pty Ltd, Victoria.
Braithwaite, J.J., Watson, D.G., Jones, R., Rowe, M., 2013. A Guide for Analysing Electrodermal Activity (EDA) & Skin Conductance Responses (SCRs) for Psychological Experiments. University of Birmingham.
Buchman, A.S., Shah, R.C., Leurgans, S.E., Boyle, P.A., Wilson, R.S., Bennett, D.A., 2010. Musculoskeletal pain and incident disability in community-dwelling elders. Arthritis Care Res. 62 (9), 1287–1293.
Carr, V., Minniti, R., Pilowsky, I., 1985. Electrodermal activity in patients with chronic pain: implications for the specificity of physiological indices in relation to psychopathology. Psychophysiology 22 (2), 208–217.
Carter, B., 2001. A pilot study to evaluate the effectiveness of Bowen technique in the management of clients with frozen shoulder. Compl. Ther. Med. 9 (4), 208–215.
Cho, N.H., Kim, I., Lim, S.H., Kim, H.A., 2012. Prevalence of widespread pain and its influence on quality of life: population study in Korea. J. Kor. Med. Sci. 27 (1),

16–21.
Cohen, J., 1988. Statistical Power Analysis for the Behavioral Sciences, second ed. Lawrence Erlbaum, Hillsdale.
Duncan, B., McHugh, P., Houghton, F., Wilson, C., 2011. Improved motor function with Bowen therapy for rehabilitation in chronic stroke: a pilot study. J Prim Health Care 3 (1), 53–57.
Dworkin, R.H., Turk, D.C., Farrar, J.T., Haythornthwaite, J.A., Jensen, M.P., Katz, N.P., Kerns, R.D., Stucki, G., Allen, R.R., Bellamy, N., Carr, D.B., Chandler, J., Cowan, P., Dionne, R., Galer, B.S., Hertz, S., Jadad, A.R., Kramer, L.D., Manning, D.C., Martin, S., McCormick, C.G., McDermott, M.P., McGrath, P., Quessy, S., Rappaport, B.A., Robbins, W., Robinson, J.P., Rothman, M., Royal, M.A., Simon, L., Stauffer, J.W., Stein, W., Tollett, J., Wernicke, J., Witter, J., 2005. Core outcome measures for chronic pain clinical trials: IMMPACT recommendations. Pain 113 (1-2), 9–19.
Electrophysiology TFotESoCatNASoPa, 1996. Heart rate variability: standards of measurement, physiological interpretation and clinical use. Circulation 93 (5), 1043–1065.
Félix, G.J.S., Black, L., Rodrigues, M., Silva, A.G., 2017. The acute effect of Bowen therapy on pressure pain thresholds and postural sway in healthy subjects. J. Bodyw. Mov. Ther. 21 (4), 804–809.
Flor, H., Birbaumer, N., Schugens, M.M., Lutzenberger, W., 1992. Symptom-specific psychophysiological responses in chronic pain patients. Psychophysiology 29 (4), 452–460.
Fregni, F., Gimenes, R., Valle, A.C., Ferreira, M.J.L., Rocha, R.R., Natalle, L., Bravo, R., Rigonatti, S.P., Freedman, S.D., Nitsche, M.A., Pascual-Leone, A., Boggio, P.S., 2006. A randomized, sham-controlled, proof of principle study of transcranial direct current stimulation for the treatment of pain in fibromyalgia. Arthritis Rheum. 54 (12), 3988–3998.
Graven-Nielsen, T., Aspegren Kendall, S., Henriksson, K.G., Bengtsson, M., Sörensen, J., Johnson, A., Gerdle, B., Arendt-Nielsen, L., 2000. Ketamine reduces muscle pain, temporal summation, and referred pain in fibromyalgia patients. Pain 85 (3), 483–491.
Graven-Nielsen, T., Wodehouse, T., Langford, R.M., Arendt-Nielsen, L., Kidd, B.L., 2012. Normalization of widespread hyperesthesia and facilitated spatial summation of deep-tissue pain in knee osteoarthritis patients after knee replacement. Arthritis Rheum. 64 (9), 2907–2916.
Hallman, D.M., Olsson, E.M.G., von Schéele, B., Melin, L., Lyskov, E., 2011. Effects of heart rate variability biofeedback in subjects with stress-related chronic neck pain: a pilot study. Appl. Psychophysiol. Biofeedback 36 (2), 71–80.
Hansen, C., Taylor-Piliae, R.E., 2011. What is Bowenwork? A systematic review. J. Alternative Compl. Med. 17 (11), 1001–1006.
Hassett, A.L., Radvanski, D.C., Vaschillo, E.G., Vaschillo, B., Sigal, L.H., Karavidas, M.K., Buyske, S., Lehrer, P.M., 2007. A pilot study of the efficacy of heart rate variability (HRV) biofeedback in patients with fibromyalgia. Appl. Psychophysiol. Biofeedback 32 (1), 1–10.
Huisstede, B.M., Feleus, A., Bierma-Zeinstra, S.M., Verhaar, J.A., Koes, B.W., 2009. Is the disability of arm, shoulder, and hand questionnaire (DASH) also valid and responsive in patients with neck complaints. Spine 34 (4), E130–E138.
Hunsaker, F.G., Cioffi, D.A., Amadio, P.C., Wright, J.G., Caughlin, B., 2002. The American Academy of Orthopaedic Surgeons outcomes instruments: normative values from the general population. J. Bone Joint Sur. 208–215.
Kalezic, N., Åsell, M., Kerschbaumer, H., Lyskov, E., 2007. Physiological reactivity to functional tests in patients with chronic low back pain. J. Muscoskel. Pain 15 (1), 29–40.
Khedr, E.M., Omran, E.A.H., Ismail, N.M., El-Hammady, D.H., Goma, S.H., Kotb, H., Galal, H., Osman, A.M., Farghaly, H.S.M., Karim, A.A., Ahmed, G.A., 2017. Effects of transcranial direct current stimulation on pain, mood and serum endorphin level in the treatment of fibromyalgia: a double blinded, randomized clinical trial. Brain Stim. 10 (5), 893–901.
Kosek, E., Roos, E.M., Ageberg, E., Nilsdotter, A., 2013. Increased pain sensitivity but normal function of exercise induced analgesia in hip and knee osteoarthritis - treatment effects of neuromuscular exercise and total joint replacement. Osteoarthritis Cartilage 21 (9), 1299–1307.
Kulshreshtha, P., Gupta, R., Yadav, R.K., Bijlani, R.L., Deepak, K.K., 2012. A comprehensive study of autonomic dysfunction in the fibromyalgia patients. Clin. Auton. Res. 22 (3), 117–122.
La Touche, R., Paris-Alemany, A., Mannheimer, J.S., Angulo-Diaz-Parreno, S., Bishop, M.D., Lopez-Valverde-Centeno, A., von Piekartz, H., Fernandez-Carnero, J., 2013. Does mobilization of the upper cervical spine affect pain sensitivity and autonomic nervous system function in patients with cervico-craniofacial pain?: a randomized-controlled trial. Clin. J. Pain 29 (3), 205–215.
Long, L., Huntley, A., Ernst, E., 2001. Which complementary and alternative therapies benefit which conditions? A survey of the opinions of 223 professional organizations. Compl. Ther. Med. 9 (3), 178–185.
Maier, C., Baron, R., Tölle, T.R., Binder, A., Birbaumer, N., Birklein, F., Gierthmühlen, J., Flor, H., Geber, C., Huge, V., Krumova, E.K., Landwehrmeyer, G.B., Magerl, W., Maihöfner, C., Richter, H., Rolke, R., Scherens, A., Schwarz, A., Sommer, C., Tronnier, V., Üçeyler, N., Valet, M., Wasner, G., Treede, R.D., 2010. Quantitative sensory testing in the German Research Network on Neuropathic Pain (DFNS): somatosensory abnormalities in 1236 patients with different neuropathic pain syndromes. Pain 150 (3), 439–450.
Marr, M., Baker, J., Lambon, N., Perry, J., 2011. The effects of the Bowen technique on hamstring flexibility over time: a randomised controlled trial. J. Bodyw. Mov. Ther. 15 (3), 281–290.
Matsubara, T., Arai, Y.-C.P., Shiro, Y., Shimo, K., Nishihara, M., Sato, J., Ushida, T., 2011. Comparative effects of acupressure at local and distal acupuncture points on pain conditions and autonomic function in females with chronic neck pain. Evid. base Compl. Alternative Med. 2011, 543296. Article ID 543291.
McKay, C., Prapavessis, H., McNair, P., 2013. Comparing the lower limb Tasks questionnaire to the western ontario and McMaster universities osteoarthritis index: agreement, responsiveness, and convergence with physical performance for knee osteoarthritis patients. Arch. Phys. Med. Rehabil. 94 (3), 474–479.
McNair, P.J., Prapavessis, H., Collier, J., Bassett, S., Bryant, A., Larmer, P.J., 2007. The Lower Limb Tasks Questionnaire: an assessment of validity, reliability, responsiveness and minimal important differences. Arch. Phys. Med. Rehabil. 88 (8), 993–1001.
Patel, K.V., Guralnik, J.M., Dansie, E.J., Turk, D.C., 2013. Prevalence and impact of pain among older adults in the United States: findings from the 2011 national health and aging trends study. Pain 154 (12), 2649–2657.
Pellissier, S., Dantzer, C., Canini, F., Mathieu, N., Bonaz, B., 2010. Psychological adjustment and autonomic disturbances in inflammatory bowel diseases and irritable bowel syndrome. Psychoneuroendocrinology 35 (5), 653–662.
Pennington, K., 2012. Bowen Therapy: a review of the profession. J. Aust. Tradit. Med. Soc. 18 (4), 217–220.
Perry, J., Green, A., Singh, S., Watson, P., 2015. A randomised, independent groups study investigating the sympathetic nervous system responses to two manual therapy treatments in patients with LBP. Man. Ther. 20 (6), 861–867.
Petersen, K.K., Arendt-Nielsen, L., Simonsen, O., Wilder-Smith, O., Laursen, M.B., 2015. Presurgical assessment of temporal summation of pain predicts the development of chronic postoperative pain 12 months after total knee replacement. Pain 156 (1), 55–61.
Phillips, K., Wright, B.J., Kent, S., 2014. Irritable bowel syndrome and symptom severity: evidence of negative attention bias, diminished vigour, and autonomic dysregulation. J. Psychosom. Res. 77 (1), 13–19.
Reyes Del Paso, G.A., Garrido, S., Pulgar, A., Martin-Vazquez, M., Duschek, S., 2010. Aberrances in autonomic cardiovascular regulation in fibromyalgia syndrome and their relevance for clinical pain reports. Psychosom. Med. 72 (5), 462–470.
Soler, M.D., Kumru, H., Pelayo, R., Vidal, J., Tormos, J.M., Fregni, F., Navarro, X., Pascual-Leone, A., 2010. Effectiveness of transcranial direct current stimulation and visual illusion on neuropathic pain in spinal cord injury. Brain 133 (9), 2565–2577.
Spetalen, S., Sandvik, L., Blomhoff, S., Jacobsen, M.B., 2008. Autonomic function at rest and in response to emotional and rectal stimuli in women with irritable bowel syndrome. Dig. Dis. Sci. 53 (6), 1652–1659.
Staud, R., Vierck, C.J., Cannon, R.L., Mauderli, A.P., Price, D.D., 2001. Abnormal sensitization and temporal summation of second pain (wind-up) in patients with fibromyalgia syndrome. Pain 91 (1-2), 165–175.
Sterling, M., Jull, G., Wright, A., 2001. Cervical mobilisation: concurrent effects on pain, sympathetic nervous system activity and motor activity. Man. Ther. 6 (2), 72–81.
Terkelsen, A.J., Molgaard, H., Hansen, J., Finnerup, N.B., Kroner, K., Jensen, T.S., 2012. Heart rate variability in complex regional pain syndrome during rest and mental and orthostatic stress. Anesthesiology 116 (1), 133–146.
Thieme, K., Turk, D.C., 2005. Heterogeneity of psychophysiological stress responses in fibromyalgia syndrome patients. Arthritis Res. Ther. 8 (1), R9.
Thieme, K., Turk, D.C., Gracely, R.H., Flor, H., 2016. Differential psychophysiological effects of operant and cognitive behavioural treatments in women with fibromyalgia. Eur. J. Pain 20 (9), 1478–1489.
Tracy, L.M., Ioannou, L., Baker, K.S., Gibson, S.J., Georgiou-Karistianis, N., Giummarra, M.J., 2016. Meta-analytic evidence for decreased heart rate variability in chronic pain implicating parasympathetic nervous system dysregulation. Pain 157 (1), 7–29.
Vicenzino, B., Collins, D., Benson, H., Wright, A., 1998. An investigation of the interrelationship between manipulative therapy-induced hypoalgesia and sympathoexcitation. J. Manipulative Physiol. Therapeut. 21 (7), 448–453.
Volz, M.S., Farmer, A., Siegmund, B., 2016. Reduction of chronic abdominal pain in patients with inflammatory bowel disease through transcranial direct current stimulation: a randomized controlled trial. Pain 157 (2), 429–437.
Weinschenk, S.W., Beise, R.D., Lorenz, J., 2016. Heart rate variability (HRV) in deep breathing tests and 5-min short-term recordings: agreement of ear photoplethysmography with ECG measurements, in 343 subjects. Eur. J. Appl. Physiol. 116 (8), 1527–1535.
Weissman-Fogel, I., Granovsky, Y., Crispel, Y., Ben-Nun, A., Best, L.A., Yarnitsky, D., Granot, M., 2009. Enhanced presurgical pain temporal summation response predicts post-thoracotomy pain intensity during the acute postoperative phase. J. Pain 10 (6), 628–636.
Wilks, J., 2013. Bowen technique: mechanisms for action. J. Aust. Tradit. Med. Soc. 19 (1), 33–35.
Wright, A., 1995. Hypoalgesia post-manipulative therapy: a review of a potential neurophysiological mechanism. Man. Ther. 1 (1), 11–16.
Wrigley, P.J., Gustin, S.M., McIndoe, L.N., Chakiath, R.J., Henderson, L.A., Siddall, P.J., 2013. Longstanding neuropathic pain after spinal cord injury is refractory to transcranial direct current stimulation: a randomized controlled trial. Pain 154 (10), 2178–2184.