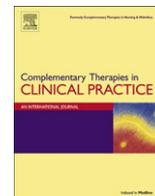


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Exploratory study on the efficacy of reflexology for pain threshold and tolerance using an ice-pain experiment and sham TENS control

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A B S T R A C T

Keywords:

Reflexology
Reflex zone therapy
Pain
Ice-pain
Heart-rate
Transcutaneous electrical
nerve stimulation (TENS)

Objectives: To explore the efficacy of reflexology on acute pain induced in healthy human subjects using a sham TENS control.

Design: An ice-pain experiment was undertaken in which the volunteers ($n = 15$; 11 female and 4 male with a mean \pm SEM age of 37.7 ± 2.6 years) were required to immerse their non-dominant hand in a container of ice-slurry whilst two indices of pain, i.e. threshold, (the time taken for subjects to experience the first pain sensation) and tolerance, (the time when the subject is unable to tolerate any further pain), were measured.

Results: Compared to control data, reflexology increased acute pain threshold ($F_{(1,14)} = 4.5958$, $p < 0.05$) and tolerance ($F_{(1,14)} = 5.1095$, $p < 0.05$).

Conclusions: These findings demonstrate that reflexology produces antinociceptive effects in a controlled experiment and suggest the possibility that reflexology may be useful on its own or as an adjunct to medication in the treatment of pain conditions in man.

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1. Introduction

Reflexology is often associated with a form of foot massage because it utilises the manual application of pressure techniques which have their basis in the principles of Traditional Chinese Medicine such as acupressure.^{1–5} However, historical evidence suggests that reflex therapy may have originated within the realms of orthodox medicine as a branch of neurophysiology.^{1,6,7} According to the tenets of reflexology the foot consists of reflex points which relate to different organs and parts of the body, and by applying pressure to these points it is possible to redress imbalances in “energy” which cause illness.⁸ The use of reflexology in Western societies has increased considerably over the last decade and claims have been made for the use of reflexology in the treatment of various conditions, including infertility, anxiety states particularly in relation to cancer, depression and pain.^{9–13} To a large extent these claims are anecdotal and have not been subject to rigorous scientific investigations. There is therefore a need to conduct controlled experiments to validate such claims.

In recent years evidence has emerged to support the claim that complementary medical treatments, such as acupuncture, transcutaneous electrical nerve stimulation (TENS) and hypnotherapy, are useful in the treatment of pain.^{14–16} Whilst there have been many anecdotal and uncontrolled reports that reflexology is also useful in the treatment of pain,^{17–19} there is a paucity of properly controlled studies on the effects of reflexology on nociception. There has however been some clinical evidence for the effectiveness of reflexology in low back pain and pain associated with cancer.^{10,18–21} Many of these studies were superimposed on drugs which subjects were already taking for pain, making it difficult to gauge any real effects of reflexology on pain indices.

The aim of this study was to explore the effects of reflexology on acute pain induced in healthy human subjects. An experimental design was used in which the subjects were required to immerse their non-dominant hand in a container of ice-slurry whilst two indices of pain, i.e. threshold, (the time taken for subjects to experience the first pain sensation) and tolerance, (the time when the subject is unable to tolerate any further pain), were measured. This paradigm has been used successfully by a number of workers to assess the effects of various treatments or procedures on pain threshold and tolerance.^{22–27} The results of the present study showed that reflexology increased both threshold and tolerance scores.

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2. Materials and methods

2.1. The subjects

Nineteen subjects were originally recruited for the study but for various reasons four of the subjects failed to complete the experiment. Eleven female and four male volunteers with a mean \pm SEM age of 37.7 ± 2.6 years completed the study. All subjects were white Caucasian and were naïve to previous experience of both TENS and reflexology.

2.2. Experimental design

The subjects were informed that they had to attend two experimental sessions, each one requiring approximately 4 h of their time. A cross-over design was used in which each subject received two treatments (sham TENS (control) and reflexology) in a random fashion given one week apart. Due to low recruitment rates, which made a parallel study untenable, a cross over design was chosen; by using subjects in this way they acted as their own control and thus avoided any within subject variability. As there is no scientific evidence regarding the post-treatment effects of reflexology, an interval of one week between treatments was allowed for a wash-out period. Ethical permission to undertake the study was obtained from the University of Portsmouth Human Ethics committee. The subjects were apprised of the experimental protocol prior to recruitment into the study. They were issued with an information sheet and informed consent was obtained when they arrived in the laboratory on the first occasion. A brief consultation was taken to confirm the subjects' suitability for entry into the experiments and subjects were excluded if they had an ongoing pain problem, and/or were being treated for this condition by their own general practitioner (GP)/consultant, if they were taking prescribed or over-the-counter medication for ongoing pain, if they had previous experience of reflexology or TENS, an interest in the outcomes of the experiments, severe psychiatric or somatic illness, an established pregnancy at project start, had or currently have a thrombosis, Reynaud's Syndrome or other neurological disorder, or if they suffered from clinical hypertension for which they were receiving regular medication.

2.3. Experimental procedures

All experiments were conducted in an isolated room where the ambient room temperature was maintained at $22 \text{ }^\circ\text{C} \pm 1 \text{ }^\circ\text{C}$.

2.4. Procedure for reflexology

Reflexology was administered to the subject by one of us (CAS) who was positioned on a low stool at the foot of a reclining chair suitable for the administration of reflexology (Lafuma Chair, Association of Reflexologists, Somerset, UK). In order to provide a clean, lint free surface for treatment the subject's feet were cleaned using un-perfumed wipes. Both feet were lightly wiped with a small amount of foot balm (ART foot balm, Association of Reflexologists, Somerset, UK) and each foot subsequently treated using appropriate reflexology techniques (see section below). The treatment period lasted for 45 min.

2.5. Reflexology treatment sequence

A variety of movements are used in reflexology and these include holding, pressing, sliding, gliding, walking, stretching and rotations.^{28–31} The most often used technique is known as

caterpillar walking in which the medial aspect of the thumb creeps slowly along in an intermittent on/off pressure. The technique used was that of the Bayly School of Reflexology³² and follows a basic treatment sequence of 45 min duration. A standard treatment method was adopted to ensure all reflex points were covered as pain is so subjective and none of the reflexology charts indicate specific reflex points for the hand or foot itself.

2.6. Procedure for sham TENS (control)

Two 40×40 mm square rubber pads were connected to TENS leads attached to a sham TENS machine with a digital timer. One of the pads was placed at 25 mm above the first wrist crease, whilst the other was placed 25 mm below the elbow crease on the ventral surface of the dominant forearm. The digital timer was used to show a running meter and to encourage the perception of an active treatment, but had no other electrical output. Treatment time reflected that given during the reflexology session to ensure consistency across the experimental procedures.

Subjects were instructed to sit upright in the treatment chair at the start of the sham TENS (control) procedure so that the head was resting on the head restraint and the legs were resting on the lower section of the chair over a support. They were then tipped backward to a semi-recumbent position where they remained throughout the treatment period. Prior to the experiment subjects were informed that some forms of TENS were imperceptible and therefore they may or may not feel any stimulating sensation. In addition, if the subjects asked, they were told that this particular type of TENS affected only the d-delta two nerve fibres, which were not as sensitive to the stimulus as some of the other nerve fibres. These nerve fibres do not exist but this script was used to further support an active treatment. Subjects were asked at regular intervals if they were experiencing any kind of tingling sensation and the dials on the box were tweaked to uphold the idea of an active treatment.

2.7. Ice-pain procedure

Crushed ice slurry ($0 \text{ }^\circ\text{C}$) was placed in an insulating box into which subjects were invited to immerse their non-dominant hand. The hand was immersed up to the first wrist crease, flat and with the fingers slightly splayed. A stopwatch was started as soon as the hand was immersed up to the first wrist crease and the two measurements (in seconds) were taken as (i) pain threshold (the time it took for the subject to find the experience painful and verbalise 'now') and (ii) pain tolerance (the time it took until the subject could no longer keep his/her hand in the crushed ice slurry and verbalise 'out'). Subjects were advised that no other communication would be permitted during the ice immersions. Subjects were not informed that there was a 5 min time restriction to the ice immersion.

After a 15-min rest period in which subjects were seated upright in the chair, baseline measurements were recorded for heart rate pre and post ice plunge (see section below) and for ice pain threshold and pain tolerance. Immediately following which subjects were then reclined to a semi-recumbent position for the 45 min treatment period (i.e. reflexology or sham TENS). Subjects remained in the semi-recumbent position for a further 30 min after the treatment period, at which point, they were assisted to the upright position and asked to plunge their non-dominant hand into the ice. Measurements were obtained for pre-plunge heart rate, pain threshold, pain tolerance and post-plunge heart rate. Subjects remained in the upright position for the remainder

of the experiment. Subsequent pain threshold and tolerance levels, together with pre/post-plunge heart rate readings were recorded at 30 min intervals until 120 min post-treatment. Subjects completed one ice immersion cycle (baseline) prior to treatment of either reflexology or sham TENS (control) and four cycles post-treatment. In order to keep the inter-interval constant within each subject, each cycle post-treatment lasted 30 min from the time the subject removed their hand from the ice. During this period, subjects remained seated in the Lafuma chair and were given either light reading material or were permitted to converse with the investigator. They were not allowed to discuss the treatment, their health concerns or the research programme.

2.8. Measurement of heart rate

The subjects were fitted with a heart rate monitor chest belt (T31 transmitter). The output device was hung from a neck cord placed over the subjects' head. A jelly type lubricant (KY Jelly, Boots, Portsmouth, UK) was used on the heart transmitter chest belt to assist in signal transmission.

2.9. Statistical analysis

The data for pain threshold, pain tolerance and heart rate were expressed as changes from pre-treatment baselines. The data were analysed using a two-way analysis of variance (ANOVA) with repeated measures.³³ Inter-session reliability of the baseline data was evaluated using the Pearson's product moment correlation coefficient statistic.³⁴

3. Results

3.1. Effects of reflexology on pain threshold

The raw data for the pre-treatment baselines between sham TENS (control) and reflexology were 8.4 ± 0.8 s and 9.1 ± 1.2 s respectively. The reliability of the pre-treatment baselines between the two treatments was evaluated using the Pearson product moment correlation coefficient. The results showed that the data were significantly correlated ($r = +0.60$, $df = 15$, $p < 0.05$), demonstrating good inter-session reliability for baseline data. This was confirmed by the paired *t*-test that revealed no significant differences between baseline scores ($p = 0.50$, n.s.).

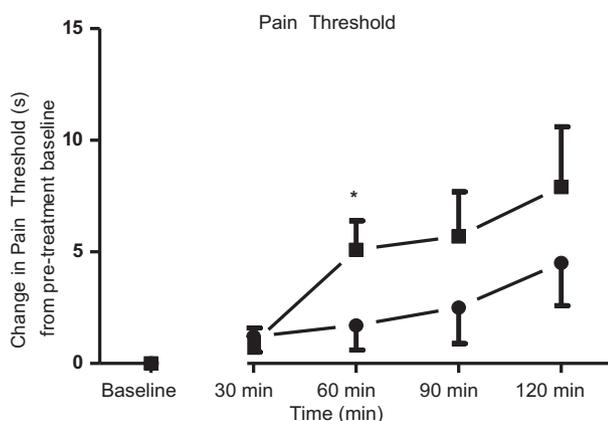


Fig. 1. The effect of sham TENS (control) and reflexology on pain threshold. Vertical lines represent \pm s.e.mean. * $p < 0.05$. ● = Sham TENS (control) ■ = Reflexology.

Fig. 1 shows the post-treatment data expressed as a change from the pre-treatment baselines. Statistical analysis of the results showed significant main effects of treatment ($F_{(1,14)} = 4.5958$, $p < 0.05$) and time ($F_{(3,42)} = 3.9736$, $p < 0.05$) but no treatment \times time interaction ($F_{(3,42)} = 0.7482$, ns). Although the data illustrated in Fig. 1 indicates that there were increases in mean pain thresholds at 60, 90 and 120 min in subjects given reflexology compared with control treatment, post-hoc tests revealed that this was only significant at 60 min ($p < 0.05$).

3.2. Effects of reflexology on pain tolerance

The raw data for the pre-treatment baselines between sham TENS (control) and reflexology were 133.7 ± 31.0 s and 112.7 ± 27.9 s respectively. The inter-session reliability statistic for pre-treatment baselines between the two treatments was significantly correlated (Pearson product moment correlation coefficient: $r = +0.70$, $df = 15$, $p < 0.01$) demonstrating good reliability for baseline data. Furthermore, the paired *t*-test confirmed that there were no significant differences between the baseline scores ($p = 3.55$, n.s.).

Fig. 2 displays the post-treatment data expressed as a change from the pre-treatment baselines. Statistical analysis of the result showed significant main effect of treatment ($F_{(1,14)} = 5.1095$, $p < 0.05$) and time ($F_{(3,42)} = 3.2505$, $p < 0.05$), but no treatment \times time interaction ($F_{(3,42)} = 1.6098$, ns). Post-hoc tests revealed that reflexology significantly increased pain tolerance at 60 min ($p < 0.01$), 90 min ($p < 0.05$) and 120 min ($p < 0.01$).

3.3. Effects of reflexology on heart rate pre-plunge

The raw data for the effects of sham TENS (control) and reflexology on heart rate pre-plunge baselines were 78.3 ± 3.8 beats per minute (bpm) and 81.2 ± 3.7 bpm respectively. The inter-session reliability statistic for pre-treatment mean baselines between sham TENS (control) and reflexology were significantly correlated (Pearson product moment correlation coefficient: $r = +0.87$, $df = 15$, $p < 0.01$) demonstrating good reliability for baseline data between the two treatment sessions. This was confirmed by the paired *t*-test that showed no significant differences between baseline scores ($p = 0.17$, n.s.).

Fig. 3 shows the change from the pre-treatment baselines for heart rate prior to the ice plunge for sham TENS (control) and

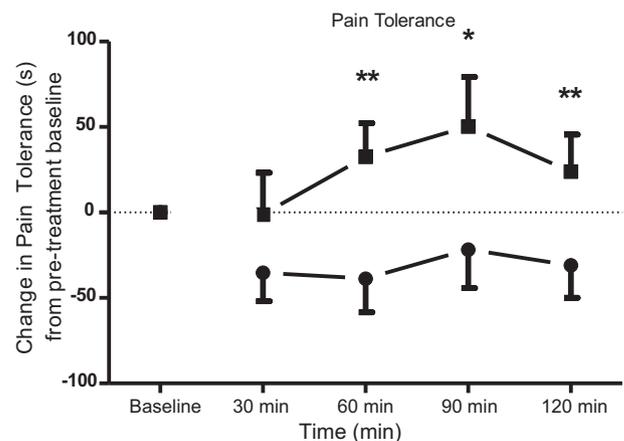


Fig. 2. The effect of sham TENS (control) and reflexology on pain tolerance. Vertical lines represent \pm s.e.mean. * $p < 0.05$, ** $p < 0.01$. ● = Sham TENS (control) ■ = Reflexology.

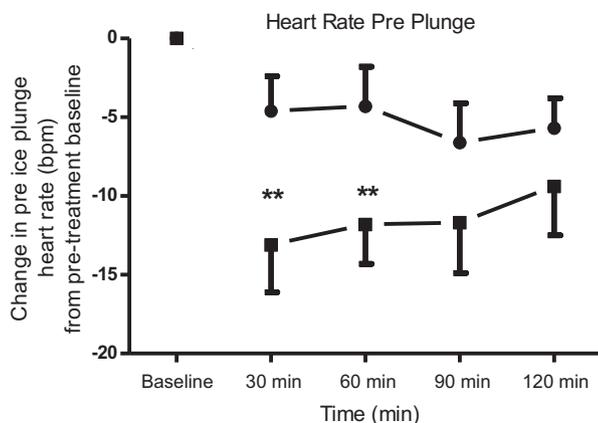


Fig. 3. The effect of sham TENS (control) and reflexology on pre-plunge heart rate. Vertical lines represent \pm s.e.mean. ** $p < 0.01$. ● = Sham TENS (control) ■ = Reflexology.

reflexology. ANOVA showed significant main effect of treatment ($F_{(1,14)} = 7.8404$, $p < 0.05$) but not for time ($F_{(3,42)} = 1.1325$, n.s.), and treatment \times time interactions ($F_{(3,42)} = 1.4748$, n.s.). Post-hoc tests revealed that the reflexology treatment significantly lowered heart rate for the first 60 min post-treatment ($p < 0.01$) when compared to the sham (TENS) control.

3.4. Effects of reflexology on heart rate post-plunge

The raw data for the effects of sham TENS (control) and reflexology on heart rate post-plunge baselines were 78.7 ± 3.9 beats per min (bpm) and 79.7 ± 3.4 bpm, respectively. The inter-session reliability statistic on the baseline data between sham TENS (control) and reflexology showed that the data were highly correlated (Pearson product moment correlation coefficient, $r = +0.83$, $df = 15$, $p < 0.01$) and the paired t -test showed no significant differences ($p = 0.64$, n.s.), thus indicating a high reliability between inter-session baselines.

Fig. 4 shows the change from the pre-treatment baselines for heart rate post ice plunge for sham TENS (control) and reflexology. ANOVA revealed no significant effects of treatment ($F_{(1,14)} = 1.7574$, n.s.), time ($F_{(3,42)} = 2.1308$, n.s) or treatment \times time interaction ($F_{(3,42)} = 1.2107$, n.s.)

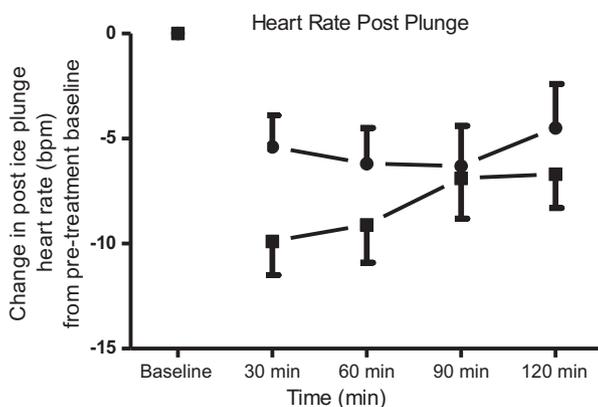


Fig. 4. The effect of sham TENS (control) and reflexology on post-plunge heart rate. Vertical lines represent \pm s.e.mean. ** $p < 0.01$. ● = Sham TENS (control) ■ = Reflexology.

4. Discussion

There have been a number of anecdotal and uncontrolled reports making claims that reflexology is effective in the treatment of pain.^{17–19} However, there has been a lack of controlled studies to test this claim more fully. Therefore, the principal aim of this study was to investigate the effects of reflexology on two indices of pain, i.e. pain threshold and tolerance, in an ice-pain experiment. Ice-pain experiments have been used previously to assess the effects of various CAM treatments on pain threshold and tolerance, such as in acupuncture and TENS.^{22,35–37}

4.1. Challenges and limitations

One of the overriding problems that we faced when designing the experiment was with the control treatment for reflexology. We considered, as possible control treatments, using a general foot massage or simply holding the feet. However, foot massage has been used in numerous reflexology experiments and was found to be a poor control because of its similarity to reflexology.^{5,13,38–40} Holding the feet without any form of stimulation was ruled out because it was felt that subjects would readily detect an inactive treatment. Similar problems have been faced by others when trying to control for CAM treatment. For example, Ashton et al. (1984) used a lactose placebo pill as the control in an acupuncture ice-pain experiment. To avoid similar problems we decided to use sham TENS as a control treatment. The rationale behind this choice was to control for the possible psychological factors that may influence subjective assessments of pain or analgesia with treatment (see [Methods and materials](#) for further details). Interestingly, when the volunteers were asked (in a subjective rating questionnaire that they filled in at the end of the study) whether they believed that the treatments had any effect on pain threshold and tolerance, 9 of the 15 subjects felt that sham TENS had improved their pain threshold and tolerance levels, compared with 12 who felt that reflexology had improved their pain threshold and tolerance levels. Thus, it is likely that sham TENS provided an adequate control for possible “placebo” subjective effects.

4.2. Recruitment challenges

The recruitment of subjects set the greatest challenge of all in these experiments as all of the subjects were unpaid volunteers. It is probable that part of the reluctance in people to volunteer may have been (a) the time commitment was too great, (b) dislike of ice pain, (c) inability to attend in the timescale allotted to the experimental sequence, (d) did not meet inclusion criteria following initial consultation.

4.3. Recruitment bias

There was a large bias towards a female population but an attempt to recruit more males into the study met with some resistance. The ratio of females to males fits the model for seekers of CAM therapies but it does not necessarily encompass a good selection of the general community.⁴¹ On the plus side however, although women are said to have reduced pain threshold and tolerance for experimentally induced pain in comparison to men,^{42,43} they are considered to be the best human model for pain studies. Furthermore their responses may be more clinically relevant than for males^{44,45} so that the results obtained in this research study will likely transfer to a clinical environment.

4.4. Non-specific effects of reflexology treatment

One of the possible major limitations in any study where there is close contact between a patient and therapist is the relationship between them.⁴⁶ Such a relationship has been interpreted as having a large placebo effect. In order to avoid some of the pitfalls associated with the patient–therapist relationship, subjects in this research study were discouraged from discussing their personal health issues and there was no attempt to provide support on health matters. A single therapist provided the treatment for all experimental conditions and this is regarded as a good method of controlling outcomes, and is certainly not exceptional in studies of this type.⁴⁷ The difficulty with such an arrangement is that a single therapist provides no personality variable and no treatment variable and so does not represent the true population of practitioners. One may argue therefore that the results may be attributed to the skills of the therapist and not the treatment³⁸ and as such this becomes a limitation to the experimental outcomes.

The results show that there were significant increases in pain threshold in the ice-pain experiment after reflexology compared to sham TENS control ($F_{(1,14)} = 5.1095$, $p < 0.05$; see Fig. 1). Under control conditions there was a small increase in mean threshold values over the 120 min measurement period. This is not surprising as it is likely that the subjects' threshold values will increase with successive trials. Interestingly, at 30 min there was no difference in threshold values between control and reflexology treatments. However, while mean threshold values were higher at the 60, 90 and 120 min measurement periods for reflexology, compared with control, post-hoc tests revealed that pain threshold was only significantly different at 60 min. It is possible that the lack of significance at the 90 and 120 min time points may be due to the relatively small number of subjects used in this study and these findings suggest that future studies using a larger cohort may be warranted. Pain tolerance was also significantly increased by reflexology treatment in the ice-pain experiment, and post-hoc tests revealed that pain tolerance was significantly higher at the 60, 90 and 120 min measurement periods compared with control values (see Fig. 2). As with pain threshold, there were no significant differences in pain tolerance between sham TENS control and reflexology treatments at 30 min. The present results thus clearly show that reflexology increases both pain threshold and tolerance in an ice-pain experiment.

There is evidence to support the notion that activation of the sympathetic nervous system produces analgesia.^{48,49} In order to assess this possibility, we also measured heart rate. An increase in heart rate would suggest activation of the sympathetic division of the autonomic nervous system. The results illustrated in Fig. 3 show that reflexology significantly decreases heart rate pre-plunge compared with control treatment. Furthermore, measurements taken post-plunge indicate that heart rate after reflexology treatment was not significantly different from control values (Fig. 4). These findings thus suggest that it is unlikely that the effects of reflexology on pain threshold and tolerance can be attributed to activation of the sympathetic nervous system.

5. Conclusions

The results of this study show that foot reflexology increases pain threshold and tolerance in human volunteers. The limitation however is that these subjects were all healthy. They were subjected to laboratory induced acute pain without the normal psychological attributes of the pain experienced by many chronic pain sufferers attending pain clinics. The effect observed for reflexology showed an acute antinociceptive effect in the majority of subjects and a small nociceptive effect in a minority. However, most subjects

underwent a single treatment of reflexology which may have proved insufficient for a clinically relevant result. The mechanism(s) involved remains to be determined. However, it has been shown that other complementary therapies, such as acupuncture and TENS, elicit their therapeutic actions by releasing endogenous neurotransmitters/neuromodulators such as enkephalin, 5-hydroxytryptamine (serotonin) and noradrenaline which act to inhibit transmission of nociceptive information to the sensory cortex.^{50–52} Therefore, it is possible to speculate that the antinociceptive effects of reflexology are mediated by release of similar endogenous neurochemicals.

In conclusion, the present findings demonstrate for the first time in a controlled study that reflexology produces antinociceptive effects. These results suggest the possibility that reflexology may be useful on its own or as an adjunct to medication in the treatment of pain conditions in man.

Conflict of interest

There is no conflict of interest with any party.

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The authors dedicated this paper to our colleague, mentor and friend, the late Dr. Sheelagh Campbell, who encouraged us to undertake this study.

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