The Effect of Reflexology on the Autonomic Nervous System in Healthy Adults: A Feasibility Study

C. M. Hughes, PhD; S. Krisnakriengkrai, PhD; S. Kumar, MD, MPhil; S. M. McDonough, PhD

Background • Reflexology has been shown to reduce anxiety and stress in various populations. The mechanism by which this occurs may be in modulating autonomic nervous system (ANS) function; however, there is limited evidence available in the area.

Primary Study Objective • The aim of the study was to investigate the feasibility of using an experimental model to determine the physiological effect of reflexology on stress.

Methods/Design • A feasibility study to assess an experimental study design to compare the effect of reflexology and control interventions on heart rate (HR) and blood pressure (BP) following mental stress tests.

Setting • The Health and Rehabilitation Science Research Institute at the University of Ulster, Northern Ireland, United Kingdom.

Participants • Twenty-six healthy volunteers.

Intervention • Mental stress was induced before and after intervention. Participants in the reflexology group received 20 minutes of reflexology, and the control group received 20 minutes of relaxation with a therapist holding each participant’s feet.

Primary Outcome Measures • The outcome measures, HR and BP, were measured throughout mental stress testing, intervention, and a second period of mental stress testing following intervention.

Results • The study design was considered feasible. There were significant reductions in systolic blood pressure (SBP) (22%; \( P = .03 \)) and in diastolic blood pressure (DBP) (26%; \( P = .01 \)) during mental stress following reflexology compared to the stress period prior to intervention. In contrast, there was a 10% reduction in SBP (\( P = .03 \)) but a 5% increase in DBP (\( P = .67 \)) during the period of mental stress following the control intervention compared to results obtained during mental stress prior to this intervention. However, there were no significant differences between reflexology and control groups.

Conclusion • This study has demonstrated the feasibility of conducting an experimental study on the effect of reflexology in stress using BP as the primary outcome measure. Results from such a study would address the lack of high-quality evidence for the physiological effects of reflexology. (Altern Ther Health Med. 2011;17(3):32-37.)

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Evidence suggests that reflexology has an effect on physiological outcomes. Frankel found that reflexology increased sinus arrhythmia, indicating a higher synchronization between heart rate (HR) and respiration, and reduced baroreceptor reflex sensitivity; therefore, reflexology helps patients maintain blood pressure (BP) homeostasis by creating changes in autonomic outflow. Zhen et al found that reflexology stimulation could increase the complexity of HR variability signal, indicating an increase the vagal activity.

When people are under stress, autonomic nervous system (ANS) disturbances are induced, which consist of suppressed vagal and/or enhanced sympathetic functions. The observed effects of reflexology on the ANS therefore may help explain why reflexology has been shown to reduce anxiety and stress in cancer patients, women with depression, dementia patients, and in the working population.

Mental stress may be induced under experimental conditions, provoking sympathoexcitatory responses following emotional or behavioral challenges. The Stroop color word test and a mental arithmetic test have been widely used as tools for...
inducing these ANS responses. These studies have shown that HR and BP increase using experimental mental stress models to levels similar to those observed during a moderate walking task, but below those associated with hypertensive risk. These experimental models therefore may be used to simulate pathological stress.

The aim of the current study was to investigate the feasibility of using an experimental model to determine the physiological effect of reflexology on stress using mental stress tests in healthy adults to induce ANS function. The feasibility of patient recruitment and retention, logistics of intervention, outcome measure sensitivity, and appropriateness of the control intervention for such a study design was carried out. These data also will provide the basis of a power analysis to determine numbers for a future trial.

MATERIALS AND METHODS

Participants
This study was approved by the Research Ethics Committee of the University of Ulster. Healthy adults aged between 18 and 45 years were recruited from within the university through e-mail announcements and advertisements. Participants were excluded if they had previously received reflexology or had any condition that might interfere with the outcome measurements such as vascular, lymphatic, or skin conditions; diabetes; pregnancy; use of a cardiac pacemaker; or current drug therapy to treat hypertension. Potential participants were informed about the experimental procedure and asked to give written informed consent. The number of participants required for this study was calculated using power analysis from a similar study of acupuncture, as there were no similar studies on reflexology in the literature. The sample size from power analysis was 10 per group. The current study recruited 25 participants who were randomly allocated into either the reflexology group or control group using computer-generated numbers and sealed opaque envelopes. An independent researcher who was otherwise uninvolved in the trial performed randomization. Participants were asked to abstain from smoking and drinking caffeine or alcohol for at least 6 hours prior to testing and to refrain from eating or performing strenuous exercise during the preceding 2 hours.

Interventions
The reflexology group received stimulation to reflex points associated with the organs that would be expected to induce a physiological response in the ANS. These points included the reflex area for the peripheral nervous system, including the ANS, which is responsible for the regulation of HR and BP; the central nervous system, the brain and spinal cord, as these areas regulate ANS function; the solar plexus, which within the theory of reflexology will calm and relax the entire nervous system; the heart, as direct reflexology stimulation to this point may affect the organ (left foot only); the kidney, due to its role in the control of BP; and the endocrine reflex points such as the pituitary, thyroid, and adrenal gland points, as the hormones released from these glands aid in the regulation of HR and BP. These points were selected using appropriate published charts and textbooks. Pressure was applied to each of these points for 30 seconds at a time on each of the feet for a total of 20 minutes. The reflexology intervention using grape-seed base oil was performed by one of two qualified reflexologists with more than 10 years' experience.

The control group did not receive reflexology stimulation; the reflexologists simply rested each participant's heels in the palms of their hands for 20 minutes. The purpose of this intervention was to control for the effects of relaxation, touch, and patient-therapist interaction. All interventions were carried out in the same room.

Mental Stress Procedure
Two mental stress tests were employed to induce ANS parameters within the participants; these were the Stroop color word test and a mental arithmetic test. A pilot study carried out prior to this experimental study indicated that both of these tests increased HR and BP to a similar degree and could therefore be used interchangeably. The experimental procedure required two periods of induced stress to the ANS and therefore two separate stress tests were used to reduce the possibility of accommodation. The participant determined the order in which the stress tests were applied by randomly selecting one of two envelopes that contained the names of the two tests. The test that the participant selected was used as the first stress test during the experiment.

The Stroop color word test consisted of presenting color-naming words, with each word printed in a color different from its meaning; for example, the word red was printed in blue ink. To perform the task, the participant had to say the names of the color of the ink, not the color designated by the word. The mental arithmetic test was a verbal serial subtraction. The participants were instructed to verbally subtract 13 serially from 1079 for 4 minutes. During the mental stress, the sound from a metronome beating at 2 Hz (120 bpm) was used as a distraction and to increase stress. As sympathetic responses to mental stress testing are strongly influenced by perception of task difficulty, each volunteer was asked to assess each mental stress test, using a standard 5-point scale: not stressful, somewhat stressful, stressful, very stressful, or very very stressful.

Outcome Measurements
HR, systolic blood pressure (SBP), and diastolic blood pressure (DBP) were measured noninvasively using an automatic upper arm blood pressure monitor (Omron M5-I, Gaiam Ltd, Louisville, Colorado). All outcomes were measured every minute at baseline and during interventions and mental stress tests (Figure 1).

Experimental Procedures
Participants were asked to lie in the supine position. The blood pressure cuff was applied to the upper arm, and HR and BP were recorded every minute throughout the experimental period. After 5 minutes of baseline measurement, the participant took part in a mental stress test (color word test or mental arithmetic) for 4 minutes, followed by a 10-minute recovery period.
The intervention was then carried out for 20 minutes according to group allocation. A second baseline was measured for 5 minutes after the intervention period, followed by a different mental stress test (color word test or mental arithmetic) for 4 minutes and another 5-minute recovery period (Figure 1). The investigators who carried out the mental stress testing and who measured the outcomes were blinded to treatment allocation.

Blinding Status
For blinding purposes, all participants were informed that they would receive one of two different forms of complementary intervention. After completion of the experiment, all participants were asked to guess which interventions they received to check for blinding status. The blinding index for each group was calculated using the method demonstrated by Bang et al. Confidence interval (CI) of a proportion was calculated according to the method described by Newcombe, which was available online at http://faculty.vassar.edu/lowry/propl.html.

Data Analysis
Each outcome measurement was analyzed using Statistical Package for Social Sciences (SPSS) version 11.5 for Windows (SPSS, Chicago, Illinois). Data were checked for a normal distribution using Kolmogorov-Smirnov test. Baseline values were averaged from the values of minute 4 and minute 5 at resting baseline. Data were analyzed for differences from preceding baseline, during intervention, and during the two periods of mental stress testing. Analyses of variance with repeated measures were used to compare treatment effects and time and post hoc comparisons, using Tukey’s Honestly Significant Difference test, were used for significant between-group and within-group comparisons. The level of significance was set at 0.05.

RESULTS
Characteristics of Subjects
Twenty-six healthy volunteers responded to the advertisements and e-mail recruitment. One of them was excluded due to previous exposure to reflexology. Twenty-five participants were randomly allocated into two groups. Seven males and six females with a mean age of 27.08 ± 6.32 years were allocated to the reflexology group. Six males and six females with a mean age of 26.76 ± 5.53 years were allocated to the control group. There was no significant difference in demographics between the groups (P > .05). There were no dropouts during the study, and no adverse effects were reported.

Experimental Profiles of All Outcomes
During the 4-minute periods of mental stress, HR, SBP, and DBP were significantly increased (P < .05) relative to the baseline (average of baseline minute 4 and minute 5). This increase was greater during the first phase of mental stress testing than the second phase of mental stress testing that occurred after the intervention. The profile for DBP obtained at each minute throughout the experiment is shown in Figure 2. Profiles for HR and SBP were similar.

Comparison of the Effects of Reflexology and Control on Responses to Mental Stress
The second baseline period was lower than the first baseline; therefore, comparison of the effects of reflexology and control on responses to mental stress was analyzed using the change in HR and BP from the preceding baseline (average values at minute 4 and minute 5 baseline). The average changes in HR and BP over the 4 minutes of induced stress from preceding baseline are shown in Table 1. There were significant reductions in SBP (22%; P = .03) and in DBP (26%; P = .01) during mental stress following reflexology compared to the stress period prior to intervention. In contrast, there was a 10% reduction in SBP (P = .03) but a 5% increase in DBP (P = .67) during the period of mental stress following the control intervention compared to results obtained during mental stress prior to this intervention. However, there were no significant differences between reflexology and control groups.

Participants’ Perception of Task Difficulty of Mental Stress
There were no significant differences in perceived difficulty between the two mental stress tasks or between the reflexology and control groups as to the perceived difficulty within each stress task. The perceived difficulty values (mean ± SD) were 1.23 ± 0.6 (reflexology group) and 1.25 ± 0.97 (control group) for the color word test and 1.92 ± 1.19 (reflexology group) and 1.25 ± 0.97 (control group) for the mental arithmetic test.
FIGURE 2 Profiles of Diastolic Blood Pressure Responses to Mental Stress and Reflexology or Control Intervention

*Significant difference from baseline (average of min 4 and 5) at P < .05

<p>| TABLE 1 Average Increase in Heart Rate and Blood Pressure During 4-minute Stress Test |
|-------------------------------------------------|---|---|---|---|</p>
<table>
<thead>
<tr>
<th>Intervention</th>
<th>Outcomes</th>
<th>Average Increase From Baseline</th>
<th>% Change Preintervention to Postintervention</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflexology</td>
<td>HR (BPM) Preintervention</td>
<td>10.79</td>
<td>20.8% decrease</td>
<td>-1.2%-42.9%</td>
</tr>
<tr>
<td></td>
<td>Postintervention</td>
<td>8.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SBP (mmHg) Preintervention</td>
<td>9.81</td>
<td>22.3% decrease</td>
<td>-0.3%-45%</td>
</tr>
<tr>
<td></td>
<td>Postintervention</td>
<td>7.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DBP (mmHg) Preintervention</td>
<td>8.31</td>
<td>25.9% decrease</td>
<td>2.1%-49.7%</td>
</tr>
<tr>
<td></td>
<td>Postintervention</td>
<td>6.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>HR (BPM) Preintervention</td>
<td>11.40</td>
<td>19.9% decrease</td>
<td>-2.8%-42.3%</td>
</tr>
<tr>
<td></td>
<td>Postintervention</td>
<td>9.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SBP (mmHg) Preintervention</td>
<td>8.58</td>
<td>9.7% decrease</td>
<td>-7.1%-26.4%</td>
</tr>
<tr>
<td></td>
<td>Postintervention</td>
<td>7.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DBP (mmHg) Preintervention</td>
<td>8.96</td>
<td>5.4% increase</td>
<td>7.4%-18.1%</td>
</tr>
<tr>
<td></td>
<td>Postintervention</td>
<td>9.44</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The % change in HR and BP during the stress test following intervention as compared to the stress test prior to intervention is shown along with confidence intervals. Abbreviations: CI, confidence interval; HR, heart rate; BPM, beats per minute; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Blinding Efficiency
Most of the participants allocated to receive reflexology treatment (53.8%) said "don’t know" when asked which experimental group they were in, while most of the participants in the control group (66.7%) guessed "control" (Table 2). The blinding index was 0.15 (95% CI, 0.03-0.46) for the reflexology group and 0.5 (95% CI, 0.22-0.78) for the control group.

Power Analysis
The current data were used to calculate the numbers required to detect significant differences for DBP between groups. Using a within-group standard deviation of 7.1, a minimum difference between groups of 2.6, alpha of 0.05, and power at 90%, a total of 180 participants per group would be required to detect significant changes between groups.


**TABLE 2 Blinding Index of Reflexology and Control Group**

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Complementary medicine</th>
<th>Control</th>
<th>Don’t know</th>
<th>Total</th>
<th>BI</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflexology</td>
<td>4 (30.8%)</td>
<td>2 (15.4%)</td>
<td>7 (53.8%)</td>
<td>13 (100%)</td>
<td>0.15</td>
<td>0.03-0.46</td>
</tr>
<tr>
<td>Control</td>
<td>2 (16.7%)</td>
<td>8 (66.7%)</td>
<td>2 (16.7%)</td>
<td>12 (100%)</td>
<td>0.5</td>
<td>0.22-0.78</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>10</td>
<td>9</td>
<td>25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: BI, blinding index; CI, confidence interval.

**DISCUSSION**

Results from this study indicate that a larger trial would require 180 participants in each arm in order to have the required power to demonstrate significant changes in DBP in participants under stress following reflexology. This study also demonstrated the feasibility of conducting a methodologically rigorous controlled study under experimental conditions using healthy volunteers. Recruitment was successful as the required numbers were randomized into the study. HR, SBP, and DBP increased significantly from baseline during both of the mental stress indicating that these tests are appropriate to use under experimental conditions. In addition, all participants self-reported the level of perceived task difficulty using the standard 5-point scale. There was no difference between reflexology and control group, which confirmed that the perceived task difficulty did not influence the results between groups.

The blinding index was calculated from the method demonstrated by Bang et al, which was scaled to an interval of -1 to 1, 1 being complete lack of blinding, 0 being consistent with perfect blinding, and -1 indicating opposite guessing which may be related to unblinding. From the results, the blinding index of the reflexology group was 0.15 (95% CI, 0.03-0.46) and the control was 0.5 (95% CI, 0.22-0.78), indicating that the blinding may not have been completely successful for the control intervention. It is difficult to define what an appropriate comparable intervention for reflexology studies would be. Many studies have demonstrated that sham interventions produced some effect. Frankel used foot massage for a comparable intervention to reflexology and found that there were no significant differences between reflexology and foot massage because the foot massage also induced some therapeutic effects. Hughes et al in a trial comparing reflexology and foot massage on pain in people with multiple sclerosis also found significant pain reduction in both group. It was suggested by this group that sham foot massage might also stimulate the reflex points associated with reflexology and therefore have some therapeutic effect.

In a review of studies published on reflexology, Kunz and Kunz discuss the problem of finding an appropriate control for reflexology trials. The authors report 14 studies comparing reflexology to a sham reflexology treatment (use of nonrelated points) and 11 studies comparing reflexology and foot massage for various conditions. The results of these trials were mixed, leading to the general conclusion that foot massage is not a reliable control procedure for reflexology. Therefore for the present study, the control intervention used a simple touch on the participants' heels, which did not stimulate and reflex points. This form of control was successful, because although there was some unblinding in this group, the intervention did not attenuate HR and DBP responses during mental stress. The study therefore effectively controlled for therapist interaction and touch without the stimulation of reflex points. Reflexology moderated BP as the increase in BP observed during the first period of stress testing was significantly reduced by 22% to 25% in this group, whereas a small reduction in SBP (10%) and an increase of 5% in DBP were observed in the control group. Similar results were reported by McVicar et al, who with a sample size of 52 demonstrated reductions in SBP and pulse rate following reflexology. However, as with the present study, McVicar et al did not find any differences between intervention and control groups. In McVicar's study, participants received reflexology for 60 minutes. In the current experimental study, the effect of 20 minutes of reflexology intervention was investigated. This methodology was based on a previously published study by Middlekauff et al, who demonstrated reduced BP following 20 minutes of acupuncture. It may be that a longer treatment period in our experimental design would produce stronger results and should therefore be considered in any future investigation. Indeed, reflexologists stress the importance of treating a patient holistically with a full treatment rather than limiting an intervention to specific points for a specific condition. Kunz and Kunz suggest that frequency and duration of treatment may vary from condition to condition. They reference multiple studies that demonstrate a reduction in pain or anxiety following one short reflexology session; however, evidence suggests that other reflexology treatments (such as for asthma control or cholesterol reduction) require daily sessions of 40 to 50 minutes over several days to demonstrate any effect. In addition, the pressure or intensity of the treatment may be a factor. The McVicar study researchers applied only a light pressure, as this group had previously demonstrated effectiveness of a light pressure within a cancer patient population. It may be that a moderate pressure is required for optimal stimulation of reflex points, although there is no robust evidence to support this.

Reflexology has been shown to reduce anxiety and stress in various populations. The mechanism by which this occurs may be in modulating ANS function. The current study demonstrates the feasibility of conducting experimental studies in the area and indicates that BP may be modulated by reflexology; however, further fully powered trials using suggested modifications to the protocol such as longer treatment time are required to confirm these findings.
REFERENCES


