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ORIGINAL REPORT

ANALGESIA BY SACRAL SURFACE ELECTRICAL STIMULATION FOR PRIMARY DYSMENORRHOEA

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Objective: To evaluate the effects of analgesia by sacral surface electrical stimulation on lower abdominal pain in women with primary dysmenorrhoea.
Design: Explorative study.
Participants: Eleven female university students, who regularly experience difficulty in their university work due to menstrual pain, or who use analgesics for more than one day each month, were recruited.
Methods: Sacral surface electrical stimulation, 5 Hz for 15 min, was performed after the onset of menstruation. Electrodes were placed on the skin, directly above the second and fourth sacral foramina. Visual analogue scale and degree of pain (calculated by using a low current to assess pain) were determined before and after electrical stimulation.
Results: Visual analogue scale score and degree of pain decreased significantly immediately after electrical stimulation ($p < 0.001$). A correlation was observed between visual analogue scale score and degree of pain before and after electrical stimulation ($r=0.516$, $p < 0.001$). No side-effects were observed in any participant.
Conclusion: Sacral surface electrical stimulation may provide immediate pain relief in women with dysmenorrhoea and lower abdominal pain.

LAY ABSTRACT

Eleven female university students, who regularly experience difficulty performing their university work due to menstrual pain, or who use analgesics for more than one day each month, received electrical stimulation for relief of lower abdominal pain. Electrodes were placed on the skin over the lower region of the spine, while participants were in the prone position. Stimulation was performed for 15 min at a frequency of 5 Hz. Lower abdominal pain associated with menstruation decreased immediately after electrical stimulation; no side-effects were observed in any participant. For women who do not wish to take analgesics, electrical stimulation could be an option for complementary therapy. These findings indicate that electrical stimulation of the skin over the lower spine may provide immediate relief of menstrual pain.

Dysmenorrhoea is defined as painful menstrual cramps of uterine origin. It is divided into primary dysmenorrhoea without organic pathology, and secondary dysmenorrhoea with an identifiable pathological condition. Lower abdominal or pelvic pain of primary dysmenorrhoea often lasts for 8–72 h, and is usually associated with the onset of menstrual flow (1–2).

Therapies for primary dysmenorrhoea have included acupressure, analgesics, herbal remedies, topical heat, and transcutaneous electrical stimulation therapy (TENS) (2). Electrical stimulation therapy uses a relatively high frequency (~120 Hz) for pain relief, applied by electrodes to the dermatomes (3–6), lower abdomen (7–8), and lower back (9–11). As a result, it has been reported that the time to the next drug administration is prolonged and the pain scale score is lowered. The effect of electrical stimulation is suspected to be exerted through presynaptic inhibition and endogenous opioid release.

Another method involves sacral surface electrical stimulation, in which stimulation is provided via electrodes

attached to the skin directly above the second and fourth sacral foramina (12, 13). For dysmenorrhoea, this has been reported to reduce the thickness of the uterine muscle layer and suppress peristaltic movement (12). However, there are no reports regarding the effects of sacral surface electrical stimulation on pain.

Nevertheless, the following problems should be considered when evaluating the effects of electrical stimulation for reducing pain, including menstrual pain. Although pain assessment by visual analogue scale (VAS) is simple, it is easily influenced by mood and physical condition; in addition, some patients report improvement in pain due to consideration for their therapists during evaluation of pain before and after treatment (14). As such, the perception/pain quantitative analyser represents a method in which a weak current is used to quantitatively assess pain, and has been used to evaluate pain associated with peripheral neuropathy after cancer chemotherapy (15, 16), post-herpetic nerve disorder (17), and low back pain (18, 19); however, it has not been used to assess dysmenorrhoea pain.

The aim of this study was to evaluate the effects of analgesia by sacral surface electrical stimulation on lower abdominal pain in women with primary dysmenorrhoea.

METHODS

Participants

This research was conducted with approval from the ethics committee of Tohoku Bunka Gakuen University (approval number 16–23). Participants received written information explaining the purpose of the study, and informed consent was obtained from all participants included in the study.

The participants comprised nulliparous women between the ages of 18 and 25 years who did not have a history of gynaecological diseases and who were not currently undergoing hospital treatment for any disease. Participants were recruited via posters on the university campus. Participants were selected based on grading and scoring of their symptoms and requirement for analgesics (20). To examine the degree of dysmenorrhoea of the participants, the grade of dysmenorrhoea (none: score 0, no effects; mild: score 1, some loss of study efficiency; moderate: score 2, want to take some rest in bed, loss of study; severe: score 3, in bed for more than 1 day) and use of analgesics (none: score 0: none; mild: score 1, take analgesics for 1 day; moderate: score 2, take analgesics for 2 days; severe: score 3, take analgesics for >3 days) were confirmed by a questionnaire. A flow chart of this study is shown in **Fig. 1**. Eleven female university students (mean age 20.2 years (standard deviation (SD) 0.8) who regularly experience difficulty in their university work due to menstrual pain, or who use analgesics for more than one day each month, were recruited.

Study design

The study design was an explorative study, which involved comparing pain before and after electrical stimulation. The study duration was 3 cycles of menstruation. Lower abdominal pain due to menstruation varies with each cycle. The examination of pain and administration of electrical stimulation were
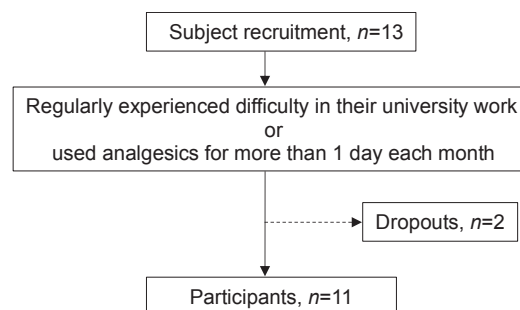

Fig. 1. Flow chart of participant recruitment.

performed by different female physical therapists. For participants using a commercially available analgesic drug, examinations and interventions were performed ≥4 h after taking the analgesics, to eliminate the influence of medication as much as possible. The introspection report was collected from participants after electrical stimulation.

Electrical stimulation

Since menstrual pain, such as lower abdominal pain, is related to the onset of menstruation (1–2) and generally begins with the onset of menstruation (21), electrical stimulation was performed as soon as possible after the onset of menstruation as reported by the participants. For electrical stimulation, a low-frequency treatment device (PULSECURE-PRO KR-7; OG Wellness Technologies Co., Ltd, Okayama, Japan) and an adhesive electrode (4.0×4.5 cm) were used. Electrodes were placed on the skin, directly above the second and fourth sacral foramina, while participants were in the prone position. Stimulation was performed for 15 min with a pulse width of 300 μs, stimulation frequency of 5 Hz, on-time 5 s, and off-time 5 s. Intensity was adjusted to strong, but comfortable, as stated by the patient.

Evaluation of pain

Evaluation of pain was performed before and after stimulation. Several of the 11 female university students reported back pain and headache in addition to abdominal pain. In all cases, lower abdominal pain was the main symptom; therefore, lower abdominal pain was evaluated. VAS score was used for the evaluation of pain in the lower abdomen. For the measurement of pain by VAS, a line with a length of 100 mm was used; the left end was "0: no pain," while the right end was "100: the strongest pain ever experienced". The participants marked the position corresponding to the pain they experienced. A perception/pain quantitative analyser (Pain Vision PS-2100; Nipro Corp., Osaka, Japan) device was used to assess the participants' pain in a quantitative manner. The participants wore the stimulation electrode on the inside of the forearm of their non-dominant hand and had a hand switch in their dominant hand to report sensation of current from the stimulation electrode. During the evaluation, the minimum current perception threshold at which the subject felt stimulation (minimum perceived current) and the amount of current corresponding to the pain (pain equivalent current) were measured, and the degree of pain was calculated (15–19). The stimulation current automatically and gradually increased from 0 μA. The participant pressed the hand switch when some stimulus was felt and when it was equivalent to the intensity of pain. Measurements were performed 4 times each, and the mean values of 2 measurements (except the maximum

Table I. Characteristics of study participants

Characteristics	
Age, years, mean (SD)	20.2 (0.8)
Height, cm, mean (SD)	161.9 (6.7)
Weight, kg, mean (SD)	56.9 (9.8)
Degree of dysmenorrhoea, *n*	
None	0
Mild	2
Moderate	9
Severe	0
Use of analgesics, *n*	
None	2
Mild	1
Moderate	6
Severe	2

SD: standard deviation.

and minimum values) were adopted. The degree of pain was calculated using the following formula:

Degree of pain = $100 \times ((\text{pain equivalent current} - \text{minimum perceived current})/\text{minimum perceived current})$.

Statistical analysis

Normality tests were performed using the Shapiro–Wilk test. VAS and degree of pain, both before and after electrical stimulation, were compared using the paired *t*-test and the Wilcoxon signed-rank sum test, respectively.

Furthermore, Spearman's correlation coefficient was calculated for all data before and after electrical stimulation, to analyse the relationship between VAS and degree of pain. Data were analysed using SPSS for Windows (Version 25.0; IBM, Armonk, NY, USA). A *p*-value < 0.05 was considered statistically significant.
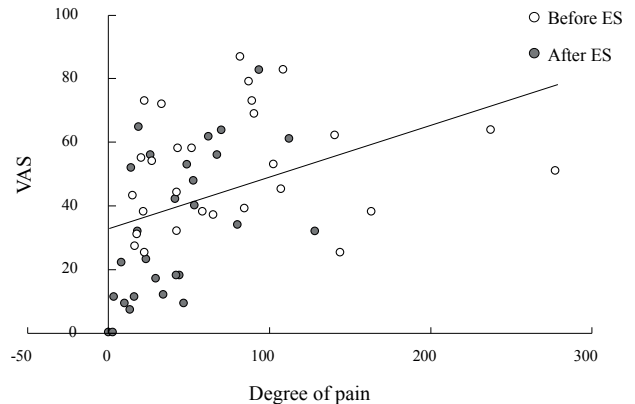
RESULTS

Table I shows the characteristics of the 11 participants. Except for the cycles of menstruation that could not be measured due to the participants' time constraints (academic work, vacation, public holiday, etc.), all other cycles were evaluated. Thus, a total of 28 cycles were analysed. One participant had one cycle with no menstrual pain and was analysed in the next cycle.

The mean time from the onset of menstruation to the electrical stimulation was 14.8 h (SD 10.8). Participants in this study took non-steroidal anti-inflammatory drugs (NSAIDs) as an analgesic. In 9 cycles of taking the commercially available analgesics before electrical stimulation, the frequency of administration was 1.8 times (SD 1.4), and the time from medication to electrical stimulation was 11.4 h (SD 6.2). The change in pain before and after electrical stimulation is shown in **Table II**.

Table II. Visual analogue scale and degree of pain before and after electrical stimulation

	Before ES	After ES	*p*-value	Effect size	β
VAS, mm, mean (SD)	51.9 (18.2)	33.5 (23.3)	<0.001	0.870	0.007
Degree of pain, 100×μA/μA, mean (SD)	79.4 (65.5)	41.2 (33.6)	<0.001	0.673	0.082

ES: electrical stimulation, VAS: visual analogue scale, SD: standard deviation.

Fig. 2. Correlation between visual analogue score (VAS) and degree of pain for lower abdominal pain in primary dysmenorrhoea. Before electrical stimulation (ES) (*white circle*); after ES (*grey circle*). Correlation between VAS and degree of pain (*r* = 0.516, β = 0.013, *p* < 0.001).

Mean VAS decreased significantly from 51.9 (SD 18.2) before to 33.5 (SD 23.3) after electrical stimulation (*p* < 0.001, β = 0.007). Mean degree of pain decreased significantly from 79.4 (SD 65.5) before to 41.2 (SD 33.6) after electrical stimulation (*p* < 0.001, β = 0.082). After electrical stimulation, 6 cycles had a VAS less than 30%, and 5 cycles had a VAS of 30% or more, but less than 50% of the VAS reported before electrical stimulation. Moreover, 6 cycles had a degree of pain less than 30%, and 8 cycles had a degree of pain of 30% or more, but less than 50% of the degree of pain reported before electrical stimulation.

A correlation was observed between VAS and degree of pain before and after electrical stimulation (r=0.516, *p* < 0.001, β = 0.013) (**Fig. 2**).

No side-effects were observed in any participant. As an introductory report, some participants reported that "there was always pain in all of the previous menstrual cycles, but there was no pain in the cycle that came after the end of 2 cycles in which electrical stimulation was conducted" and "the pain disappeared right after electrical stimulation".

DISCUSSION

The analgesic effects of sacral surface electrical stimulation were compared before and after stimulation, and a significant reduction in VAS score and degree of pain was observed.

As a common electrical stimulation method so far, electrical stimulation for primary dysmenorrhoea includes some methods in which electrodes are attached at the level of the T10 to L1 dermatomes, which include the uterine base and body sense control dominant region; these are stimulated at 70–100 Hz (3–6). Painful lower abdomen (7–8) and lower back (9–11) have been reported to be similarly stimulated at 100–120 Hz. Most reports use relatively high frequencies, which enables reductions in scores of numerous pain scales, such as VAS, numerical

rating scale (NRS), and McGill pain questionnaires, as well as a reduction in the number of doses of analgesics required, and postponement of dosing intervals. In particular, it has been reported that, although the intrauterine pressure does not decrease when electrodes are attached to the lower abdomen and lumbar region and stimulated at 70–100 Hz, the pain scale score decreases (22). High-frequency stimulation shows a pain-relieving effect, compared with placebo stimulation; however, low-frequency stimulation shows no pain-relieving effect compared with placebo stimulation (23). This supports the use of high-frequency electrical stimulation to reduce the pain of primary dysmenorrhoea. On the other hand, animal experiments have shown that the type of opioid released differs, depending on the frequency (24); thus, the continuous use of high-frequency stimulation may not be ideal. Another study showed that electrical stimulation was applied after lower abdominal gynaecological surgery by using an electrode to sandwich the surgical wound site in the lower abdomen with a mixed stimulus of 2 Hz and 100 Hz. This was reported to alleviate pain and to lower the requirement for opioid analgesics, thus reducing their side-effects (25). In primary dysmenorrhoea, electrodes affixed to a painful lower abdomen at a frequency of 2 to 100 Hz have been reported to decrease NRS and the amount of ibuprofen used (26). Conventional electrical stimulation changes the perception of the pain signals, without directly acting on uterine contraction, which is the cause of dysmenorrhoea (22).

In contrast, the low-frequency stimulation used in this study showed that uterine peristalsis was suppressed during electrical stimulation on the sacral surface, on magnetic resonance imaging (12), but also after electrical stimulation on transvaginal ultrasound (13). It is thought that this afferent volley induced by pudendal nerve stimulation inhibited the pelvic nerve, and simultaneously stimulated the hypogastric nerve, because anal sphincter contraction was inspected or palpated (27). The cause of primary dysmenorrhoea is the excessive release of prostaglandins, which cause the uterus to contract excessively, thereby causing pain. It can be inferred that the electrical stimulation suppresses hyper-contraction of the uterus, which results in pain relief.

When menstrual pain is severe, it would be desirable for the patient to be able to attach electrodes to the skin and perform electrical stimulation independently. For dysmenorrhoea, electrodes are typically placed on the lower abdomen, or the dermatome. Electrodes can be easily and accurately placed in these positions because the patient can visually confirm their position. However, the sacral surface electrical stimulation used in this study places electrodes on the skin immediately above the sacrum of each of the left and right S2 and S4 vertebrae, which makes it more difficult for the patient to visually confirm the accuracy of the electrode positioning. Therefore, it may be desirable for this method to be performed by a healthcare provider.

This study found a correlation ($r=0.516$, $p<0.001$, $β=0.013$) between VAS and the assessed degree of pain in lower abdominal pain due to dysmenorrhoea. The correlation between VAS and the assessed degree of pain has been reported previously as $r=0.274–0.584$ for peripheral neuropathy associated with cancer chemotherapy (15, 16) and $r=0.453–0.64$ for post-herpetic neuropathy (17); similar results were obtained in the current study. The stimulus current used for examination uses a rectangular pulse of 50 Hz and 300 µs to stimulate Aβ and Aδ fibres, without exciting C fibres. Therefore, when measuring the pain response current value, it appeared that participants were confused regarding when to press the switch. As a result, correlation with VAS was observed, and we speculated that a quantitative evaluation should be performed using the perception/pain quantitative analyser. VAS after stimulation may be affected by the memory of visual information from the VAS examination before stimulation. Some patients have reported improvements in pain owing to consideration for their therapists after treatment (14). However, the perception/pain quantitative analyser is a tool in which the participant does not look at the current stimulus. Instead, this method identifies the current intensity at which the pain and the sensation of current from the stimulation are equal. Therefore, although this device is limited in use, it can be used as a quantitative measurement of pain.

Study limitations

This study had some limitations. First, analgesia by sacral surface electrical stimulation for menstrual lower abdominal pain had only an immediate effect. To use the device for pain evaluation, it is necessary for the participants to go to the place where the device is located, and it was not possible to perform an evaluation every 30 min or every hour after the electrical stimulation. Therefore, we were unable to determine the sustained effect of analgesia by electrical stimulation in this study. Secondly, determining the effects of electrical stimulation is difficult in controlled trials. However, comparing the frequency of medications during menstrual periods without electrical stimulation may further clarify the effect of electrical stimulation. Some women desire non-pharmacological therapy, with statements such as, "I do not want to use the drug" and "I do not use the drug". For such women, we expect that electrical stimulation could be an option for complementary therapy.

Further research is required into the effect immediately after electrical stimulation and the sustained effect after several hours or cycles of menstruation, changes in dose, and comparisons with drug therapy.

Conclusion

On performing sacral surface electrical stimulation during menstruation on 11 female university students who

presented with primary dysmenorrhoea, the VAS score and degree of pain decreased significantly immediately after sacral surface electrical stimulation. Furthermore, there was a correlation between VAS scores and degree of pain. It is speculated that electrical stimulation provides pain relief, and thus, this method may be useful for immediate pain relief.

The authors have no conflicts of interest to declare.

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