The effect of sacroiliac joint manual therapy on heart rate variability in women with primary dysmenorrhea

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Objective: Disorder of the autonomic nervous system is considered to be the cause of primary dysmenorrhea. The spine has a close relationship with the autonomic nervous system, and the sacrum is mechanically and neurologically connected to the uterus through ligaments. Therefore, this study was conducted to check the effect on the autonomic nervous system through measurement of heart rate variability by applying manual therapy to the sacroiliac joints of subjects with primary dysmenorrhea and to suggest an effective treatment method for dysmenorrhea.

Design: Randomized controlled trial.

Methods: Thirty females with dysmenorrhea were assigned to either the manual therapy group and sham treatment group according to the random treatment method. The manual therapy was applied to the sacroiliac joints, and the sham treatment was only treated with the hands placed in the same position of the intervention. Heart rate variability and the Visual Analogue Scale (VAS) were measured on the day when menstruation began ± 2 . Interventions were performed between the groups, followed by a 5-minute break and then re-measurements were made.

Results: There were significant differences in autonomic balance and VAS scores in the manual therapy group before and after the intervention between groups ($p < 0.05$). In the sham treatment group, there were significant differences in low frequency, autonomic balance, and VAS scores ($p < 0.05$). There were significant differences in autonomic balance between groups ($p < 0.05$).

Conclusions: In females with primary dysmenorrhea, manual therapy applied to the sacroiliac joint was found to be effective for a short time on autonomic activity.

Key Words: Dysmenorrhea, Heart rate variability, Musculoskeletal manipulations, Sacroiliac joint

Introduction

Pain in the lower abdomen, which occurs when the cervix convulsion continues for 6 to 72 hours with the onset of menstrual flow, is called dysmenorrhea [1,2]. During this period, back and thigh pain, fatigue, diarrhea, constipation, and headache may be accompanied. This leads to absenteeism from work or school, interruptions in daily life, and in-

creased social costs [3].

Dysmenorrhea is mainly classified into primary and secondary dysmenorrhea. Primary dysmenorrhea has no pathological findings. Most females experience this, and it occurs most often during the menstrual cycle [4]. Secondary dysmenorrhea has pathological findings such as pelvic inflammatory disease, fibroids, polycystic ovary syndrome, and endometriosis [5].

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Prostaglandin is considered the physiological cause of dysmenorrhea. Secreted from endometrial cells during the menstrual period, prostaglandin causes ischemia and contraction of the uterine muscles [2]. However, the pathophysiology of dysmenorrhea is still under discussion and is not completely clear [6].

Another cause of dysmenorrhea is a disorder of the autonomic nervous system accompanied by inhibition of the vagus nerve function and enhancement of sympathetic activity [7]. Previous studies compared women with dysmenorrhea and healthy women, and the result showed different autonomic reactions [8]. Compared to healthy women, sympathetic activity increased significantly and parasympathetic activity decreased in women with premenstrual syndrome [9,10].

In obstetrics and gynecology, it is reported that the treatment of menstrual disorders related to dysmenorrhea is effective through autonomic nervous system regulation [11,12]. The autonomic nerve maintains the homeostasis of the internal environment of the human body through the interaction between the sympathetic nerve and the parasympathetic nerve according to the change of the external environment. Therefore, the disharmony between the 2 systems may cause various symptoms [9]. Previous studies reported that the sympathetic activity of women with menstrual disorder was significantly increased and that the parasympathetic activity was significantly decreased during the late luteal phase [9,10,13], while another study reported that healthy women had greater parasympathetic activity in the early to intermediate follicular stages of the menstrual cycle than in the luteal phase [14]. This is considering sympathetic hyperactivity, and it is believed that the more severe the dysmenorrhea is, the more the autonomic imbalance will be [7].

Heart rate variability (HRV) analysis is a non-invasive method that can easily apply autonomic function assessment [15]. Previous studies also used this analysis method to confirm the association between dysmenorrhea and the autonomic nerve system [7,16,17]. HRV refers to the change in the interval between the heart rate and rate (RR interval) [18]. When the autonomic nervous system function is abnormal or weak, the change in HRV does not appear to be significant. Conversely, when the autonomic nervous system functions well, a severe change in HRV appears, which means adapting to various changes [15].

Nonsteroidal anti-inflammatory drugs (NSAIDs) and hormonal contraceptives are available to relieve menstrual pain and relax the uterine muscles [2]. However, alternative

treatment methods have been studied due to the 20%-25% failure rate of drug treatment and a wide range of side effects [19]. Among the many alternative treatment methods for treating primary dysmenorrhea, physical therapy and manual therapy show the highest proportion of physician referral [20]. Recently, the number of patients seeking manual therapy as an approach to pain has been increasing [21].

Previous studies reported that abnormal spine arrangement is a decisive cause of not only spinal diseases, but also degenerative changes such as changes in blood vessels, decline in organ function, headache, and chronic fatigue, as well as abnormalities in the autonomic nervous system [22]. In particular, the 10th spine to the 1st lumbar bone and the 2nd to 4th sacrum segments are closely related to the sympathetic and parasympathetic nerves [23].

Among them, the sacrum and the uterus are neurologically connected to the pelvic splanchnic nerves (parasympathetic) starting from the 2nd to the 5th sacrum and mechanically connected to the uterosacral ligament [24-26]. In addition, the anterior and posterior inclinations of the sacrum may affect not only the 5th lumbar bone and the 1st sacrum, but also the higher vertebral segments [27].

According to previous studies, the ligaments that connect the sacrum and the surrounding frame or the sacrum nerve roots passing around them have a close relationship with the uterus [28]. Therefore, excessive uterine contraction during the menstrual period affects blood circulation by compressing the surrounding soft tissues and blood vessels, leading to the judgment that it is related to pain in the pelvis as well as pain in the sacrum [28]. Another study reported that manual therapy was applied to the sacrum and as a result, dysmenorrhea could be relieved by reducing the tension in the ligaments around the uterus or pelvic nerve roots [5].

Several studies have evaluated the effectiveness of manual therapy in women with primary menstrual pain. As a result, manual therapy affected pain perception, dysmenorrhea, and plasma levels of some chemical mediators [5,29-31].

Based on these results, manual therapy that affects the location of the sacrum may be highly related to dysmenorrhea. In the previous studies to date, however, there have been only a few studies that performed manual therapy on a specific spinal joint, and an evaluation method involving a large number of subjective factors of the patient has been used.

Therefore, this study was conducted to present a more effective treatment method by applying manual therapy to the sacroiliac joint in women with primary dysmenorrhea and confirming changes in the autonomic nervous system

through the HRV analysis.

Methods

Participants

We recruited women aged 18 and 50 with primary dysmenorrhea symptoms for at least 1 year through flyer advertisement from September 14, 2020 to September 29, 2020 at The Wells Clinic, Minimal Pilates, in Seoul, Easy Rehabilitation Medicine Clinic in Suwon.

The selection criteria for this study were those who have a menstrual cycle (24 to 32 days), those with dysmenorrhea-related back pain symptoms above 50 mm on the Visual Analogue Scale (VAS), and those with a body mass index between 20 kg/m² and 30 kg/m² [32]. The exclusion criteria included those with gynecological findings such as pelvic inflammatory disease, fibroids, polycystic ovary syndrome, endometriosis, etc., those who used intrauterine contraceptive devices, those who took contraceptives or NSAIDs at the time of the experiment, those who received manipulation within 1 month of the experiment, those who were

contraindicated to manipulation, and those who were scared or stressed by manipulation [33].

A total of 37 subjects were recruited, and the final 33 were selected through the selection and exclusion criteria. After that, they were randomly assigned to either the manual therapy group (n=17) or the sham treatment group (n=16) through the Microsoft Excel 2016 (Microsoft, Redmond, WA, USA). In the sham treatment group, however, a total of 3 patients were eliminated due to fear of manipulation (n=3) and due to feeling burdensome of the treatment postures caused by menstrual blood leakage (n=1) (Figure 1). This study was conducted according to the approval of the Institutional Review Board of Sahmyook University (IRB No. 2-1040781-A-N-012020101HR).

All participants were given detailed explanations on the purpose and necessary matters of the study, and voluntarily signed the relevant consent form. In addition, an experienced physical therapist explained to the subjects that they could stop whenever they wanted even during the study.

Figure 1. Flow chart.

Experimental methods

Intervention in the manual therapy group

The manual therapy method applied to the sacroiliac joint used high-velocity, low amplitude (HVLA) manipulation. Applying force to the treatment is typically performed in less than 200 milliseconds [34]. To manipulate the sacroiliac joint, the subject laid on her side. The mediator bent the upper knee and pelvis to flex the lumbar bone. Then, the pisiform bone in the mediator's hand was contacted between the sacroiliac joint and the posterior superior iliac spine (PSIS), and the manipulation is performed.

After this, the pisiform bone in the mediator's hand was in contact between the sacroiliac joint and the PSIS, and a line of drive manipulation was performed in the anterosuperior and medial to lateral direction. Manipulation was performed to both sides of the sacroiliac joint [35].

Previous studies used audible release as an indirect indication that the manipulation was performed at a sufficient manipulation rate to elicit a reflex response in the surrounding muscles [36]. Therefore, if the movement of the sacroiliac joint was not enough or there was no audible release after the mediator's 1st manipulation, the manipulation was performed once more. Up to 2 manipulations were applied to each subject (Figure 2).

Intervention in the sham treatment group

The subjects are asked to assume the same position and posture as previously described and then to hold it for 30 seconds (time taken for the manipulation of one sacroiliac joint). The mediator did not apply tension or manipulate it.

Figure 2. Manual therapy. Blue arrows indicate the line of drive. Blue X indicate the contact point (posterior superior iliac spine).

Measure

Based on the fact that the subjects generally complained of a lot of pain on the 1st day of menstruation [37], the evaluation period was set to the day of menstruation ± 2 in the previous studies.

Heart rate variability

In order to prevent the autonomic nervous system from being affected by the external environment when measuring HRV, the measurement was conducted in a room maintained at a constant temperature between 20°C and 25°C. In addition, excessive exercise, smoking and drinking were prohibited within 12 hours of measurement.

As a measuring device, an autonomic nerve balance tester (SA-3000new; MEDICORE Co., Seongnam, Korea) was used. While the subject was lying with her eyes open, electrodes were placed in 3 areas (left arm, left leg, and right leg) and carried out for 3 minutes. After the intervention, the subject was re-measured after taking a break for 5 minutes (Figure 3).

HRV is evaluated by 2 methods: time domain analysis and frequency domain analysis [38]. As the time domain analysis, the standard deviation of all normal R-R intervals (SDNN) is the root mean square of successive normal to normal interval difference (RMSSD) was the square root of the

Figure 3. Autonomic nervous system electrode placement.

mean of the sum of the square of differences between adjacent N-N intervals. It is used to evaluate the parasympathetic regulation of the heart in the time domain analysis.

In the frequency domain, TP (total power) is the sum of the intensity of very low frequency, low frequency (LF), and high frequency (HF), representing overall autonomic activity, and LF reflects the function of the sympathetic nerve and HF reflects the function of the parasympathetic nerve.

LF/HF refers to the relative balance and ratio of the sympathetic and parasympathetic nervous systems [15,39]. In addition, items automatically recorded in the analyzer after data processing based on the measured value of HRV include autonomic activity and autonomic balance [40].

In this study, SDNN, RMSSD, TP, LF, and HF were measured. However, since TP, LF, and HF showed an ex-

ponential increase in actual analysis, logarithmic values of $\ln$ TP, $\ln$ LF, and $\ln$ HF were used [38].

A physical therapist who did not receive information about the group performed the HRV assessment.

Pain

The VAS was used to measure the level of pain in the lower back. At both ends on the 100 mm line, 0 indicated 'no pain', 10 indicated 'very painful', and the subject was asked to mark the question "What is the intensity of the pain you are currently experiencing?".

Simple size

Based on previous studies that applied pelvic manipulation to female with primary dysmenorrhea, an effect size of 0.57 was obtained through the change values in the VAS before and after intervention [33]. Therefore, the authors set the effect size, the power and the significance level to 0.57, 0.80 and 0.05, respectively and performed the calculation with G*power 3.1.9.6 (Franz Faul, Universität Kiel, Kiel, Germany) program, requiring a total of 28 subjects. However, it was not easy to match the exact menstrual cycle, and a total of 37 subjects were recruited in consideration of the 30% dropout rate.

Statistical analysis

IBM SPSS Statistics for Windows, Ver. 22.0 (IBM Co.,

Table 1. General characteristics of patients (N=30)

Parameters	Manual treatment (n=17)	Sham therapy (n=13)	t (p)
Age (y)	30.24 (5.57)	28.54 (4.48)	0.92 (0.36)
Height (cm)	164.78 (5.59)	164.38 (3.50)	0.24 (0.81)
Weight (kg)	57.29 (4.13)	56.23 (3.14)	0.80 (0.47)
BMI (kg/m ²)	21.08 (0.87)	20.81 (1.17)	0.69 (0.47)

Values are presented as mean (SD).

BMI: body mass index.

Table 2. Comparison of HRV and VAS between groups

(N=30)

Parameters	Manual treatment (n=17)			Sham therapy (n=13)			F	CI
	Pre	Post	Change	Pre	Post	Change		
SDNN (ms)	44.52 (15.12)	43.04 (17.58)	-1.48 (12.04)	44.41 (10.79)	44.51 (12.53)	0.09 (11.35)	0.005	-5.12-3.74
RMSSD (ms)	43.94 (18.62)	42.44 (18.11)	-1.49 (6.41)	40.93 (14.21)	41.83 (16.44)	0.89 (7.57)	0.224	-2.91-2.31
TP (log ms ²)	7.13 (0.73)	7.14 (0.76)	0.00 (0.48)	6.85 (0.85)	6.52 (0.81)	-0.32 (0.77)	1.968	-0.37-0.12
LF (log ms ²)	5.81 (1.20)	5.82 (0.85)	0.24 (0.72)	5.76 (0.66)	5.17 (0.91)	-0.65 (0.92)*	<0.001	-0.47-0.137
HF (log ms ²)	6.01 (0.86)	5.91 (0.87)	-0.09 (0.38)	6.03 (0.92)	6.05 (1.06)	0.01 (0.41)	0.096	-0.18-0.11
ANS activity (score)	105.88 (19.30)	106.57 (18.66)	0.69 (12.01)	99.93 (16.39)	101.15 (14.36)	1.22 (14.25)	1.446	-3.97-5.89
Balance of ANS (score)	106.38 (32.83)	75.18 (46.68)	-31.20 (34.96)*	79.73 (46.71)	124.68 (10.84)	44.94 (46.98)*	4.631*	-8.43-22.17
VAS (mm)	72.35 (18.55)	52.94 (23.65)	-19.41 (18.19)*	60.77 (11.15)	51.54 (11.43)	-9.23 (11.15)*	0.990	8.44-20.19

Values are presented as mean (SD).

SDNN: the standard deviation of all normal R-R intervals, RMSSD: the root mean square of successive normal to normal interval difference, TP: total power, LF: low frequency, HF: high frequency, ANS: autonomic nervous system, VAS: visual analogue scale, CI: confidence intervals.

*Significant difference between pre-test and post-test ($p < 0.05$).

Armonk, NY, USA) was used for data analysis and statistical processing. All subjects were tested for Kolmogorov-Smirnov normality, and descriptive statistics were used for general characteristics of subjects. The comparison before and after treatment was performed by a paired sample t-test, and repeated measurement analysis of variance was used to find out the differences between groups. The significance level was set to 0.05.

Results

The general characteristics of the manual therapy group and the sham therapy group were found to be identical in both groups. The general characteristics of the subjects were as follows (Table 1).

Changes in heart rate variability according to treatment

In manual therapy, the autonomic balance of HRV decreased significantly by 29.32% from 106.38 to 75.18 ($p<0.05$). In the sham therapy group, LF significantly decreased by 10.24% from 5.76 log ms^2 to 5.17 log ms^2 , while significantly increasing by 55.65% from 79.73 to 124.68 in the autonomic renal balance ($p<0.05$). In the difference between the 2 groups according to treatment, there was a significant difference only for autonomic balance ($p<0.05$) (Table 2).

Changes in the visual analogue scale according to treatment

The VAS decreased significantly by 26.93% from 72.35 mm to 52.94 mm in manual therapy ($p<0.05$), while it decreased by 15.29% from 60.77 mm to 51.54 mm in the sham therapy group ($p<0.05$). There was no significant difference between the 2 groups according to treatment ($p>0.05$) (Table 2).

Discussion

In this study, manual therapy was applied to the sacroiliac joint in patients with primary dysmenorrhea to confirm for changes in back pain and HRV.

As a result, autonomic balance significantly decreased by 29.32% from 106.38 score to 75.18 score in the manual therapy group ($p<0.05$). In the sham therapy group, LF significantly decreased by 10.24% from 5.76 ms^2 to 5.17 ms^2 ($p<0.05$), and autonomic balance increased significantly by 55.65% from a score of 79.73 to 124.68 ($p<0.05$). There was

a significant difference in autonomic balance between the 2 groups ($p<0.05$).

When the ratio of the sympathetic and parasympathetic nervous system is 6:4, it is reported that the balance of the autonomic nervous system is stable [15,39]. When recalculated, it may be considered as 1:0.6. In addition, autonomic balance of less than 50 is the normal category [39], and the lower it is, the more it is included in the normal category.

Before treatment, the ratio of the sympathetic nervous system to the parasympathetic nervous system was calculated as 1:1.03 before treatment in the manual therapy group applied in this study, while it was 1:1.04 in the sham treatment group. In order to be included in the normal category, LF must be increased or HF must be decreased. In the manual therapy group, HF decreased from 6.01 to 5.91 and changed to 1:1.01, a ratio slightly closer to the normal category, while in the sham treatment group, LF decreased from 5.76 to 5.17, changing to 1:1.17, which is a ratio away from the normal category. Therefore, it is judged that the manual therapy group is more effective in achieving autonomic balance than the sham therapy group.

Previous studies confirming the association between the spine and the autonomic nervous system found out whether it affected blood pressure, heart rate, and renal sympathetic activity through mechanical stimulation of the spine, and showed afferent activation of the spine [41]. Another study reported that when a harmful chemical stimulus was applied to the interspinous tissues in rats, the blood pressure of the whole body was greatly increased and blood flow of the sciatic nerve increased [42]. A similar study reported that when a harmful chemical stimulus was applied to the spinal tissues of the spine and lumbar bones, the adrenal sympathetic nerve and catecholamine secretion increased [43].

It also reported that sympathetic activity increased significantly and parasympathetic activity decreased significantly in women with menstrual disorders during the late luteal phase [9,10,13]. Another study found out that healthy women had greater parasympathetic nerves during the early to intermediate follicular stages of the menstrual cycle compared to the luteal phase [14]. This is considered to be sympathetic hyperactivity, and it is believed that the more severe dysmenorrhea, the more the autonomic imbalance [7].

Based on these facts, it is judged that the spine and primary dysmenorrhea are closely related. In particular, dysfunction shown in the sacroiliac joint [44], which may affect the function of all spinal joints, can lead to disorders in autonomic nervous system balance, biomechanical movement

and circulation capacity [45]. In addition, the free movement of the sacrum may have an effect on maintaining the balance of the autonomic nerve by the activity of the parasympathetic nerve of the 2nd to 4th sacral ventral rami (S2-4 ventral rami) [46].

Therefore, it is believed that the manual therapy of sacroiliac joints used in this study may have affected the upper spine along with the change in the location of the sacrum and the autonomic nerve [47]. As a result, it is judged that it was linked to the activity of the parasympathetic nerve and had a significant effect on the autonomic balance.

The VAS for back pain significantly decreased by 26.93% from 72.35 mm to 52.94 mm in the sacroiliac joint manual therapy group, while 15.29% from 60.77 mm to 51.54 mm in the sham treatment group ($p < 0.05$). There was no significant difference between the 2 groups ($p > 0.05$).

For subjects with back pain, the minimum detectable change (MDC) on the VAS after treatment should have a difference of 18-19 mm for the mean value of 64 mm [48]. The MDC was identified for the subjects participating in the experiment. As a result, it was found in 76.47% of the subjects in the manual therapy group, while only 30.76% of the subjects showed a difference in the sham treatment group. It can be seen that manual therapy is more effective in relieving back pain than sham therapy.

The HVLA used in this study is believed to be able to temporarily change the cortical plasticity while significantly reducing the excitability of the cortical spinal cord and spinal cord reflexes [49]. In addition, the release of β endorphins [50] and the opioid effect on the peripheral nervous system were also judged to be related to pain relief [51].

Therefore, pain relief in the manual therapy group is thought to be neurophysiological responses to the central and peripheral nervous systems [52] and the effects on chemical mediators at the plasma level associated with pain, including prostaglandins [31,53,54], and finally, the effects of autonomic balance.

Based on these results, it is believed that manual therapy of the sacroiliac joint would be an appropriate alternative treatment method for female with primary dysmenorrhea.

The limitations of this study are as follows: The autonomic nervous system is highly related to age, but the age of the subjects who participated in the experiment varied from 18 to 50 years old. Also, the degree to which the effect of the manual therapy was maintained was not confirmed. Finally, the number of test subjects was too insufficient to generalize. In order to compensate for these limitations, ad-

ditional studies that prove various effects after applying manual therapy for a long time and a large number of subjects of the same age are considered to be necessary.

As a result, manual therapy applied to the sacroiliac joints of female with primary dysmenorrhea reduced the change in autonomic balance and lower back pain of HRV in a short time. This may indicate that manual therapy is effective for primary dysmenorrhea, and if a longer-term interventional protocol is applied, it will help to overcome chronic primary dysmenorrhea.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

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