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Effects of High-Frequency Treatment using Radiofrequency on Autonomic Nervous System and Pain in Women with Dysmenorrhea

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Objective: The purpose of this study is to present basic data for appropriate therapeutic intervention by confirming changes in the autonomic nervous system and pain by applying high-frequency deep diathermy to the lower abdomen in patients with primary dysmenorrhea.

Design: A randomized controlled clinical trial.

Methods: Thirty-eight women aged 18-50 years who complained of regular menstrual cycles (24-32 days) and primary dysmenorrhea symptoms were randomly assigned to a high-frequency therapy group (5, 7, or 9 mins) and a superficial heat therapy group (20 min). High frequency treatment group: The subject was in a supine position, and radio frequency was applied to the lower abdomen below the umbilicus. The radio frequency therapy device used in this study uses a 300 kHz capacitive electrode and a 500 kHz resistive electric transfer to deliver deep heat. Superficial heat treatment Group: Subjects applied a hot pack to the lower abdomen for 20 minutes while lying on their back. Evaluations were made of Heart rate variability and Visual Analogue Scale.

Results: In subjects with menstrual pain, there was a significant difference in pain between the high-frequency therapy group and the superficial heat therapy group ($p = 0.026$). However, there was no significant difference between the autonomic nervous system and the stress resistance ($p > 0.05$).

Conclusions: As a result of this study, high-frequencytreatment using radiofrequency was effective in relieving pain because it can penetrate deeper tissues than conventional hot packs using superficial heat. In particular, it was found that the optimum effect was obtained when high frequency was applied forfive-seven minutes.

Key Words: High-frequency, Heart rate variability, Superficial heat, Dysmenorrhea, Autonomic nervous system

Introduction

Dysmenorrhea is a condition in which cervical spasm continues for 6 to 72 hours with the onset of menstrual flow, resulting in pain in the lower abdomen [1]. Back and thigh pain, fatigue, diarrhea, constipation, and headaches may accompany this period. This causes absenteeism from work or school, interruption of daily life and increased social costs [2]. Dysmenorrhea is broadly classified into primary and secondary. Primary dysmenorrhea has no pathological findings, and most women suffer from it, and it most often occurs during the menstrual cycle [3]. Secondary dysmenorrhea has pathological findings such as pelvic inflammatory disease, uterine fibroids, polycystic ovary syndrome, and endometriosis [4]. Prostaglandin is regarded as a physiological cause of dysmenorrhea. Prostaglandin is secreted from endometrial cells during

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menstruation and causes muscle contraction and ischemia [1]. However, the physiopathology of dysmenorrhea is still under discussion and not entirely clear [5]. Another cause of dysmenorrhea is a disorder of the autonomic nervous system accompanied by suppression of the function of the vagus nerve and enhancement of the sympathetic nerve [6]. A previous study compared women with dysmenorrhea and healthy women and found that different autonomic responses were seen [7]. Compared to healthy women, women with premenstrual syndrome showed significantly reduced sympathetic and parasympathetic nervous activity [8].

Heart rate variability (HRV) analysis is a non-invasive method that can be easily applied to evaluate autonomic function [9]. Heart rate variability refers to the change in the interval between heartbeats (RR interval) [10]. When the function of the autonomic nervous system is abnormal or weak, such as stress or anxiety, the change in heart rate variability is not large. Conversely, when the autonomic nervous system functions well, there are severe changes in heart rate variability, which means that it adapts to various changes [9].

Nonsteroidal anti-inflammatory drugs (NSAIDs) and hormonal contraceptives are available to relieve dysmenorrhea and relax uterine muscle [1], but drug treatment has a failure rate of 20-25% and a wide range of side effects [11]. Therefore, many women are seeking alternative therapies such as heating pads to manage dysmenorrhea [12]. Heat therapy is used as a common method for 36.5 to 50% of dysmenorrhea reduction [13], and according to a recent systematic review, heat therapy is associated with dysmenorrhea reduction[12]. In addition, heat treatment inhibits the sympathetic nerve when the sympathetic nerve is activated and activates the sympathetic nerve when the parasympathetic nerve is activated. So, it regulates the autonomic nerve to balance the sympathetic and parasympathetic nerves [14]. For thermal treatment, superficial heat using hot packs, infrared rays, etc., and deep heat, such as ultrasound, high frequency, short-wave diathermy, and microwave diathermy, can be used [15]. High frequency is representative of generating deep heat. When electromagnetic waves are delivered to tissues, they are converted into thermal energy by the back-and-forth motion of ions, rotational motion of polarized molecules, and twisting of non-polarized molecules to penetrate deep tissues [16]. In addition, since the pulsation period of the high-frequency current is very short, it does not stimulate sensory nerves and motor nerves, so it has the advantage of being able to heat a specific part in the body tissue without causing discomfort or muscle contraction [17]. However, it was recommended not to use it continuously for more than 5 to 10 minutes because it caused a much larger temperature change than other heat treatments [18].

As such, in previous studies, it is judged that heat treatment is clinically effective for patients with primary dysmenorrhea. However, there are few studies examining the effect of deep heat treatment using high frequency on changes in the autonomic nervous system and pain in women with primary dysmenorrhea. Therefore, this study aims to provide basic data for appropriate therapeutic intervention by confirming changes in the autonomic nervous system and pain by applying radiofrequency waves at different times to the lower abdomen in patients with primary dysmenorrhea.

Methods

Participants

The selection criteria for subjects were women between the ages of 18 and 50 who had a regular menstrual cycle (24 to 32 days).

The specific selection criteria were as follows.

- Those who have had primary dysmenorrhea occurred during all of their menstrual cycles during the previous year, minimum duration of symptoms for 1 year.
- Subjects with dysmenorrhea-related back pain scores of 5 or more on the visual analysis scale (VAS) [19]
- A person whose BMI is between 20 and 30 [20]

Exclusion criteria

- Those with gynecological findings (pelvic inflammatory disease, uterine fibroids, polycystic ovarian syndrome, endometriosis, etc.)
- A person using an intrauterine contraceptive device

- Those taking birth control pills or non-steroidal anti-inflammatory drugs

This study was conducted after approval from the Institutional review board (IRB) of S University (2-1040781-A-N-012021046HR). The subjects who participated in this study explained the purpose and necessary matters of the study in detail, and voluntarily signed a written consent form. In addition, it was informed that the subject could stop at any time during the study and that there would be no disadvantages caused by this.

Design and Randomization Procedure

Design for this study was a randomized controlled clinical trial. Subjects were recruited through flyer advertisements from June 21, 2021 to September 31, 2022 at T Clinic located in Seoul. Afterwards, 38 people who met the subject selection criteria were assigned to groups through simple randomization using an Excel (ver. 2019, Microsoft, Redmond, WA, USA) (Figure 1).

Blinding

Because the therapist in charge of intervention in a specific phase of the treatment method had no choice but to recognize the difference in the treatment group, the therapist in charge of intervention and the person in charge of evaluation were assigned differently. In addition, the raters who did the data collection were blinded to which treatment group the subjects were assigned to.

Experimental methods

High frequency treatment group

With the subject lying supine, the moderator applied radiofrequency to the lower abdomen below the navel. The high-frequency therapy device (WINBACK, Villeneuve Loubet, France) used in this study uses 300

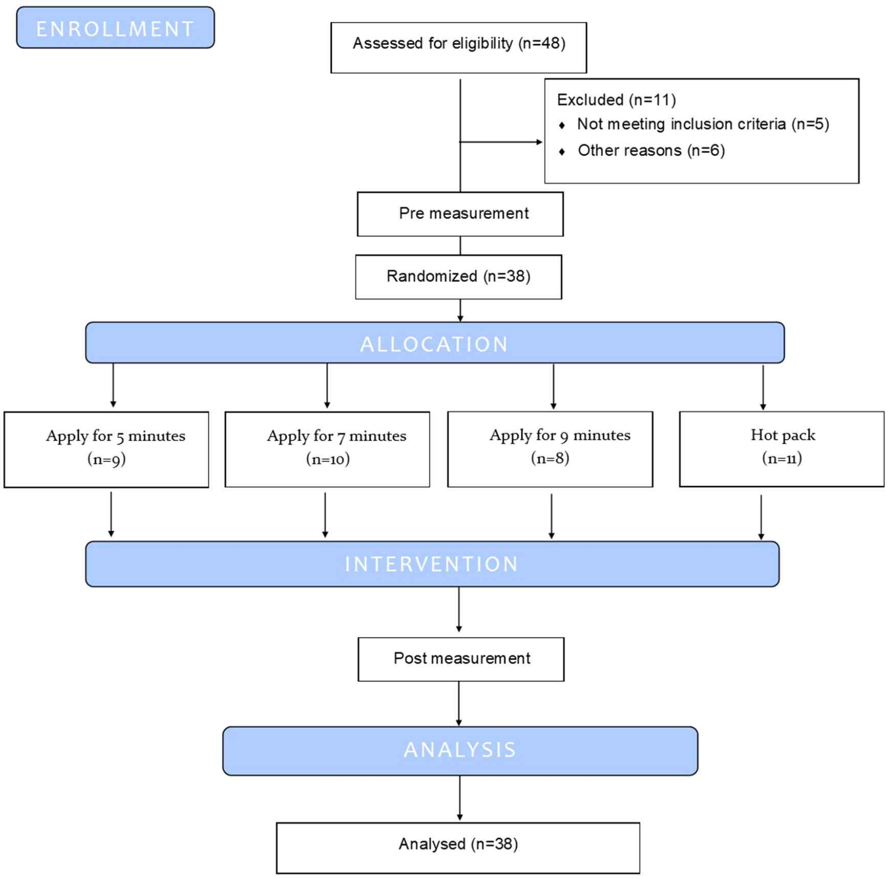

Figure 1. Experimental Flow.

kHz capacitive electrodes (Capacity electric transfer, CET) and 500 kHz resistive electrodes (Resistive electric transfer, RET) to deliver deep heat.

Using shortwave diathermy, which is a part of deep heat, the effect on the rate of fibroblast and chondrocyte proliferation over time was confirmed and based on a previous study [21] that cell proliferation was highest at 5 minutes, the minimum treatment time was reduced to 5 minutes. decided. In addition, since it is not recommended to use deep heat for more than 5 to 10 minutes, the maximum application time was set at 9 minutes, and 7 minutes was calculated using the median value of 5 and 9 minutes. Based on these results, the radiofrequency application time for patients with primary dysmenorrhea was determined to be 5, 7, and 9 minutes, and subjects were randomly assigned to create three groups and radiofrequency was applied.

Superficial heat treatment group

The treatment time in this study was determined based on the application of heat treatment for 20 minutes in a previous study [22]. A hot pack (40-45 °C) was applied to the lower abdomen for 20 minutes while the subject lay down.

Measurements

Autonomic nervous system measurement was based on complaints of pain on the first day of menstruation in previous studies [23], and the evaluation period was based on ±2 days of menstruation.

Autonomic nervous system

The autonomic nervous system is involved in many psychosomatic diseases and stress-related diseases, and a heart rate variability (HRV) test is a way to evaluate these autonomic nervous system functions neuro-cardiologically and neurophysiologically [24]. Time-domain analysis method indicators include the standard deviation of the NN interval (SDNN) and the square root of the mean squared differences of successive NN intervals (RMSSD), and by short-term measurement for 5 minutes, three power spectrum components of very low frequency (VLF), low frequency (LF), and high frequency (HF) and total power) can be obtained [25]. In general, the HF component associated with parasympathetic nervous system activity indicates power between 0.15 and 0.4 Hz, and the LF component associated with sympathetic nervous system activity indicates power between 0.04 and 0.15 Hz [26].

In order to prevent the autonomic nervous system from being affected by the external environment when measuring heart rate variability, the measurement location was conducted in a room maintained at a temperature between 20 °C and 22 °C. In addition, excessive exercise, smoking, and drinking were prohibited within 12 hours before measurement. An autonomic nerve balance tester (SA3000new, Medicore, Korea) was used as the measurement device. The subjects were measured for 5 minutes by attaching electrodes to three sites (left arm, left leg, right leg) while lying down.

Pain

Based on previous studies similar to this study, pain was measured using a visual numeric scale (VNS) [27]. In addition, since dysmenorrhea appears in the abdomen in 70-90% of women [28], pain in the lower abdomen was set as dysmenorrhea pain. The visual numeric scale was a self-report scale, and the evaluation was conducted verbally from 0 (no pain) to 10 (severe pain).

Sample size

An effect size of 0.57 was obtained through the change value of the visual analog scale before and after the intervention based on a previous study that applied pelvic orthodontic treatment to women with primary dysmenorrhea [29]. Therefore, in this study, the effect size was set to 0.57 for one-way ANOVA analysis, the power was set to 0.80, and the significance level was set to 0.05, and the results were calculated with G*power 3.1.9.6 (Franz Faul, Universitiat Kiel, Germany) program. A total of 40 subjects were required. However, it is not easy to set the exact menstrual cycle, and considering the dropout rate of 20%, a total of 48 subjects were recruited in advance, but 38 subjects finally participated in the experiment.

Data analysis

All tasks and statistics in this study were statistically analyzed using SPSS (Statistics 25 version, IBM, USA). For the general characteristics of the subjects, descriptive statistics were used, and the Kolmogorov-Smirnov normality test was performed. A paired-sample t-test was conducted to compare heart rate variability and pain before and after applying radiofrequency and thermal therapy, and one-way ANOVA was used for differences between groups. All statistical significance levels (α) of the data were set at 0.05.

Results

General characteristics

Age, height, and weight characteristics between the high-frequency treatment group and the superficial heat treatment group were found to be homogeneous in all four groups (Table 1).

Homogeneity for measured variables

As a result of the test on the measured variables between the high-frequency treatment group and the superficial heat treatment group, there was no significant difference, indicating that all four groups were homogeneous (Table 2).

Changes in the autonomic nervous system and pain following treatment

In subjects with dysmenorrhea, there was a significant difference in pain between the high frequency treatment group and the superficial heat treatment group (Table 3) ($p = 0.026$). However, there was no significant difference between autonomic nervous system and stress resistance ($p > 0.05$).

Table 1. Homogeneity of General Characteristics

	High-frequency			Superficial heat (n=11)	F	p
	5 minutes (n=9)	7 minutes (n=10)	9 minutes (n=8)			
Age (year)	31.11±7.20	31.70±6.25	24.88±3.64	29.09±4.48	2.61	0.068
Hight (cm)	164.44±3.97	162.80±4.29	164.00±5.76	162.52±2.94	0.46	0.712
Weight (kg)	57.11±6.21	57.10±6.71	58.25±4.43	59.35±3.07	0.43	0.735

The values are presented mean ± SD

Table 2. Homogeneity of autonomic nervous system and pain among groups

	High-frequency			Superficial heat (n=11)	F	p
	5 minutes (n=9)	7 minutes (n=10)	9 minutes (n=8)			
RMSSD (ms)	43.46±16.85	44.18±32.91	38.85±21.65	35.51±15.28	0.33	0.806
SDNN (ms)	45.62±12.30	43.05±24.20	38.02±13.81	37.19±7.68	0.63	0.603
lnLF (ms^2)	5.57±0.67	5.29±1.43	5.21±1.17	5.46±0.79	0.21	0.890
lnHF (ms^2)	6.07±0.84	5.95±1.24	5.32±0.93	5.56±0.89	1.09	0.368
ANS Balance	91.31±37.31	94.49±40.01	99.75±42.75	101.27±26.03	0.15	0.931
ANS Activity	106.29±15.20	99.57±32.15	90.21±15.00	95.92±15.12	0.89	0.458
Stress Resistance	108.89±16.26	102.6±31.53	92.38±19.61	94.64±11.92	1.16	0.339
VNS (score)	5.78±1.39	6.20±1.14	7.00±1.20	5.64±0.67	2.68	0.062

The values are presented mean ± SD

RMSSD; The square root of the mean of the sum of the squares of differences of between adjacent R-R intervals, SDNN; Standard deviation of all normal R-R intervals, ln LF; log-transformed in low frequency; ln HF; log-transformed in high frequency, ANS; Autonomic nervous system, VNS; Visual numeric scale

Table 3. Comparison of autonomic nervous system and pain among groups after intervention

	High-frequency			Superficial heat (n=11)	F	p
	5 minutes (n=9)	7 minutes (n=10)	9 minutes (n=8)			
RMSSD (ms)	48.54±36.85	42.77±24.13	35.95±16.91	43.00±18.32	0.36	0.786
SDNN (ms)	40.92±11.46	41.28±17.67	38.45±18.21	43.38±13.70	0.16	0.923
lnLF (ms^2)	5.06±2.00	4.89±1.23	5.52±1.26	5.58±0.69	0.63	0.598
lnHF (ms^2)	5.35±1.61	5.88±1.05	5.46±1.28	5.86±1.09	0.44	0.725
ANS Balance	96.84±28.03	109.84±36.07	96.30±30.10	87.67±30.99	0.82	0.493
ANS Activity	100.87±24.13	92.87±25.76	92.89±27.63	102.66±14.42	0.49	0.692
Stress Resistance	102.33±14.21	101.5±25.83	93.75±26.62	103.09±18.55	0.34	0.798
VNS (score)	2.67±1.22[a]	2.90±0.57[a]	3.38±1.06	3.91±0.83[b]	5.64	0.026

The values are presented mean ± SD

RMSSD; The square root of the mean of the sum of the squares of differences of between adjacent R-R intervals, SDNN; Standard deviation of all normal R-R intervals, ln LF; log-transformed in low frequency; ln HF; log-transformed in high frequency, ANS; Autonomic nervous system, VNS; Visual numeric scale

Discussion

In this study, we applied deep heat treatment using radiofrequency to the lower abdomen in women with primary dysmenorrhea to examine the effect on the autonomic nervous system and pain. As a result, there were positive changes in heart rate variability according to changes in the autonomic nervous system after treatment in the three groups to which high frequency was applied and the superficial heat group to which hot packs were applied, but there was no statistically significant difference. Sloan et al. [24] reported that mental stress increased LF activity and decreased HF activity, and factors such as chronic stress, fear, and anxiety also appeared to decrease HF, which was not the same as the present result. Considering the short single treatment time and small number of subjects with the high frequency applied in this study, it is judged that better effects can be expected when repetitive treatment sections are applied. However, when applied for 7 minutes during high frequency treatment in the three groups, it was found that lnLF decreased slightly, and lnHF and autonomic nervous system balance slightly increased to relieve stress. Since this phenomenon was found to be more positive than the control group, the surface reheat group, the part about the high frequency application time is a task to be identified through follow-up studies.

Pain related to the lower abdomen was lower in all three groups to which high frequency was applied than in the superficial heat group to which hot pack was applied. In particular, a significant difference was found between the group to which high frequency was applied for 5 and 7 minutes and the group to which hot pack was applied. This is because there were positive effects such as an increase in the pain threshold by acting on the transmission of afferent stimulation due to pain as a direct effect through heat treatment and by changing the permeability of the cell membrane to sodium ions. As for the indirect effect, it was consistent with the report that it was due to the mechanism of promoting oxygen supply to the hypoxic region by increasing blood flow and capillary permeability and reducing the chemical sensitivity of pain receptors [30]. Akin et al. [30] reported that a warm abdominal wrap was as effective as ibuprofen in relieving dysmenorrhea and more effective than acetaminophen. A similar study found that applying topical heat to women with dysmenorrhea reduced pain by reducing muscle tension and relaxing abdominal muscles. In addition, heat can increase blood circulation in the pelvis to reduce retention of local blood and body fluids, thereby reducing congestion and swelling, thereby reducing pain due to nerve compression [31]. Besides this, heat can produce a direct inhibitory effect on muscle spindle elements that produce muscle spasm [32]. Therefore, it is considered that heat-related treatment is closely related to primary dysmenorrhea, and since the intervention method used in this study was also related to heat treatment, it is thought that all significant differences in pain reduction were shown in this study.

Women with dysmenorrhea have hyperalgesia to pain in deep tissues such as muscle and subcutaneous tissue, not at the skin level[33, 34]. Therefore, hyperalgesia is related to tissue depth, and nociceptive activity occurring in deep tissues such as muscle seems to have a greater inhibitory influence than activity occurring in the skin [35]. Based on these facts, it seems that in order to relieve pain in women with primary dysmenorrhea, it is necessary to affect the deep tissue rather than the epidermis. Therefore, it is thought that the deep tissue treatment using high frequency used in this study can affect the deep tissue more than superficial heat using a hot pack. However, heat creates side effects such as a weak inflammatory response (biophysical principles of superficial heating and deep heating agents), and myelin sheath and blood vessels in peripheral nerves are the structures most sensitive to heat. In a study by Froise and Dunscombe [36], when heat at three different temperatures was applied to a 5 mm-long nerve segment in the extensor muscle of the hind limb of a rat, 58 minutes at 43°C, 32 minutes at 44°C, and 32 minutes at 45°C When applied for 12 minutes, there was a 50% loss of hindlimb extensor function. Based on this fact, it is judged that it can be a good thermal treatment method to replace traditional hot packs clinically if the time applied during deep treatment is properly adjusted because applying high frequency for a long time can cause side effects. In particular, there is no need to boil hot water to apply a traditional hot pack, reducing the risk of burns, and the convenience of applying high-frequency heat quickly and easily if only electricity is supplied. In addition, various methods of applying heart rate variability to measure pain-induced stress have been tried, but there are still several limitations as a definitive test tool. However, since the concept of pain itself is not easy to objectify through measurement tools, heart rate variability, which can be measured relatively easily, will be very useful in the future as research on pain and development of analysis methods develop.

Conclusion

As a result of applying high-frequencytherapy to the lower abdomen of women with primary dysmenorrhea, there was no significant change in heart rate variability, which reflects the autonomic nervous system. However, there was a significant effect on pain relief in the lower abdomen, and if a continuous intervention protocol is created and applied thereafter, it will help reduce dysmenorrhea easily.

References

1. Proctor M, Farquhar C. Diagnosis and management of dysmenorrhoea. Bmj. 2006;332:1134-8.
2. Polat A, Celik H, Gurates B, Kaya D, Nalbant M, Kavak E, et al. Prevalence of primary dysmenorrhea in young adult female university students. Arch ObstetGynaecol. 2009;279:527-32.
3. Dawood MY. Primary dysmenorrhea: advances in pathogenesis and management. Obstet Gynecol. 2006;108:428-41.
4. Holtzman DA, Petrocco-Napuli KL, Burke JR. Prospective case series on the effects of lumbosacral manipulation on dysmenorrhea. J Manipulative PhysiolTher. 2008;31:237-46.
5. Proctor M, Hing W, Johnson TC, Murphy PA. Spinal manipulation for primary and secondary dysmenorrhoea. Cochrane Database Syst Rev. 2001.
6. Lee J-M, Lee C-H, Cho J-H, Jang J-B, Lee K-S, Lee J-Y. Analysis on the Heart Rate Variability of Dysmenorrhoea Patients. JKorean Obstet Gynecol. 2007;20:164-77.
7. Park M-K, Watanuki S. Specific physiological responses in women with severe primary dysmenorrhea during the menstrual cycle. J PhysiolAnthropol Appl Human Sci. 2005;24:601-9.
8. Matsumoto T, Ushiroyama T, Morimura M, Moritani T, Hayashi T, Suzuki T, et al. Autonomic nervous system activity in the late luteal phase of eumenorrheic women with premenstrual symptomatology.

J Psychosom Obstet Gynaecol. 2006;27:131-9.
9. Pumprla J, Howorka K, Groves D, Chester M, Nolan J. Functional assessment of heart rate variability: physiological basis and practical applications. Int J Cardiol. 2002;84:1-14.
10. Tarvainen MP, Niskanen J-P. Kubios HRV. Finland: Biosignal Analysis and Medical Imaging Group (BSAMIG), Department of Applied Physics, University of Eastern Finland. 2012:39.
11. Yu A. Complementary and alternative treatments for primary dysmenorrhea in adolescents. Nurse Pract. 2014;39:1-12.
12. Iacovides S, Avidon I, Baker FC. What we know about primary dysmenorrhea today: a critical review. Hum Reprod Update. 2015;21:762-78.
13. Potur DC, Komurcu N. The effects of local low-dose heat application on dysmenorrhea. J PediatrAdolesc Gynecol. 2014;27:216-21.
14. Michalsen A, Loer D, Melchart D, Dobos G. Changes of short-time heart rate variability during hyperthermia treatment with infrared A whole body irradiation. ForschKomplementmed. 1999;6:212-5.
15. Chung SG. Rehabilitative treatments of chronic low back pain. J Korean Med Assoc. 2007;50:494-506.
16. Park R-J. A study on treatment effect of electrical stimulation. J Rehabil Sci, 1993;11:67-77.
17. Ganzit G, Stefanini L, Stesina G. New methods in the treatment of joint-muscular pathologies in athletes: The" TECAR" therapy. Med Sport (Roma). 2000;53:361-8.
18. Park K-h, Kim J-y, Park R-J. Biophysical principles of superficial heating and deep heating agents. JKorean Phys Ther. 2002;14:197-203.
19. Holtzman DA, Petrocco-Napuli KL, Burke JR. Prospective case series on the effects of lumbosacral manipulation on dysmenorrhea. J Manipulative Physiol Ther. 2008;31(3):237-46.
20. Zecchillo D, Acquati A, Aquino A, Pisa V, Uberti S, Ratti S. Osteopathic manipulative treatment of primary dysmenorrhea and related factors: A randomized controlled trial. International Journal of Medical Research & Health Sciences. 2017;6(11): 165-74.
21. Hill J, Lewis M, Mills P, Kielty C. Pulsed short-wave diathermy effects on human fibroblast proliferation. Arch of Phys Med Rehabil. 2002; 83:832-6.
22. Bachtiar F, Mursyid ARM, Sadmita S. A Comparison of Hot Pack and Stretching Exercises on Primary Dysmenorrhea in Adolescent Girls. Indones Contemp Nurs J. 2019:38-43.
23. Harlow SD, Park M. A longitudinal study of risk factors for the occurrence, duration and severity of menstrual cramps in a cohort of college women. BJOG. 1996;103:1134-42.
24. Sloan RP, Shapiro PA, Bagiella, Boni SM, Paik M, Bigger JT Jr., et al. Effect of mental stress throughout the day on cardiac autonomic control. Biol Psychol 1994;37:89-99.
25. Klein E, Cnaani E, Harel T, Braun S, Ben-Haim SA. Altered heart rate variability in panic disorder patients. Biol Psychiatry.1995;37(1):18-24.
26. Woo JM. The Concept and Clinical Application for the Measurement of Heart Rate Variability. Korean JPsychosom Med. 2004;12(1):3-14.
27. Perez Machado AF, Perracini MR, Cruz Saraiva de Morais AD, da Silva BO, Driusso P, Liebano RE. Microwave diathermy and transcutaneous electrical nerve stimulation effects in primary dysmenorrhea: clinical trial protocol. Pain Manag. 2017;7:359-66.
28. Montero P, Bernis C, Loukid M, Hilali K, Baali A. Characteristics of menstrual cycles in Moroccan girls: prevalence of dysfunctions and associated behaviours. Ann Hum Biol. 1999;26:243-9.
29. Molins-Cubero S, Rodriguez-Blanco C, Oliva-Pascual -Vaca A, Heredia-Rizo AM, Bosca-Gandia JJ, Ricard F. Changes in pain perception after pelvis manipulation in women with primary dysmenorrhea: a randomized controlled trial. Pain Med. 2014; 15:1455-63.
30. Valma JR, Kerry GB. A Review of Therapeutic Ultrasound: Effectiveness Studies, Phys Ther. 2001;81(7):1339–50.
31. Akin MD, Weingand KW, Hengehold DA, Goodale MB, Hinkle RT, Smith RP. Continuous low-level topical heat in the treatment of dysmenorrhea. Obstet Gynecol. 2001;97(3):343-9.
32. Mense S. Effects of temperature on the discharges of muscle spindles and tendon organs. Pflugers Arch. 1978;374(2):159-66.
33. Iacovides S, Baker FC, Avidon I, Bentley A. Women with dysmenorrhea are hypersensitive to

experimental deep muscle pain across the menstrual cycle. J Pain. 2013;14(10):1066-76.

34. Brinkert W, Dimcevski G, Arendt-Nielsen L, Drewes AM, Wilder-Smith OHG. Dysmenorrhoea is associated with hypersensitivity in the sigmoid colon and rectum. Pain. 2007;132:S46-S51.
35. Mense S. Structure-function relationships in identified afferent neurones. AnatEmbryol (Berl). 1990; 181(1):1-17.
36. Froese G, Das RM, Dunscombe PB. The sensitivity of the thoracolumbar spinal cord of the mouse to hyperthermia. Radiat Res. 1991;125(2):173-80.