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Research Article

Effects of Transcutaneous Electrical Nerves Stimulation (TENS) on Pain Intensity in Patients with Primary Dysmenorrhea among the Undergraduates of a Nigerian University: A Randomized Control Study

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Abstract

Background: Non-steroidal anti-inflammatory drug has been reported to be effective in the management of primary dysmenorrhea, but it has associated side effects. The present study determined the influence of electrical stimulation on the pain intensity in female undergraduates with primary dysmenorrhea.
Methods: This is a randomized control study including 50 participants with primary dysmenorrhea lasting for five days equally. They were randomly allocated into two groups: transcutaneous electrical nerve stimulation (TENS) and Control. Subjects in TENS group were treated with TENS for 15 minutes twice daily while the other group served as control. Participants were treated for five days, the severity of pain was examined in both groups pre-treatment and post-intervention. Values of the obtained variables were analyzed and the significant level was set at 0.05.
Results: Results revealed a significant reduction ($t=7.956$, $P<0.001$) in the severity of pain between pre-treatment and post-treatment on the 1st day; also, in the TENS group, there was a substantial change ($t=3.610$, $P<0.001$) in the severity of pain on the 5th day post-treatment. There was a substantial reduction ($t=2.599$, $P<0.001$) in the severity of pain in the TENS group compared with the control group on the 3rd day (1.80 1.15, 2.38±1.77,) and 5th day (0.52±0.65, 0.94±1.33), respectively.
Conclusion: Transcutaneous Electrical Nerve Stimulation was found to be an effective approach to relieving primary dysmenorrhea among female undergraduates.

Keywords: TENS, Dysmenorrhea, Pain intensity, Female undergraduates

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1. Introduction

One of the major challenges of women in the reproductive age is pain and discomfort during the regular monthly mensural cycle, called dysmenorrhea (1). There are two types of dysmenorrhea, namely primary (a basic dysmenorrhea) and secondary, which is pathologically inclined (2). The basic one involves pain or discomfort experienced during the mensural cycle without any cause or underlying pathology (2, 3). The experience is more at the onset of early adolescence in women with normal pelvic anatomical structure (4). Organic diseases such as salpingitis, pelvic inflammatory disease, endometriosis, uterine myoma, and ovarian cyst may present with associated secondary dysmenorrhea (5). Pain in the head, mental exhaustion, and nausea are among the complaints associated with severe mensural pain (6, 7). The pain is usually spasmodic in character and felt mainly in the lower abdomen; however, it might radiate to the back and along the thighs (8). The pain usually occurs in the beginning of menstrual flow or precedes it only by a few hours (9). The commonly associated symptoms are nausea, vomiting, increased frequency of defecation, headaches, muscular cramps, irritability, sweating, increased body temperature, dizziness, and syncope (10, 11).

Given the prevalence of dysmenorrhea in Nigeria, Bello and co-workers reported a 63.6% prevalence for the population for primary dysmenorrhea and 19.4% for secondary dysmenorrhea. Also, Loto and his colleagues documented prevalence of 53.3% for the students experienced pain at the onset of menses; half of the students reported the interference of the pain with their normal daily activity (12, 13). Within the environment of the present study, a prevalence of 72.3% and 77.3% were reported in different studies (14, 15).

Dysmenorrhea is a symptom complex, not only

affecting life quality but also reducing productivity (16). In addition to its interference with daily function and its impact on the physical and emotional conditions, (16, 17), it negatively influences academic and daily activities (9, 18). Ovulation increases the production of fatty acids, which is the precursor for the production of prostaglandins; the implication is that women who do not ovulate, may not experience cramps and primary dysmenorrhea (19). Therefore, primary dysmenorrhea can be treated by inhibiting ovulation with oral contraceptives (20).

Research has shown that females with pain during monthly period present with increased prostaglandin levels; however, non-steroidal anti-inflammatory drug (NSAID) was found to have properties not allowing for the production of prostaglandin (21). Non-steroidal anti-inflammatory drugs are reported to be effective; nonetheless, there are studies on their associated side effects such as dizziness, nausea, dry mouth, and paresthesia (22, 23) in controlling primary dysmenorrhea. Furthermore, based on literature, despite non-steroidal anti-inflammatory drugs relieving primary dysmenorrhea, close to 20% of women might not respond to the treatment, pushing them to consider alternative interventions (24).

One of the non-invasive methods for relieving pain in health care is the stimulation of nerves with electric current, popularly called Transcutaneous Electrical Nerve Stimulation (TENS) (25). The primary objective of TENS is to excite the sensational nerves in the body and relieve discomfort. These are achieved by either stimulation of pain gate mechanism or by production of opioid in the brain (26).

Pain associated with primary dysmenorrhea has been a challenge among young ladies especially in higher institution. They have attempted to find approaches to alleviating the pain using various analgesia. The continuous usage of such drugs has been associated with side effects such as duodenum ulcer, dizziness, and nausea. It is necessary to prevent these side effects and still relieve the pain; therefore, the current study was intended to evaluate whether TENS can effectively ameliorate primary dysmenorrhea among female undergraduates of a Nigerian university.

2. Methods

2.1 Study Design

The true experimental with a randomized control study was conducted on undergraduates with primary dysmenorrhea for a minimum period of five days at the Obafemi Awolowo University, Ile Ife, Nigeria.

2.2 Ethical Issues

Ethical approval was obtained (IPHOAU/12/887) from Health and Ethics Research Committee, Institute of Public Health, College of Health Sciences, Obafemi Awolowo University, Ile Ife. Inform consent was obtained from each participant.

2.3 Inclusion Criteria

A minimum five days of primary dysmenorrhea, 16-30 years of age, and no use of any forms of contraception were the inclusion criteria. Subjects meeting these criteria were invited as soon as their period started.

2.4 Exclusion Criteria

Primary dysmenorrhea undergraduates with pelvic and cardiac diseases and a history of conception and currently using analgesia for pain relief and with a pain lasting less than five days were excluded.

2.5 Sample Size Determination and Technique

A sample size equation comparing the two means was used to ascertain the number of participants suitable for the study: (27)

$$N=4\delta^2(Z_{crit} + Z_{power)}{}^2 /D^2$$

where N is the sample size for the two groups, δ is the standard deviation, which could be six according to Akinbo and colleagues (2) and the same for the two groups, and Z_{crit} is the standard normal deviation equivalent to the selective significant level [i.e. 0.05 (95%=1.960)].

Z_{power} is the accepted and excellent normal deviation in conformity with the selective strength of the statistics (i.e 0.80=0.842), and D is the least significant change between the two mean values; to be significant, the value should be 2, so D=5 was chosen.

$$N=4*6^2(1.96 + 0.842)^2/5^2$$

$$=45.22=45$$

However, a total number of 50 subjects enrolled in the study to account for the attrition. They were equally

divided into two groups.

Participants of the study were purposively selected to take part in the research. Undergraduates with a painful menstrual period of at least five days were recruited for the study. The purpose of the study was explained to each subject and written informed consent was obtained from the participation of the study. Of the 120 female undergraduates, 50 were eventually recruited to participate based on the sample size. The flow chart is presented in Figure 1.

2.6 Instruments

Transcutaneous electrical nerve stimulation (MH6000 Combo, MH6100 EMS, MH6200 TENS) was manufactured by Medihightec Medical Co., Ltd 30175 Hannover, Germany.

A numeric pain rating scale (NPRS) is a 10-point numerical scale for assessing the pain perception of the participants. NPRS is a scale that visually measures the pain based on a 10-point scale ranging from 0 to 10; 0 indicates no pain and 10 shows unbearable pain intensity. Numeric pain rating scale was confirmed to be truthful in measuring pain when it was compared with verbal rating scale by Williamson and Hoggart (28). They concluded that NPRS could be employed interchangeably with verbal rating scale during pain intensity evaluation.

Procedure

Ethical approval was obtained from the Research and Ethics Committee, Institute of Public Health, Obafemi Awolowo University, Ile Ife. Consent of each participant was further obtained.

Upon arrival at the participant's address for data collection, their height, weight, and waist and hip circumferences were measured.

Randomization

The process of randomization was based on fish bowl method. Fifty wraps were placed in an envelope. TENS was written on 25 and Control was written on another set of 25. Each participant was asked to pick a wrap from that envelope upon arrival at the study site until the last wrap was picked. Participants were allocated to the group they picked, which is either TENS or control group without bias, Figure 1.

Subjects were educated on the usage of NPRS and were requested to rate the discomfort level prior to the commencement of the intervention.

Experimental Group

The overall test procedure was primarily explained. The subject was placed in a supine comfortable

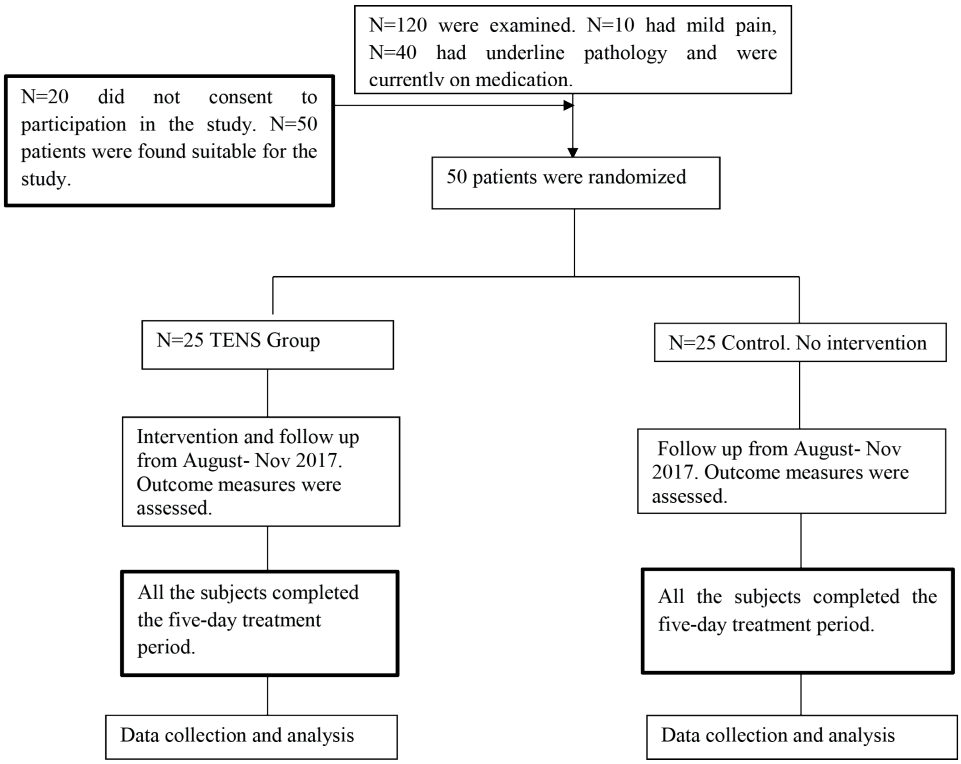

Figure 1: The figure shows the randomization of the participants.

position. The inguinal region of each patient was exposed, inspected for cuts, skin infections, and abnormalities, and cleaned using cotton wool and methylated spirit. The absence of such skin conditions as well as intact skin sensation indicate suitability for further procedures. The electrode was then placed at the cleaned inguinal region. A quadripolar method of electrode placement was used according to Akinbo and colleagues (2). The level of pubic symphysis was considered in the stimulation where, based on Akinbo and colleagues, a pair of active electrodes were placed at the right and left region and another pair of inactive electrodes were positioned at the right and left inferior region of the umbilicus (2).

The TENS (a conventional one) was switched on to a pulse amplitude of 25 to 50 mA, duration of 500–800μs, and frequency of 1–250 pps according to the tolerance of the patient.

The treatment was carried out for 30 minutes in each treatment session, and the procedure was performed once a day on the 1st, 3rd and 5th days (2). Using the NPRS, pain intensity was measured pre-treatment and post-treatment on each treatment day.

Control Group

There were no interventions in this group. Through visual analogue scale, the pain intensity of the subject in the group was evaluated at the onset of the treatment and on days 3 and 5. Subjects in this group were encouraged to take analgesic only if the pain intensity was unbearable. However, none of the participants reported taking drugs at the end of the study as it was not their usual practice during this period.

Outcome measure: In the TENS group, pain intensity was assessed on the first, 3rd, and 5th day of assessment prior to and 10 minutes following the application of TENS. In the control group, the pain intensity was assessed once on days 1, 3, and 5. To provide certain elements of blinding, a research assistance oblivious to the details of intervention was asked to evaluate the pain intensity.

2.8 Data analysis

The obtained values were analyzed using Statistical Pakages for Social Sciences version 17. Descriptive statistics was used to summarize the participants' age, weight, height, Body Mass Index, and waist circumference. Repeated measures analysis of variance was further used to summarize the changes in pain intensity in the experimental and control group at pretreatment and on days 3 and 5. Post hoc analysis was used to examine the direction of significance. Paired t- test was utilized to compare the pre- and post-treatment intensity of pain on the 1st, 3rd, and 5th day of treatment session. Alpha was set at<0.05.

3. Results

Table 1 compares the TENS and control groups in terms of physical characteristics. There was no observable difference between the two groups regarding age (t=-0.274, P<0.785), BMI (t=-1.239, P<0.221), and waist to hip ratio (t=0.177, P<0.860).

Table 2 presents the comparison between pre- and post-treatment pain intensity in the TENS group. There was a significant difference between the pain intensity of the pre- and post-treatment on the 1st day (t=7.956, P<0.001), 3rd day (t=4.758, P<0.001), and 5th day (t=3.610, P<0.001).

Figure 2 shows the comparison of the pain intensity on 1st day, 3rd day, and 5th day of participants in TENS group. There was a significant difference between the pain intensity (F=95.215, P<0.001) on the 1st, 3rd, and 5th days on the subjects in TENS group.

Table 1: Comparison between Tens and Control Groups' Physical Characteristics N=50

Variables	Experiments Mean±SD n=25	Control Mean±SD n=25	t value	P value
Age (years)	20.28±2.25	20.40±1.47	-0.274	0.785
Weight (kg)	57.36±6.59	57.52±9.79	0.121	0.904
Height (m)	1.61±0.06	1.64±0.07	1.923	0.060
BMI (kg/m^2)	22.26±2.36	21.14±3.15	-1.239	0.221
Wc (cm)	69.84±5.82	70.12±6.37	0.256	0.799
Hc (cm)	92.20±6.03	92.56±8.33	0.277	0.783
WHR	0.76±0.04	0.76±0.04	0.177	0.860
WHtR	0.43±0.04	0.43±0.04	-0.606	0.547

Wc: Waist circumference, WHR: Waist to Hip ratio, Hc: Hip circumference, WHtR: Waist to Height ratio, SD: Standard deviation

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Table 3 draws a comparison among days 1, 3, and 5 concerning pain intensity in the control group where there was a significant difference (F=117.694, P<0.001)

Figure 3 compares TENS and control groups in terms of pain intensity on the 1st, 3rd, and 5th days. There was no significant difference (P>0.05) between the groups regarding pain intensity on the 1st day. However, on days 3 (P<0.05) and 5 (F=95.215, P<0.001), there was a significant reduction in pain intensity in the TENS group compared with the control group.

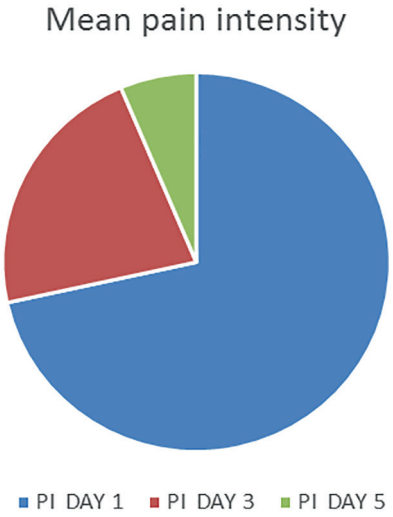

Figure 2: The figure displays pie chart comparison of the pain intensity among days 1, 3, and 5.

4. Discussion

This study examined the effectiveness of conventional TENS on primary dysmenorrhea. There was a notable meaningful reduction in pain intensity after comparing pre-treatment and post-treatment values in the TENS group. This indicates that conventional TENS is an appropriate method for reducing primary dysmenorrhea. KaDlan and co-workers studied 61 women suffering from primary dysmenorrhea treated with Transcutaneous Electrical Nerve Stimulation (TENS) for two menstrual cycles; they reported determined the nature of treatment on the pain (29). Thirty percent of the patients reported marked pain relief and 60% reported moderate pain relief. They concluded that TENS is an effective and safe non-pharmacological tool for treating primary

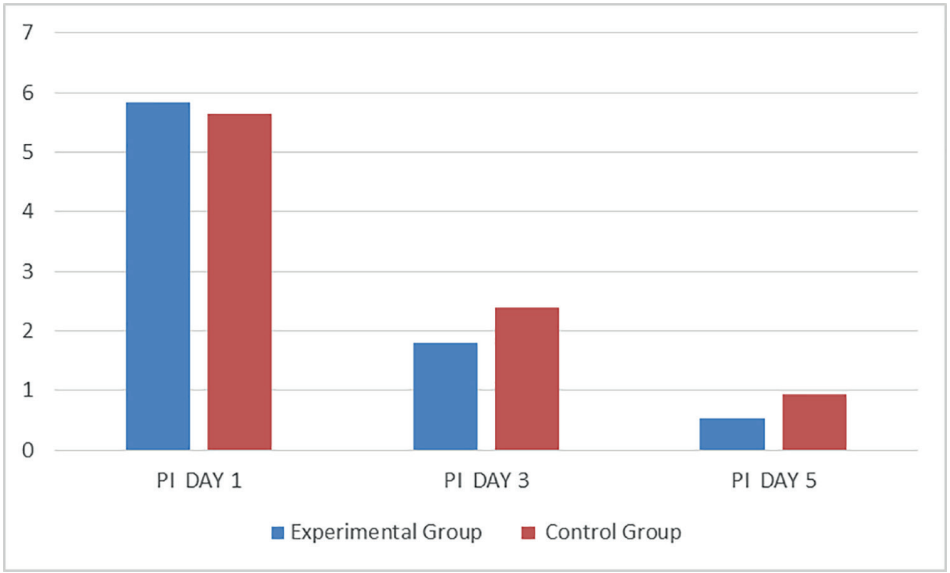

Figure 3: The figure shows the comparison between the experimental and control group regarding pain intensity on days 1, 3 and 5.

Table 3: Comparison of pain intensity on the 1st, 3rd, and 5th day of control group N=25

Variables	Control Mean±SD	F value	P value
PI Day 1	5.64±1.57		
PI Day 3	2.38±1.77	117.694	0.000**
PI Day 5	0.94±1.33		

** Significant at P<0.001, *Significant at P<0.05, PI: Pain intensity, SD: Standard deviation

dysmenorrhea, which is in agreement with our study. In their study carried out with TENS, Bai and colleagues observed a significant pain relief. Similarly, Lundeberg obtained a pain relief of more than 50% with TENS in dysmenorrhea treatment (30, 31). These results are in line with the findings of the present study. Lewers and co-workers showed an average pain relief of 50% immediately after treatment (32). Tugay and colleagues compared the effectiveness of TENS and interferential current on primary dysmenorrhea (33). Their results confirmed that both TENS and interferential current (IFC) could be effective in pain reduction among women with primary dysmenorrhea.

The purpose of TENS is to stimulate small diameter, high threshold cutaneous afferents (A-delta) so as to block the transmission of nociceptive information in peripheral nerves and activate extra-segmental analgesic mechanisms (34). Low-intensity, non-noxious conventional TENS paranesthesia relieves pain through a segmental mechanism. Higher intensity TENS increases the likelihood of activating extra-segmental descending pain inhibitory pathways. The resultant effect is a counter-irritant from a diffused noxious inhibitory. TENS further causes the peripheral blockade of afferent impulses originating from a peripheral structure. With respect to segmental mechanism, evidence from animal studies shows that TENS reduces ongoing nociceptor cell activity and sensitization in the central nervous system when applied to somatic receptive fields and following spinal cord transection (35, 36). TENS-induced A-delta activity causes the long-term depression of central nociceptor cell activity for up to two hours (35, 36). In addition, skin stimulation causes local vasodilatation in the same dermatome area. Considering the extra segmental mechanism, TENS-induced activity in small diameter afferents (A-delta) leads to the activation of the midbrain periaqueductal grey and descending pain inhibitory pathways and inhibition of descending pain facilitatory pathways. Larger effects were observed when muscles rather than skin afferents were activated (35, 36)

Furthermore, in the present study, there was a significant reduction in the severity of pain in the TENS group compared with the control group on the third and fifth day of treatment session, with the former day having a larger effect size. This indicated that effects of TENS on primary dysmenorrhea were significant from the first day to the last day. TENS effects are mediated by many neurochemicals, including opioids, serotonin, acetylcholine, noradrenaline, and gamma-aminobutyric acid (GABA) (36). Low but not high-frequency TENS has been shown to involve opioid and 5-HT2 and 5-HT3 receptors. High but not low-frequency TENS has been shown to involve delta opioid receptors and reduce aspartate and glutamate levels in the spinal cord (32). The results of this study showed that TENS was effective in reducing dysmenorrhea symptoms with no potential adverse effects.

The results also revealed the immediate pain relief effect of TENS three days following its application. The stimulation intensity of TENS at the largest tolerable level was proven to improve pain relief (37). However, for the sake of safety during TENS usage, the stimulation intensity was set according to each individual's tolerance level (38). Smith and Heltzel also investigated the effect of TENS on dysmenorrhea and found it conducive to reducing the pain by altering the body's ability to receive or perceive the pain signal (39). In clinical use, treatment choice depends on factors such as practical use, expense, accessibility, and efficacy. TENS machines are relatively inexpensive, portable, easy to use, and safe. Patients can be trained to self-administer TENS. The present study showed that TENS is an effective non-medicated modality to treat patients with primary dysmenorrhea.

5. Conclusion

TENS provides effective and immediate pain relief in controlling primary dysmenorrhea. It is expected that pain of primary dysmenorrhea disappear within the menstruation period; however, TENS has proved effective in ameliorating the pain.

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Name of the public trials registry and the registration number:

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Conflict of Interest: The authors declared no conflict of interest.

References

1. William F, Ganong MD. The Female Reproductive System. *Review of Medical Physiology*. Lange 21st Ed. 2003;437-451.
2. Akinbo SR, Onwudimegwu WN, Ajayi GO. Evaluation of the Efficacy of Transcutaneous Electrical Nerve Stimulator (TENS) Compared with Analgesics in the management of primary dysmenorrhea. *Journal of Nigeria Medical Rehabilitation Therapist*. 2000;**5**(2):27-30. Nigeria.
3. Proctor ML, Hing W, Johnson TC, Murphy PA. Spinal manipulation for primary and secondary dysmenorrhoea. *Cochrane Database Syst Rev*. 2006;(3):CD002119. doi: 10.1002/14651858.CD002119.pub3. [PubMed: 16855988]. [PubMed Central: PMC6718213].
4. French L. Dysmenorrhea. *Am Fam Physician*. 2005;**71**(2):285-91. [PubMed: 15686299].
5. Dawood MY. Dysmenorrhea. *J Reprod Med*. 1985;**30**(3):154-67. [PubMed: 3158737].
6. Ng TP, Tan NC, Wansaicheong GK. A prevalence study of dysmenorrhoea in female residents aged 15-54 years in Clementi Town, Singapore. *Ann Acad Med Singapore*. 1992;**21**(3):323-7. [PubMed: 1416778].
7. Wilson C, Emans SJ, Mansfield J, Podolsky C, Grace E. The relationships of calculated percent body fat, sports participation, age, and place of residence on menstrual patterns in healthy adolescent girls at an independent New England high school. *J Adolesc Health Care*. 1984;**5**(4):248-53. doi: 10.1016/s0197-0070(84)80126-6. [PubMed: 6541639].
8. Abbaspour Z, Rostami M, Najjar Sh. The Effect of Exercise on Primary Dysmenorrhea. *J Res Health Sci*. 2006;**6**(1):26-31.
9. Klein JR, Litt IF. Epidemiology of adolescent dysmenorrhea. *Pediatrics*. 1981;**68**(5):661-4. [PubMed: 7312467].
10. Proctor M, Farquhar C. Diagnosis and management of dysmenorrhoea. *BMJ*. 2006;**332**(7550),1134-8. doi: 10.1136/bmj.332.7550.1134. [PubMed: 16690671]. [PubMed Central: PMC1459624].
11. 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. *Br J Obstet Gynaecol*. 1996;**103**(11):1134-42. doi: 10.1111/j.1471-0528.1996.tb09597.x. [PubMed: 8917003].
12. Bello FA, Akinyotu OO, Odubamowo KH. Dysmenorrhea among female students at a Teaching Hospital in South-Western Nigeria. *Trop J Obstet Gynaecol*. 2017;**34**(2):129-33. doi: 10.4103/TJOG.TJOG_10_17.
13. Loto OM, Adewumi TA, Adewuya AO. Prevalence and correlates of dysmenorrhea among Nigerian college women. *Aust N Z J Obstet Gynaecol*. 2008;**48**(4):442-4. doi: 10.1111/j.1479-828X.2008.00869.x. [PubMed: 18837854].
14. Thomas KD, Okonofua FE, Chiboka O. A study of the menstrual patterns of adolescents in Ile-Ife, Nigeria. *Int J Gynaecol Obstet*. 1990;**33**(1):31-4. doi: 10.1016/0020-7292(90)90651-z. [PubMed: 1974529].
15. Amu EO, Bamidele JO. Prevalence of menstrual disorders among adolescent girls in Osogbo, South Western Nigeria. *Int J Adolesc Med Health*. 2014;**26**(1):101-6. doi: 10.1515/ijamh-2013-0500. [PubMed: 24501153].
16. Andersch B, Milsom I. An epidemiologic study of young women with dysmenorrhea. *Am J Obstet Gynecol*. 1982;**144**(6):655-60. doi: 10.1016/0002-9378(82)90433-1. [PubMed: 7137249].
17. Proctor ML, Murphy PA. Herbal and dietary therapies for primary and secondary dysmenorrhea. *Cochrane Database Syst Rev*. 2001;(3):CD002124. doi: 10.1002/14651858.CD002124. [PubMed: 11687013].
18. McEvoy M, Chang J, Coupey SM. Common menstrual disorders in adolescence nursing interventions. *MCN Am J Matern Child Nurs*.

2004;**29**(1):41-9. doi: 10.1097/00005721-200401000-00011. [PubMed: 14734964].
19. Akin M, Price W, Rodriguez G Jr, Erasala G, Hurley G, Smith RP. Continuous low level topical heat compared to acetaminophen for primary dysmenorrhea. *J Reprod Med*. 2004;**49**(9):739-45. [PubMed: 15493566].
20. Steiner M, Dunn E, Born L. Hormones and mood: from menarche to menopause and beyond. *J Affect Disord*. 2003;**74**(1):67-83. doi: 10.1016/s0165-0327(02)00432-9. [PubMed: 12646300].
21. Marjoribanks J, Proctor ML, Farquhar C. Nonsteroidal anti-inflammatory drugs for primary dysmenorrhoea. *Cochrane Database Syst Rev.* 2003;(4):CD001751. doi: 10.1002/14651858.CD001751. [PubMed: 14583938].
22. Martin VT, Ballard J, Diamond MP, Mannix LK, Derosier FJ, Lener SE, et al. Relief of menstrual symptoms and migraine with a single-tablet formulation of sumatriptan and naproxen sodium. *J Womens Health*. 2014;**23**(5):389-96. doi: 10.1089/jwh.2013.4577. [PubMed: 24579886]. [PubMed Central: PMC4011418].
23. Mannix LK, Martin VT, Cady RK, Diamond ML, Lener SE, White JD, et al. Combination treatment for menstrual migraine and dysmenorrhea using sumatriptan-naproxen: two randomized controlled trials. *Obstet Gynecol.* 2009;**114**(1):106-13. doi: 10.1097/AOG.0b013e3181a98e4d. [PubMed: 19546766].
24. Oladosu FA, Tu FF, Hellman KM. Nonsteroidal anti-inflammatory drug resistance in dysmenorrhea: epidemiology, causes, and treatment. *Am J Obstet Gynecol*. 2018;**218**(4):390-400. doi: 10.1016/j.ajog.2017.08.108. [PubMed: 28888592]. [PubMed Central: PMC5839921].
25. Robertson V, Spurritt D. Electrophysical agents: Implications of their availability and use in undergraduate clinical placements. *Physiotherapy*. 1998;**84**:335-44.
26. Watson T. Transcutaneous Electrical Nerve Stimulation [Internet]. Available from: www.electrotherapy.org.
27. Eng J. Sample Size Estimation: How many individuals should be studied? *Radiology*. 2003;**227**(2):309-13. doi: 10.1148/radiol.2272012051. [PubMed: 12732691].
28. Williamson A, Hoggart B. Pain: a review of three commonly used pain rating scales. *J Clin Nurs*. 2005;**14**(7):798-804. doi: 10.1111/j.1365-2702.2005.01121.x. [PubMed: 16000093].
29. Kaplan B, Rabinerson D, Pardo J, Krieser RU, Neri A. Transcutaneous electrical nerve stimulation (TENS) as a pain-relief device in obstetrics and gynecology. *Clin Exp Obstet Gynecol*. 1997;**24**(3):123-6. [PubMed: 9478293].
30. Bai HY, Bai HY, Yang ZQ. Effect of transcutaneous electrical nerve stimulation therapy for the treatment of primary dysmenorrheal. *Medicine*. 2017;**96**(36):e7959. doi: 10.1097/MD.0000000000007959. [PubMed: 28885348]. [PubMed Central: PMC6392990].
31. Lundeberg T, Bondesson L, Lundström V. Relief of primary dysmenorrhea by transcutaneous electrical nerve stimulation. *Acta Obstet Gynecol Scand*. 1985;**64**(6):491-7. doi: 10.3109/00016348509156727. [PubMed: 3904321].
32. Lewers D, Clelland JA, Jackson JR, Varner RE, Bergman J. Transcutaneous electrical nerve stimulation in the relief of primary dysmenorrhoea. *Phys Ther.* 1989;**69**(1):3-9. doi: 10.1093/ptj/69.1.3. [PubMed: 2783493].
33. Tugay N1, Akbayrak T, Demirtürk F, Karakaya IC, Kocaacar O, Tugay U, et al. Effectiveness of transcutaneous electrical nerve stimulation and interferential current in primary dysmenorrhea. *Pain Med.* 2007;**8**(4):295-300. doi: 10.1111/j.1526-4637.2007.00308.x. [PubMed: 17610451].
34. Charlton J. Core Curriculum for Professional Education in Pain. 3rd ed. Seattle: IASP Press; 2005. p. 93-96.
35. Johnson MI. Transcutaneous Electrical Nerve Stimulation. In: Kitchen S, editors. Electrotherapy: Evidence- Based Practice. Edinburgh: Churchill Livingstone; 2002. p. 259-286.
36. Sluka KA, Walsh D. Transcutaneous electrical nerve stimulation: basic science mechanisms and clinical effectiveness. *J Pain*. 2003;**4**(3):109-21. doi: 10.1054/jpai.2003.434. [PubMed: 14622708].
37. Dawood MY, Ramos J. Transcutaneous electrical nerve stimulation (TENS) for the treatment of primary dysmenorrhea: a randomized crossover comparison with placebo TENS and ibuprofen. *Obstet Gynecol*. 1990;**75**(4):656-60. [PubMed: 2179780].
38. Finniss DG, Benedetti F. Mechanisms of the placebo response and their impact on clinical trials and clinical practice. *Pain*. 2005;**114**(1-2):3-6. doi: 10.1016/j.pain.2004.12.012. [PubMed: 15733625].
39. Smith RP, Heltzel JA. Interrelation of analgesia and uterine activity in women with primary dysmenorrhea. A preliminary report. *J Reprod Med*. 1991;**36**(4):260-4. [PubMed: 2072357].