Transcutaneous Electrical Nerve Stimulation (TENS) for the treatment of chronic LBP

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***Abstract*— Introduction:** Transcutaneous electric nerve stimulation (TENS) has emerged as a popular method to treat various chronic pain conditions. The purpose of this review is to examine the effect of TENS on pain management in patients with chronic low back pain. **Methods:** A search was conducted in Greek and English language, at Google Scholar, PubMed, PEDro, Science Direct, and Cochrane Library electronic databases, combining keywords of the central axes of the issue such as "chronic low back pain" or "CLBP", "pain relief", "electrotherapy", "transcutaneous electrical nerve stimulation" or "TENS". **Results:** Eight studies, RCT (n=4) and systematic reviews (n=4), which examine the effectiveness of TENS were included in this review. A total of 1.605 patients were included in this review, 512 patients in RCTs and 1093 in systematic reviews. Most studies (n=6) compared TENS with placebo, two studies compared different type of TENS and one TENS with educative treatment program. **Conclusions:** The results of this review demonstrates that the application of the TENS and mainly the bTENS can contribute short-term to pain adjustment and to the limitation of painkiller consumption when it comes to patients with CLBP. There was contradictory evidence that showed that TENS currents when used as an isolated treatment cannot be supported.

***Keywords*— chronic low back pain; electrotherapy; pain relief; TENS.**

I. INTRODUCTION

Low back pain (LBP) is a leading cause of work absenteeism and visits to healthcare professionals [1-2]. Sixty to 90% of the adult population is at risk of developing LBP at some point in their lifetime [1-9]. Of those who develop acute LBP, 30% develop chronic LBP [10]. The use of multiple complementary treatments is frequent and active therapies encouraging individuals to participate in the treatment process are increasingly advocated [11]. One of these methods is transcutaneous electrical nerve stimulation (TENS), a noninvasive treatment that can be self-administered by patients and is generally associated with few safety concerns, adverse effects being principally limited to transient skin irritation.

TENS is widely used in the management of chronic pain [12]. TENS is used in a variety of clinical settings to treat a range of different acute and chronic pain conditions, and has become popular with both patients and health professionals of different disciplines, including physiotherapists, midwives, nurses and doctors [13]. TENS units deliver electrical stimulation to the underlying peripheral nerves via electrodes placed over the intact skin surface, near the source of maximal pain [14-17]. The development and application of TENS was based on the Gate Control Theory, conceptualized by Melzack and Wall [18].

There are three main therapeutic methods of administrating TENS [19]: continuous TENS (frequency bigger than 80 Hz, pulse width bigger than 50 ms, short stimulation duration, very high volume sufficient for the activation of the fibers that cause pain), burst mode TENS (bursting of high frequency pulses, it is given with low frequency less than 10 Hz, high volume) and modulation TENS (one or more parameters are shaped randomly while treatment) [20]. Whether there is a significant difference in clinical effectiveness between high frequency and low frequency modes is unclear and not well defined [21-22].

This approach has emerged as a popular method to treat various chronic pain conditions [23-38] including chronic low back pain (CLBP) [38-45]. Despite its wide use, its effectiveness to chronic low back pain is still debatable. The purpose of this review is to examine the effect of TENS on pain management in patients with CLBP.

II. METHODS

Data design: A search on Google Scholar, PubMed, PEDro, Science Direct and Cochrane Library was conducted, combing key words of the main parts of the topic like chronic low back pain or CLBP, pain relief, electrotherapy, transcutaneous electrical nerve stimulation or TENS. The results are presented as per the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) reporting guideline (supporting checklist/diagram). [46] A total of 8 studies, RCT (n=4) and systematic reviews (n=4), which examine the effectiveness of TENS at patients with CLBP were included in this review. A total of 1.605 patients were included in this review, 512 patients in RCTs and 1093 in systematic reviews. Most studies (n=6) compared TENS with placebo, two studies compared different type of TENS and one TENS with educative treatment program.

Inclusion Criteria: The review included studies designed to evaluate the effect of TENS at patients with CLBP in Greek and English language, with no limitation about the publication date. Case reports and case series were excluded.

Study selection: Eligibility screening of the studies was conducted in a blinded standardized way by two independent reviewers (Ev.T. and S.T.). Titles and abstracts were screened using and duplicate articles were excluded. After screening titles and abstracts, full paper copies were retrieved. Full text screening was also performed blinded by the same reviewers (Ev.T. and S.T.). Disagreements between authors during any stage of the screening process were resolved by consulting a third reviewer (Em.T.).

III. RESULTS

Yakşi et al. (2021) [47] examined the effectiveness of TENS at people with CLBP for more than 12 weeks' time, with no inflammation or tumorous disease. A total of 74 patients participated in this research, 27 female and 47 male (18 to 65 years old). The participants were randomly divided into 3 groups, the first group (n=25) received bTENS treatment (burst TENS), the second group (n=25) received cTENS treatment (continuous TENS), while the third group (n=24) received placebo TENS treatment. The parameters for the continuous TENS form were 60-80 Hz frequency, duration 50-80 ms and volume 10-30 mA. Concerning the explosive TENS form, low frequency current 1-4 Hz was combined with high frequency current 50-100 Hz. All patients fulfilled 15 sessions, 5 times a week for 3 weeks and were informed for both the treatment method and for the possible side effects that might appear. A statistically significant improvement was observed in mean VAS scores post treatment (postT) compared to pretreatment (preT) in all three groups. Intergroup comparison revealed a significant difference between preT and postT values, that difference being assessed in favor of bTENS at multiple comparison analysis. Although significant improvement was determined in neuropathic pain DN4 scores measured at postT3 compared to preT in all groups, there was no significant difference between the groups. No

statistically significant difference was also observed between the groups in terms of MOS, BDI, or SSR values at postT3 (P > 0.05). Based on the study results it was obvious that bTENS administration to patients with low back pain is an effective and safe method which can be used for short term pain control.

In Garaud et al.'s study (2018) [48] the effectiveness of TENS current for the treatment of chronic low back pain when combined with an educative treatment program was examined. The study sample consisted of 97 patients with CLBP, between 18 and 75 years old, who were divided into 2 groups. A combination of 50 received routine treatment with TENS current and 47 received routine treatment with TENS current with an educative treatment program based on a nurse's advisory support was conducted. A conventional TENS program was dispensed as interference tool, a program that is characterized by continuous stimulation with high frequencies 80-100 Hz, with wave duration from 50 to 100 ms and with low volumes achieving painless paresthesia at the part of the body that is being treated. During the test part a "Burst Mode" TENS program, was used, a program that is characterized by continuous stimulation with low frequencies (1-4 Hz), with wave duration from 100 to 400 ms and high volumes so as to cause feeble muscular contractions. The results indicated that only 44% of the first group were still evaluative at the end of the study, while in the second group 70%. The questionnaire scores evolved similarly between the groups through time. No significant differences between the two groups concerning inactivity pain and motion pain, and the administration of painkillers and social impact were observed. This study does not support the use of TENS current for the treatment of patients with CLBP, even though the patients profited from the educative treatment program.

Buchmuller et al.'s study (2012) [49] evaluated the effectiveness of TENS to patients with CLBP. A total of 236 adult patients aging from 25 to 86 years with CLBP, with or without radicular pain, participated in this study. Those patients were randomly divided into 2 groups. The first (n=117) received TENS treatment and the second (n=119) received placebo TENS treatment for 1 hour, 4 times a week for 3 months of treatment. A combination of conventional TENS current with continuous high frequency stimulation 80-100 Hz, with wave duration 50-100 ms and with low volume achieving a potential painless body paresthesia, and explosive TENS form, that is characterized by non-continuous stimulation with low frequency 1-4 Hz, wave duration 100-400 ms and high volume causing painless muscular contractions, was used. According to the results a significant improvement between the first and the last treatment with TENS for pain relief on the VAS scale was observed. No other significant difference at the results was noted for both groups. The researchers supported based on these results that there is not functional benefit of the TENS treatment for the handling of CLBP.

The main aim at Pivovarsky et al.'s (2021) [50] study was the comparison and evaluation of the immediate relief results of the conventional and the explosive TENS form to patients with CLBP. The sample consisted of 105 patients with non-specific CLBP, aging between 18 and 85 years, who were randomly classified in the following groups. The 1st group that received placebo TENS treatment, the 2nd group that received conventional TENS treatment of continuous stimulation 100 Hz and pulse rate 100 ms and the 3rd group that received bTENS treatment of 100 Hz frequency, shaped pulse rate 2 Hz and pulse duration 100 ms. The results showed that pain intensity and pain quality were both mitigated to both interference groups (conventional TENS group and burst mode TENS group). More specifically, a positive effect was observed on TENS interventions in comparison to the placebo TENS group in every aspect of the McGill questionnaire, except from the pain volume and the pressure pain threshold that were intensified significantly right after the TENS currents in both intervention groups, but not in the placebo medication group. Both ways of TENS application were effective for pain regulation, but significant results that indicate the best way for chronic low back pain treatment were not found.

In Jauregui et al.'s (2016) [51] meta-analysis, the researchers evaluated TENS effectiveness to patients with CLBP. In this meta-analysis the researchers included randomized controlled tests, cohort studies and randomized cross-studies which mentioned TENS current as the medium of CLBP treatment. This study's sample included 267 patients who attended a 7-week treatment program. At the subdivision of the treatment duration it resulted that the patients who received treatment for less than 5 weeks had significant impacts concerning the pain, while those who received treatment for more than 5 weeks did not have significant impacts concerning the pain. The results showed that TENS treatment for the handling of CLBP indicated significant pain limitation. Thus, the implementation of TENS currents can lead to less use of painkillers and should be incorporated to the treatment program for the handling of CLBP.

In Khadilkar et al.'s (2005) [52] systematic review, RCT trials that evaluated the effect of TENS treatment to people with CLBP were used. In total, 2 RCTs were included, where 175 patients over 18 years of age participated, patients who had been diagnosed with CLBP, which is defined as chronic mechanical persisting pain that lasts more than 12 weeks. In the first RCT was observed significant pain relief in TENS treatment in comparison to placebo TENS, but in the second RCT statistically significant differences were not observed between the two treatment groups and the control groups. The researchers highlighted that more attention should be given to the dangers and benefits of long-term use, which would treat CLBP more appropriately.

Another systematic review that was conducted by Gaid and Cozens (2009) [53] aimed at the investigation of the effectiveness of TENS treatment for the handling of CLBP. Controlled tests that involved TENS as treatment (regardless of type or constructor) were included and the people had been diagnosed with CLBP. Only three controlled trials about the effectiveness of TENS treatment were included in the review. The results supported that TENS can be used for short-term results on pain to people with CLBP. However, the researchers noted that

more studies are needed for the tracing of clinical changes for a bigger period of time and the appropriate frequency for treatment with the use of TENS needs to me examined.

Odebiyi et al. (2013) [54] conducted a systematic review with RCT, that compared the effectiveness of TENS current and the placebo for handling of LBP. In the review 4 RCTs were included, 585 patients over 18 years of age with CLBP for more than 12 weeks participated. Conflicting evidence emerged as to whether TENS contributes positively to the limitation of the pain, while two trials indicated strong evidence (410 patients) of no improvement of the functional situation of the lumbar part. Moreover, there were conflicting evidence about the general health condition in the two trials, as one study did not indicate any improvement, while the other showed significant improvements to many but not to all the subsections of the SF-36 questionnaire. Multiple numbers of natural outcome presented no significant statistical improvement in relation to the placebo. Overall, the patients that received treatment with TENS similar to acupuncture reacted similarly to those that were treated with conventional TENS. Based on this evidence the review concluded that TENS use for the treatment of CLBP cannot be supported and more research is required for its effectiveness can be drawn.

Table 1. Studies included in this review concerning TENS for treating CLBP.

Author (year)	Method	Sample(n)	Intervention	Conclusion
Pivovarsky et al., 2021	Randomized controlled trial	105	1st group: conventional TENS 2nd group: bTENS	Both TENS forms were effective for pain regulation.
Yakşi et al., 2021	Randomized placebo-controlled study	74	1st group: bTENS 2nd group: cTENS 3rd group: placebo TENS	bTENS treatment to patients with CLBP is an effective and safe method that can in the short term contribute to pain control.
Garaud et al., 2018	Randomized study	97	1st group: TENS 2nd group: TENS and educative treatment program	This study does not support TENS use for the treatment of patients with CLBP even though the patients were profited by the educative treatment program.
Buchmuller et al., 2012	Randomized controlled trial	236	1st group: TENS 2nd group: placebo TENS	There was not functional profit of TENS use to patients with CLBP.
Khadikar et al., 2015	Systematic review	175	1st group: TENS 2nd group: placebo medicine	The evidence for the effectiveness of TENS currents as the only intervention for the handling of CLBP is limited.
Gaid& Cozens, 2009	Systematic review	241	1st group: TENS 2nd group: placebo medicine	This systematic literature review provides evidence that supports that TENS use for the treatment of CLBP can have short term results.
Odebiyi et al., 2013	Systematic review	585	1st group: TENS 2nd group: placebo medicine	The use of TENS currents for chronic low back pain treatment cannot be supported and further research is required for the determination of their effectiveness.
Jaurequi et al., 2016	Meta-analysis	267	1st group: TENS 2nd group: placebo medicine	CLBP treatment with TENS showed significant pain mitigation as TENS use can lead to the use of less painkillers, that's why it should be incorporated in the treatment of CLBP program.

IV. DISCUSSION

Eight studies, RCT (n=4) [47-50] and systematic reviews (n=4) [51-54], which examine the effectiveness of TENS were included in this review. A total of 1.605 patients were included in this review, 512 patients in RCTs and 1093

in systematic reviews. Most studies (n=6) compared TENS with placebo, two studies compared different type of TENS and one TENS with educative treatment program.

The findings from three studies [47, 49-50] comparing TENS with placebo medicine showed that the use of TENS cannot be supported as a treatment method for the handling of pain of the patients with CLBP, as there is not any statistically significant functional benefit between the two treatments. However, a meta-analysis indicated that the use of TENS aids at the reduction of pain and leads to less use of painkillers [51]. Another systematic review mentioned that TENS currents should be integrated in the treatment program for the handling of CLBP, as their use contributes to short-term results [53].

A study [50] that compared the effectiveness of the conventional and bTENS showed that both application methods were effective for pain regulation. However, no strong evidence was found to indicate which method provides betters results. Another study [47] that compared the effectiveness of bTENS, conventional TENS and the placebo medicine showed that the use of bTENS on patients with CLBP is an effective and safe method and presented promising results in the short-term aid at pain control. Finally, a randomized trial [48] where TENS currents were compared with a therapeutic treatment program led to the conclusion that the use of TENS cannot be supported for the treatment of patients with CLBP even though the patients benefited by the therapeutic education program.

According to this review the data for the effectiveness of TENS as an isolated intervention are limited. The use of TENS at RCTs presents no statistically important improvements compared with placebo medicine. While two reviews support them and suggests their implementation in a therapeutic protocol. As far as the type of TENS, the bTENS has showed to be more beneficial. A therapeutic education programs shows greater results than the use of TENS.

V. Conclusion

The results of this review demonstrates that the application of the TENS and mainly the bTENS can contribute short-term to pain adjustment and to the limitation of painkiller consumption when it comes to patients with CLBP. There was contradictory evidence that showed that TENS currents when used as an isolated treatment cannot be supported. The benefits of this study can be used as a reference to determine the treatment protocol for people with CLBP, as well as a research material. The limitation of this review is that there was sparse literature concerning TENS as an isolated treatment, thus no clear conclusions can be drawn. Further research is needed in order to fully examine the effects of this treatment in large number of patients with CLBP and to examine the effects and the implications their long-term use can entail.

VI. References

[1] Andersson GBJ. Epidemiologic features of chronic low-back pain. Lancet 1999;354:581–5.

[2] Deveraux MW. Low back pain. Prim Care Clin Office Pract 2004;31:33–51.

[3] Andersson GBJ. The epidemiology of spinal disorders. In: J.W. Frymoyer editor(s). The adult spine: principles and practice. 2nd Edition. New York: Raven Press, Ltd, 1997:93-141.

[4] Coste J, Paolaggi JB. Critical review of the epidemiology of backache [Revue critique de l'épidémiologie des lombalgies]. Revue D'épidémiologie et de Santé Publique 1989;37:371-83.

[5] Deyo R, Mirza S, Martin BI. Back pain prevalence and visit rates: estimates from US national surveys, 2002. Spine 2006;31(23):2724-7.

[6] Deyo RA, Tsui-Wu YJ. Descriptive epidemiology of low-back pain and its related medical care in the United States. Spine 1987;12:264-8.

[7] Sierpina VS, Curtis P, Doering J. An integrative approach to low back pain. Clinics in Family Practice 2002;4(4):817-31.

[8] Skovron ML. Epidemiology of low back pain. Baillieres Clinical Rheumatologia 1992;6:559-73.

[9] Smeal WL, Tyburski M, Alleva J, Prather H, Hunt D. Conservative management of low back pain. Part I. Discogenic/radicular pain. Dis Mon 2004;50(12):636-69.

[10] Bowman JM. The meaning of chronic Low Back Pain. 381-384, 1991.

[11] Sebnem Koldaş Doğan, Birkan Sonel Tur, Yeşim Kurtaiş, Mesut Birol Atay. Comparison of three different approaches in the treatment of chronic low back pain. Clin Rheumatol. 2008 Jul;27(7):873-81. doi: 10.1007/s10067-007-0815-7. Epub 2008 Jan 11.

[12] Rowlingson JC. The role of the pain in clinic. In: Carron H, McLaughlin RE, eds. Managemet of low back pain. Boston: John Wright-PSG, 1986:3.

[13] Carroll D, Moore RA, McQuay HJ, Fairman F, Tramèr M, Leijon G. Transcutaneous electrical nerve stimulation (TENS) for chronic pain. Cochrane Database of Systematic Reviews 2000, Issue 4. Art. No.: CD003222. DOI: 10.1002/14651858.CD003222

[14] American Physical Therapy Association. American Physical Therapy Association Anthology. 1993; Vol. Vol 2.

[15] Barr JO. Transcutaneous Electrical Nerve Stimulation for pain management. In: Nelson RM, Hayes KW, Currier DP editor(s). Clinical electrotherapy. 3rd Edition. Appleton & Lange, 1999:291-354.

[16] Deyo RA, Walsh NE, Martin DC, Schoenfield LS, Ramamurthy S. A controlled trial of transcutaneous electrical stimulation (TENS) and exercise for chronic low back pain. New England Journal of Medicine 1990;322(23):1627-34.

[17] Sluka KA, Walsh D. Transcutaneous electrical nerve stimulation basic science mechanisms and clinical eLectiveness. Journal of Pain 2003;4(3):109-21.

[18] Melzack R, Wall PD. The challenge of pain. New York: Penguin Books Ltd, 1982.

[19] Kaye V, Brandstater ME. Transcutaneous Electrical Nerve Stimulation. eMedicine.com, Inc., 2002.

[20] Odebiyi DO, Henschke N, Chesterton L, Ferreira ML, Tella A. Transcutaneous electrical nerve stimulation (TENS) for chronic low-back pain. Cochrane Database of Systematic Reviews 2013, Issue 4. [DOI: 10.1002/14651858.CD010500]

[21] Belanger AY. Evidence based guide to therapeutic physical agents. Lippincott Williams & Wilkins, 2002.

[22] Johnson MI, Ashton CH, Thompson JW. The consistency of pulse frequencies and pulse patterns of transcutaneous electrical nerve stimulation (TENS) used by chronic pain patients. Pain 1991;44(3):231-4.

[23] Meyer, G.A. and Fields, H.L., Causalgia treated by selective large fibre stimulation of peripheral nerve, Brain, 9.5 (1972) 163-168.

[24] Thorsteinsson, G., Stonnington, H.H., Stillwell, G.K. and Elveback, L.R., The placebo effect of transcutaneous electrical stimulation, Pain, 5 (1978) 31-41.

[25] Francini, F., Maresca, M., Procacci, P. and Zoppi, M., The effects of non-painful transcutaneous electrical nerve stimulation on cutaneous pain threshold and muscular reflexes in normal men and in subjects with chronic pain, Pain, 11 (1981) 49-63.

[26] Fried, T., Johnson, R. and McCracken, W., Transcutaneous electrical nerve stimulation: its role in the control of chronic pain, Arch. Phys. Med. Rehabil., 65 (1984) 228-231.

[27] Lundeberg, T., A comparative study of the pain alleviating effect vibratory stimulation, transcutaneous electrical nerve stimulation, electroacupuncture and placebo, Am. J. Chin. Med., 12 (1984) 72-79.

[28] Brill, MM. and Whiffen, J.R., Application of 24-hour burst TENS in a back school, Phys. Ther., 65 (1985) 135.5-1357.

[29] Lehmann, T.R., Russell, D.W., Spratt, K.F., Colby, H., Liu, Y.K., Fairchild, M.L. and Christensen, S., Efficacy of electroacupuncture and TENS in the rehabilitation of chronic low back pain patients, Pain, 26 (1986) 277-290.

[30] Cheng, R.S.S. and Pomeranz, B., Electrotherapy of chronic musculoskeletal pain: comparison of electroacupuncture and acupuncture-like transcutaneous electrical nerve stimulation, Clin. J. Pain, 2 (1987) 143-149.

[31] Lampe, J. and Dunn, B., Symmetrical biphasic TENS waveform for treatment of back pain, Clin. J. Pain, 3 (1987) 145-151.

[32] Phero, J.C., Prithvi Raj, P. and McDonald, J.S., Transcutaneom electrical nerve stimulation and myoneural injection therapy for management of chronic myofascial pain, Dent. Clin. N. Am., 31 (1987) 703-723.

[33] Umeh, B.U.O., Initial experience with transcutaneous electrical nerve stimulation (TENS) for pain relief in Nigeria, Clin. J. Pain, 3 (1987) 142-144.

[34] Bremerich, A., Wolfgang, W., Thein, T. and Dietze, T., Transcutaneous electric nerve stimulation (TENS) in the therapy of chronic facial pain, J. Cranio-Max. Facial Surg., 16 (1988) 379-381.

[35] Graff-Radford, S.B., Reeves, J.L., Baker, R.L. and Chiu, D., Effects of transcutaneous electrical nerve stimulation on myofascial pain and trigger point sensitivity, Pain, 37 (1989a) l-5.

[36] Graff-Radford, S.B., Reeves, J.L., Baker, R.L. and Chiu, D., Effects of transcutaneous electrical nerve stimulation on myofascial pain and trigger point sensitivity, Pain, 37 (1989b) 1-5.

[37] Leandri, M., Parodi, CL, Corrieri, N. and Rigardo, S., Comparison of TENS treatments in hemiplegic shoulder pain. Stand. J. Rehab. Med., 22 (1990) 69-72.

[38] Marchand, S., Bushnell, M.C. and Duncan, G.H., Modulation of heat pain perception by high frequency transcutaneous electrical nerve stimulation (TENS), Clin. J. Pain, 7 (1991a) 122-129.

[39] Fox, E.J. and Melzack, R., Transcutaneous electrical stimulation and acupuncture: comparison of treatment for low-back pain, Pain, 2 (1976) 141-148.

[40] Mannheimer, C. and Carlsson, C.-A., The analgesic effect of transcutaneous electrical nerve stimulation (TENS) in patients with rheumatoid arthritis. A comparative study of different pulse patterns, Pain, 6 (1979) 329-334.

[41] Dougherty, R.J., Transcutaneous electrical nerve stimulation: an alternative to drugs in the treatment of acute and chronic pain, Ann". Sci. Assemb., (1982) Abst.

[42] Deyo, R.A., Conservative therapy for low back pain, J. Am. Med. Assoc., 250 (1983) 1057-1062.

[43] Lehmann, T.R., Russel, D.W. and Spratt, K.F., The impact of patients with nonorganic physical findings on a controlled trial of transcutaneous electrical nerve stimulation and electroacupuncture, Spine, 8 (1983) 625-634.

[44] Melzack, R., Vetere, P. and Finch, L., Transcutaneous electrical nerve stimulation for low back pain comparison of TENS and massage for pain and range of motion, Phys. Ther., 63 (1983) 489-493.

[45] Deyo, R.A., Walsh, N.E., Martin, D.C., Schoenfeld, L.S. and Ramamurthy, S., A controlled trial of transcutaneous electrical nerve stimulation (Tens) and exercise for chronic low back pain, N. Engl. J. Med., 322 (1990) 1627-1634]

[46] Moher d, liberati a, tetzlaff J, altmandG; prisMa Group. Preferred reporting items for systematic reviews and meta-analyses: the prisMa statement. ann intern Med 2009;151:264–9, W64.

[47] Yakşi, E., Ketenci, A., Baslo, M. B., & Orhan, E. K. (2021). Does transcutaneous electrical nerve stimulation affect pain, neuropathic pain, and sympathetic skin responses in the treatment of chronic low back pain? A randomized, placebo-controlled study. The Korean Journal of Pain, 34(2), pp. 217.

[48] Garaud, T., Gervais, C., Szekely, B., Michel-Cherqui, M., Dreyfus, J. F., & Fischler, M. (2018). Randomized study of the impact of a therapeutic education program on patients suffering from chronic low-back pain who are treated with transcutaneous electrical nerve stimulation. Medicine, 97(52).

[49] Buchmuller, A., Navez, M., Milletre-Bernardin, M., Pouplin, S., Presles, E., Lantéri-Minet, M., ... & Lombotens Trial Group. (2012). Value of TENS for relief of chronic low back pain with or without radicular pain. European Journal of Pain, 16(5), pp. 656-665.

[50] Pivovarsky, M. L. F., Gaideski, F., Macedo, R. M. D., Korelo, R. I. G., Guarita-Souza, L. C., Liebano, R. E., & Macedo, A. C. B. D. (2021). Immediate analgesic effect of two modes of transcutaneous electrical nerve stimulation on patients with chronic low back pain: a randomized controlled trial. Einstein (São Paulo), pp. 19.

[51] Jauregui, J. J., Cherian, J. J., Gwam, C. U., Chughtai, M., Mistry, J. B., Elmallah, R. K., Harwin, S. F., Bhave, A., & Mont, M. A. (2016). A Meta-Analysis of Transcutaneous Electrical Nerve Stimulation for Chronic Low Back Pain. Surgical technology international, 28, pp. 296–302.

[52] Khadilkar, A., Milne, S., Brosseau, L., Wells, G., Tugwell, P., Robinson, V., ... & Saginur, M. (2005). Transcutaneous electrical nerve stimulation for the treatment of chronic low back pain: a systematic review. Spine, 30(23), pp. 2657-2666.

[53] Gaid, M., & Cozens, A. (2009). The role of transcutaneous electric nerve stimulation (TENS) for the management of chronic low back pain. International Musculoskeletal Medicine, 31(1), pp. 19-23.

[54] Odebiyi, D. O., Henschke, N., Ferreira, M. L., & Tella, A. (2013). Transcutaneous electrical nerve stimulation (TENS) for chronic low-back pain. Cochrane Database of Systematic Reviews, (4).