Effect of TENS application on pain intensity and release of endogenous opioids in patients with low back pain

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Summary
Introduction. Low back pain (LBP) is a most frequent ailment reported by patients to the doctors. This pain results from static and dynamic overloads and low physical activity. LBP increases degenerative changes and leads to the reduction of the range of motion (ROM), daily activity and occupational life. LBP is also a social and either economical problem as well. *The aim of the study* was to assess the influence of TENS application on the pain intensity and blood level of endogenous opioids in patients with LBP.
Material and methods. The study group consisted of 33 patients (22 women and 11 men) with LBP, which were qualified to the study on the basis of medical diagnosis defined by physician. The physical therapy consisted of 10 TENS applications, performed every consecutive days by 15 minutes. Before and after treatment the spine ROM was examined by Schöber test, the blood samples were taken from all participants. Before and after TENS applications the patients were asked to fill up the questionnaires: Oswestry Disability Index (ODI), Roland Morris Disability Questionnaire (RMDQ) and Visual Analogue Scale (VAS). The results therefore underwent statistical analysis.
Results. Analysis of correlation between change in the level of pain and ODI has evidenced that pain reduction is accompanied by significant increase of patient's physical efficiency ($p<0,05$). The improvement of the spine ROM in the study group was also observed (flexion by 67%, extension by 10%) as the result of TENS treatment. The significant decrease of concentration of cortisol from 41,91 to 32,49 ng/ml and significant increase of ß-endorphin blood level from 12,26 to 14,54 ng/ml have been found after TENS application.
Conclusions. TENS therapy in patients with low back pain increases spine range of motion, improves patient's physical efficiency and decreases intensity of pain.
Key words: low back pain, endogenous opioids, TENS

Streszczenie
Wstęp. Bóle okolicy lędźwiowo-krzyżowej (ang. low back pain), są jedną z najczęściej występujących dolegliwości, z powodu których pacjenci zgłaszają się do lekarza. Głównymi przyczynami powstawania tych bólów są przeciążenia statyczne i dynamiczne. Bóle dolnego odcinka kręgosłupa prowadzą do ograniczenia zakresów ruchomości oraz zmniejszenia aktywności w życiu codziennym i zawodowym. Są problemem nie tylko społecznym ale również ekonomicznym.
Celem pracy była ocena wpływu prądów TENS na odczucie bólu oraz poziom endogennych opiatów w surowicy krwi u pacjentów z dolegliwościami bólowymi dolnego odcinka kręgosłupa.
Materiał i metodyka. Badaniami objęto grupę 33 osób: 22 kobiety i 11 mężczyzn z bólem okolicy lędźwiowo-krzyżowej, którzy zostali zakwalifikowani do badań na podstawie rozpoznania określonego przez lekarza prowadzącego. Postępowanie fizykoterapeutyczne obejmowało 10 zabiegów prądami TENS. Zabiegi były wykonywane codziennie, każdy zabieg trwał 15 minut. Przed rozpoczęciem serii zabiegów i bezpośrednio po ich zakończeniu zbadano ruchomość kręgosłupa za pomocą testu Schobera, pobrano od pacjentów krew oraz poproszono pacjentów o wypełnienie kwestionariuszy: Oswestry Disability Index i Roland Morris Questionnaire oraz zaznaczenie na skali wizualno-analogowej (VAS) odczucia bólu. Wyniki badań poddano analizie statystycznej.
Wyniki. Stwierdzona zależność pomiędzy zmianą w poziomie odczuwania bólu, a wynikami kwestionariusza niepełnosprawności Oswestry, pozwala wnioskować, że wraz ze spadkiem odczuwania bólu dochodzi do wzrostu sprawności funkcjonalnej pacjenta. Zaobserwowano również poprawę ruchomości w odcinku lędźwiowym kręgosłupa (skłon tułowia w przód – poprawa o 67%, skłon tułowia w tył – poprawa o 10%). Wykazano spadek stężenia kortyzolu od 41,91 do 32,49 ng/ml oraz wzrost stężenia ß-endorfin od 12,26 do 14,54 ng/ml w surowicy krwi po zastosowaniu prądów TENS ($p<0,05$).
Wnioski. Stosowanie prądów TENS w dolegliwościach bólowych dolnego odcinka kręgosłupa wpływa na zwiększenie ruchomości kręgosłupa, poprawę aktywności fizycznej i zmniejszenie bólu.
Słowa kluczowe: bóle dolnego odcinka kręgosłupa, endogenne opiaty, TENS

INTRODUCTION

Low back pain (LBP) is a most frequent ailment reported by patients to the general medical practitioners, orthopedists and chiropractors [1, 2]. About 70-90% of population suffer from LBP (both women and men). There are now many randomized controlled trials concerning the problem of acute and chronic LBP [3, 4].

The main causes of this pain are static and dynamic overloads and limitation of physical activity. The lumbosacral region is the most important part of the vertebral column in terms of mobility and weight bearing. Mechanical disorders of this region very often resulted in low back pain. This pain reduces the range of motion (ROM), as well as, daily activity and occupational life. LBP is also a social, economical and either civilization problem as well [5].

One of the nonpharmacological, analgesic method used in medicine and physiotherapy for the management of low back pain is transcutaneous electrical nerve stimulation (TENS) [6]. Analgesic effect of this therapy is related to the stimulation of inhibitory interneurons in the substantia gelatinosa of spinal cord and to the decreased conduction of nociceptive signals to the brain. This mechanisms involves the activation of endogenous opioid system according to the theory of 'Gate Control' conceptualized by Melzack and Wall [7, 8].

AIM OF THE STUDY

The aim of the study was to assess the influence of TENS treatment on pain and blood levels of endogenous opioids (ß-endorphin, enkephalin) and cortisol in patients with LBP.

MATERIAL AND METHODS

The study group consisted of 33 persons (22 women and 11 men) suffering from LBP. Patients were qualified to the study on the basis of the medical diagnosis defined by physician. The participants comes from the region of Ciężkowice commune, district of Tarnów (Poland). The physical therapy consisted of 10 TENS BURST applications as two twin series of pulses per second, low frequency stimulation (70-100 Hz) and duration 100-200 µs, performed every consecutive days by 15 minutes. Before and after treatment the ROM of spine was measured by Schöber test. The patients were asked to fill up the questionnaires: Oswestry Disability Index (ODI) and Roland Morris Disability Questionnaire (RMDQ) which includes questions concerning the activities of daily living (ADL) and Visual Analogue Scale (VAS) used to estimate pain intensity [9, 10].

Before and after TENS application 5ml blood samples were collected from all patients for measurement of plasma levels of ß-endorphin, enkephalin and cortisol by enzyme-linked immunosorbent assay (ELISA). Determination of opioids and cortisol plasma levels was done using commercial kits from Phoenix Pharmaceuticals, Inc. (USA), Demeditec Diagnostics GmbH (Germany). The results therefore underwent statistical analysis. All data were analyzed using Statistica version 7. Differences between mean values were assessed by Student's – *t*- tests, the normality of data distribution were assessed by Shapiro-Wilk's test for continuous variables, Wilcoxon's test was used to estimate the median value differences before and after treatment. The decreases in VAS, ODI and RMDQ scores were calculated by subtracting the end value form the initial value, expressed as a percentage.

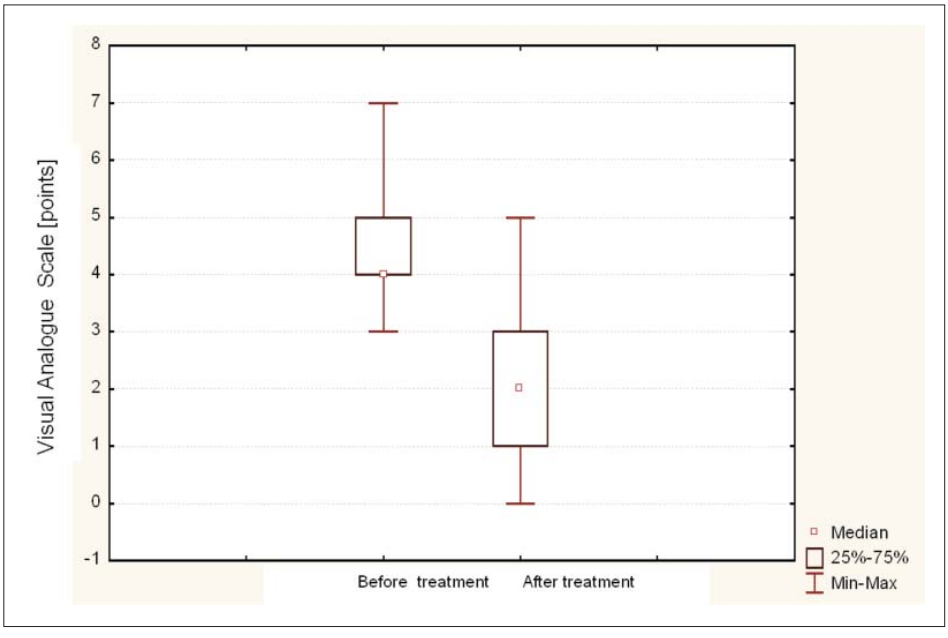

Fig. 1. Subjective pain intensity level measured by Visual Analog Scale before and after TENS application

RESULTS

Analysis of pain intensity using the Visual Analogue Scale showed significant improvement which was reported at the end of TENS treatment. Reduction of mean pain intensity was observed in all participants. The difference amounted 67%. The decrease of pain was statistically significant $p<0,001$ (Fig 1.).

Disability was analyzed by the Oswestry Disability Index and Roland Morris Disability Questionnaire. Patients reported a marked improvement in their activities of daily living with respect of RMDQ and ODI following TENS application. Physical activity and pain levels measured by ODI were also improved from 38,31 ± 13,23 before treatment to 18,31 ± 12,46 at the end of TENS application (Figs. 2 and 3). Changes of back pain level and functional status measured by RMDQ were noticed. The level of disability decreased from 7,71 ± 4,48 before TENS to 4,19 ± 3,21 at the end of therapy (by 59%). Above changes of ODI and RMDQ were statistically significant ($p<0,001$).

We also examined sacrolumbar spine range of motion (ROM) in sagittal plane using Schöber test. The results have shown that after series of TENS the sacrolumbar spine ROM was increased, as compared to the ROM before treatment. The improvement of trunk flexion and trunk extension exceeded 0,5cm. The difference was statistically significant ($p<0,05$) (Fig. 4)

As expected, treatment by TENS resulted in the changes of plasma concentrations of cortisol as well as of ß-endorphin and enkephalin (n=33). The mean value of ß-endorphin blood level increase from 12,26 ± 2,37 ng/ml before treatment to 14,54 ± 3,74 ng/ml at the end

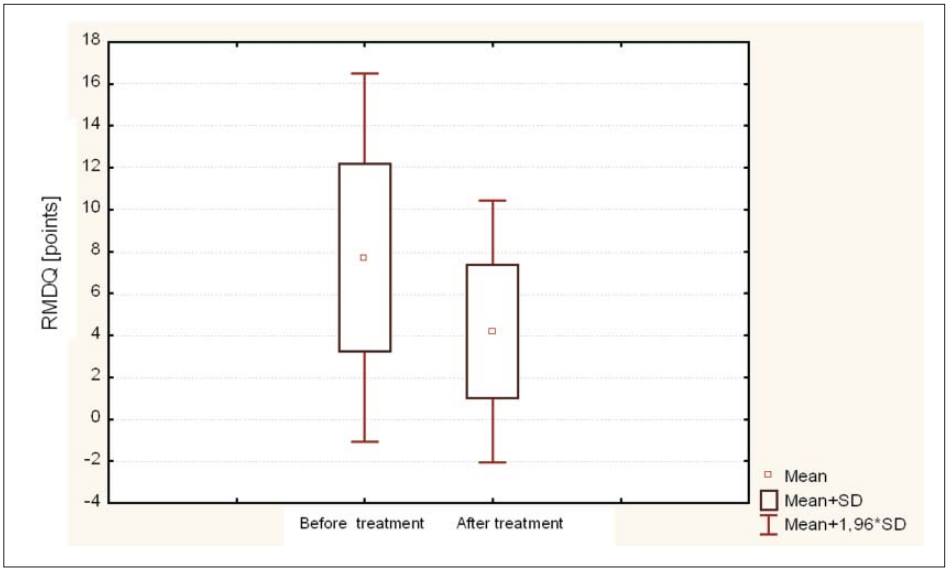

Fig. 2. Mean pain level measured by RMDQ scale before and after treatment

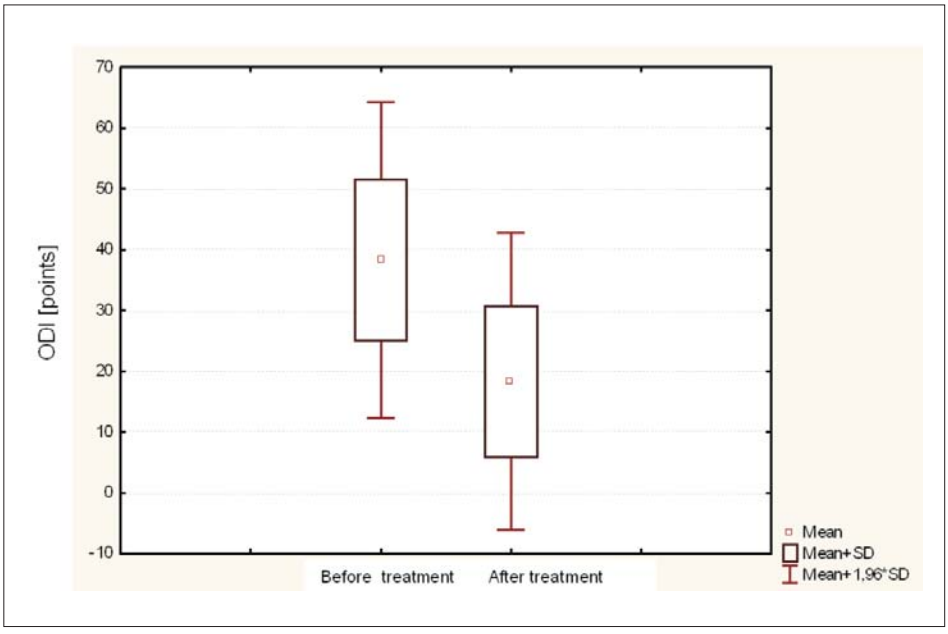

Fig. 3. Changes of aggravation of pain at daily living activities by the ODI scale before and after TENS application

of TENS application (17%). This difference was statistically significant (p=0,022) (Fig. 5). The mean value of plasma level of cortisol before treatment was 41,91 ± 11,2 ng/ml, whereas plasma level of this hormone after TENS application reached 32,49 ± 9,1 ng/ml. This difference (25%) was also statistically significant (p=0,013) (Fig. 6). Plasma level of enkephalin after treatment with TENS was slightly higher than before TENS application (2,1 ± 0,43 versus 2,36 ± 0,65 ng/ml) but value of this increase was minimal (p=0,049) (Fig. 7).

DISCUSSION

According to the presented results, application of TENS to the patients, produced beneficial effects in relation to the reduction of pain intensity, improvement of disability and spine range of motion. These results are in agreement with effects reported in previous clinical trials but the clinical benefit provided by TENS still remains controversial [11-16].

Previous studies conducted by Cheing [15], Jarzem [17] and Shimoji [18] have shown significant reduction in pain intensity after TENS treatment as compared to placebo and sham TENS. Above authors recommended TENS as a beneficial method for patients with low back pain.

However in the other publications which examined the effectiveness of TENS in patients with low back pain, randomized controlled trial failed to show the significant difference between this physical therapy and placebo in term of pain relief, functional status and the range of motion. Deyo [16], Van Tulder [14] and Sherry [13] also concluded no benefit in patient's functional status after TENS application in low back pain.

It should be mentioned, that this analgesic effect of TENS was not supported by subsequent studies of pain intensity among people with LBP exposed to TENS application [19, 20]. This disagreement between these studies and results of others, including our present data, was probably related to the differences in study design, samples size and method of TENS application.

Cortisol is the most important of glucocorticosteroid hormones, released in high amount in response to stress

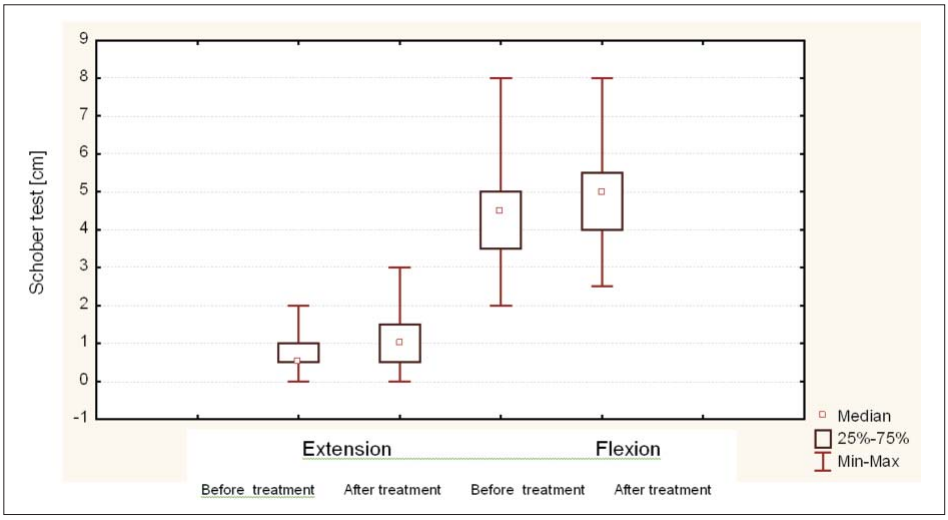

Fig. 4. Changes of the lumbar spine range of motion before and after treatment measured by Schober test

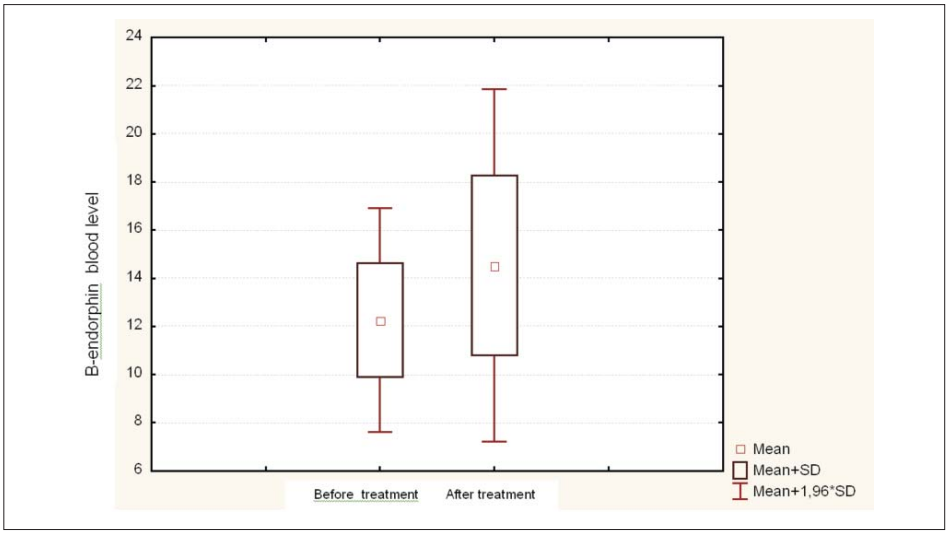

Fig. 5. Changes of ß – endorphin blood level before and after TENS application

or pain. The results of previous studies have shown that mean plasma level of cortisol was higher in patients with chronic low back pain in comparison to the control healthy subjects [21, 22]. Our present study have shown that transcutaneous electrical nerve stimulation caused changes on ß-endorphin, enkephalin and cortisol blood levels. Following series of TENS the significant increase of ß-endorphin plasma levels was observed. It was accompanied by marked decrease of cortisol plasma level as the result of reduction of pain – dependent stress.

Results of our study support and reinforced previous observations of Lynch [23] and Johnson [24] who also found the positive effects of TENS in relation to the blood level of ß-endorphin and enkephalin after TENS application [23-25]. The analgesic effects of TENS have been ascribed to the release of ß-endorphin interacting with opioid receptors. Similar results were reported in the earlier clinical trials [26-29], but the mechanism of nociceptive dysfunction and potential roles of opioid neurotransmitters are still unresolved in low back pain.

CONCLUSIONS

Application of TENS to the patients with LBP resulted in the significant decrease of pain intensity level, increase of spine range of motion and improvement of patient's physical efficiency. Analysis of correlation between changes of pain intensity and Oswestry Disability Questionnaire clearly shown that pain reduction is accompanied by significant increase of patient's physical efficiency.

Our results have shown that beneficial effect of TENS application is related, at last in part, to the release of endogenous opioids and decrease of cortisol secretion in patients with low back pain.

Comparing the results of previous publication and our present study we could conclude that high quality randomized-controlled trials are needed to determine the effectiveness of TENS in the management of low back pain.

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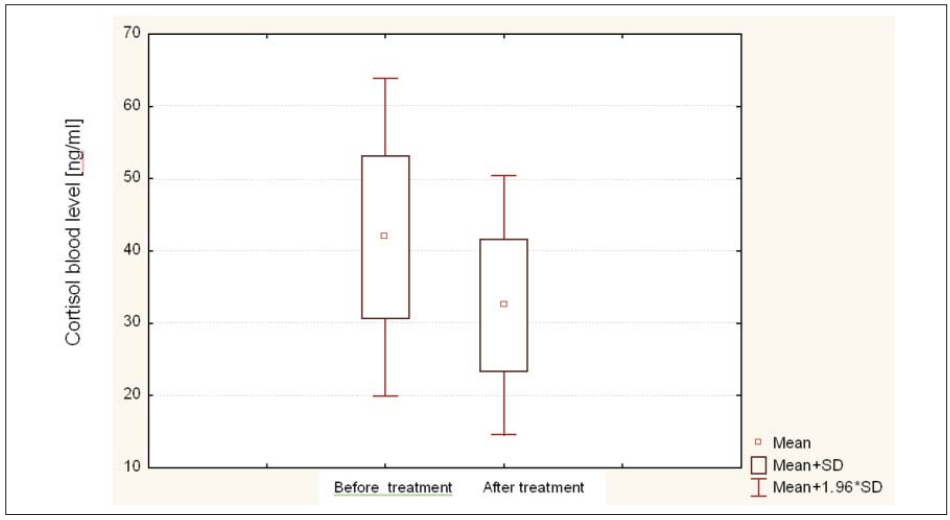

Fig. 6. Changes of cortisol blood level before and after TENS application

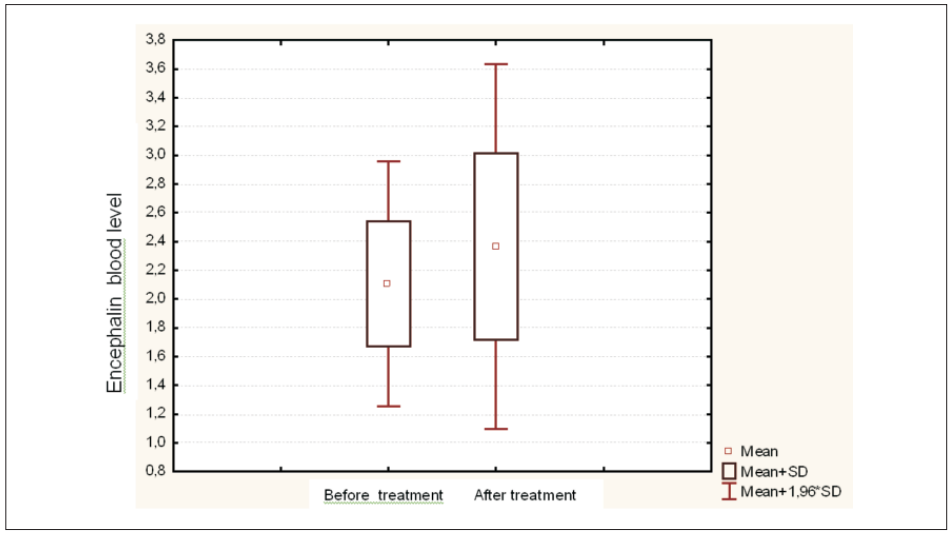

Fig. 7. Changes of encephalin blood level before and after TENS application

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