Dynamic Surface Electromyographic Responses in Chronic Low Back Pain Treated by Traditional Bone Setting and Conventional Physical Therapy

Tiina Ritvanen,[a] Nina Zaproudina, MD,[b] Mette Nissen, MS,[c] Ville Leinonen, DrMedSci,[d] and Osmo Hänninen, DrMedSci, PhD[e]

Abstract

Objective: This study compared the dynamic surface electromyographic (EMG) activities of back muscles and pain before and after traditional bone setting and physical therapy.

Methods: This study was a prospective clinical trial that compared surface EMG dynamic activities after traditional bone setting and physical therapy. Sixty-one patients (mean age, 41 years) with nonspecific low back pain were randomized into two subgroups by treatment. The patients underwent a dynamic EMG evaluation for which they were asked to stand and then bend forward as far as possible, stay fully flexed, and return to standing. A flexion-relaxation ratio was calculated by comparing maximal EMG activity while flexing with the average EMG activity in full flexion. Concentric (maximal EMG activity during extension) and eccentric (maximal EMG activity during flexion) ratios were also used in the analyses.

Results: Disability, depression, and visual analog scale scores decreased significantly after both treatments. The concentric ratio increased statistically in both groups after the treatments. The study failed to show a significant association between experienced back pain and EMG parameters.

Conclusions: Both treatments seem to have a positive influence on back muscle function by improving muscle symmetry; however, the treatments had no effect on the flexion-relaxation phenomenon after 1 month. Active back exercise at home together with rehabilitation treatments might be effective and improve function for patients with chronic low back pain. (J Manipulative Physiol Ther 2007;30:31-37)

Key Indexing Terms: *Electromyography; Low Back Pain; Physical Therapy Modalities; Musculoskeletal Manipulations; Traditional Bone Setting*

Back pain is a major cause of absenteeism, disability, and decreased working capacity.[1,2] Poor lumbar muscle function is considered to be an important factor in back problems. Musculoskeletal abnormalities and limited movement ability may be involved in the development and maintenance of chronic low back pain (CLBP).[3,4] The most common conservative treatments for low back problems are exercise, physical therapy (PT), and massage. Traditional bone setting (TBS) is common and being widely used in Finland as an alternative mobilization treatment for patients with back pain. The adverse consequences and high economic costs associated with LBP have led to an increased emphasis on research examining the outcomes of various interventions for individuals with this disorder.

Back muscle function electromyographic (EMG) tests are commonly used in the assessment of physical performance capacity improvement in the rehabilitation of patients with LBP. In healthy subjects, EMG activity is electrically nearly silent when they are standing at rest and in full trunk flexion; the electric patterns of bending-reextension cycles in erector spinae muscles are similar in both sides.[5,6] In trunk flexion with straight knees, the surface EMG (sEMG) activity initially increases during the initial position of flexion and then decreases with increased flexion, and relaxation of the muscles occurs in the fully bent posture; this is called the flexion-relaxation phenomenon (FRP). In the reextension of the spine, the EMG activity pattern is reversed until an erect position is attained.

[a] Lecturer, Institute of Biomedicine, University of Kuopio, Kuopio, Finland.
[b] Project researcher, Institute of Biomedicine, University of Kuopio, Kuopio, Finland.
[c] Medical student, Institute of Biomedicine, University of Kuopio, Kuopio, Finland.
[d] Researcher and specialized doctor, Institute of Clinical Medicine, Kuopio University Hospital, Kuopio, Finland.
[e] Professor Emeritus, Institute of Biomedicine, University of Kuopio, Kuopio, Finland.
Submit requests for reprints to: Oosteinde 8, 1636 XV Schermerhorn, Netherlands (e-mails: *tiina.ritvanen@uku.fi*, *nina.zaproudina@uku.fi*, *mette.nissen@messi.uku.fi*, *ville.leinonen@kuh.fi*, *osmo.hanninen@uku.fi*).
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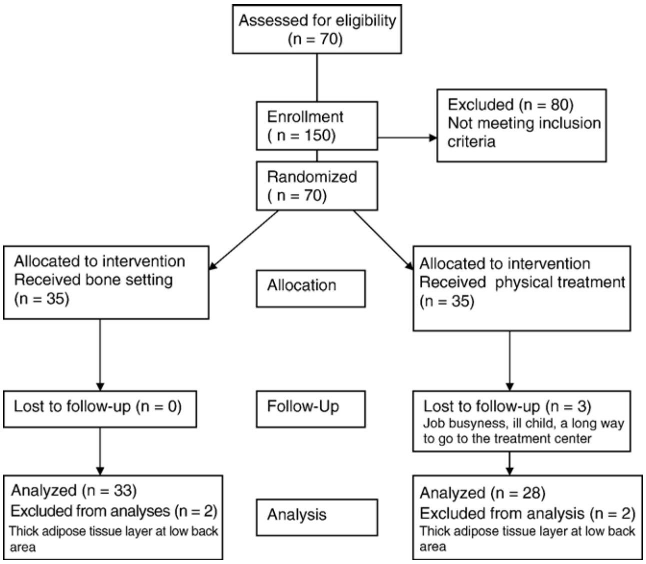

Fig 1. *Study flowchart.*

A smaller flexion-relaxation ratio (FRR)[4,7-9] and a smaller extension-flexion ratio (EFR)[6] in patients with back pain are the most common differences in erector spinae muscle activity as compared with healthy subjects, indicating that neuromuscular coordination between the trunk and the hip could be abnormal in patients with CLBP. In addition, the time lag between trunk and hip movements is much greater in patients than in healthy subjects.[10]

The aims of this study were to examine EMG activities during trunk flexion and extension among patients with LBP before and after TBS and PT and to estimate the results of dynamic sEMG activity in relation to pain level.

Methods

The study patients were recruited by announcements posted in a local newspaper in April 2003. Patients were included in the study if they were between 20 and 60 years old, had LBP that restricted functioning (referred pain not distal to the knee), and had LBP present on at least half of the days in a 12-month period in a single episode or in multiple episodes. Patients were excluded from the study if they had severe neurologic, metabolic, or cardiovascular diseases, had undergone back surgery, had mental diseases, a major structural abnormality (eg, kyphoscoliosis), or any pensionable disease, or were pregnant. Of the 150 patients, 70 were found to be eligible for study inclusion and were randomized into two subgroups by treatment. One group received TBS (n = 35), whereas the other group received PT (n = 35).

Eligible patients underwent a standardized interview about the medical history of their back condition, including current symptoms. Randomization was carried out after the patients were identified for study inclusion and after outcome measurements. The patients were randomized by a closed envelope system. The closed envelopes were set in two boxes (for men and women separately). Upon leaving, the patients drew an envelope at random. Each envelope contained instructions concerning the examination and treatments and as to which group a patient was randomized. An independent assessor generated the allocation sequence, enrolled the patients, and assigned the patients to their groups. Intervention sessions lasted for 2 months, from June to July 2003. Outcome measurements were repeated 1 month after the last treatment by independent assessors who were unaware of the patients' treatment histories.

Of the 70 patients, 61 were accepted for final EMG analyses (TBS group, n = 33; PT group, n = 28; Fig 1). Case patients with thick adipose tissue layers in the low back area were excluded (n = 6); 3 case patients were not available for the outcome measurements. Those who administered the interventions were not blinded to study data, but the assessor who evaluated the outcomes was blinded to group assignment. The randomization was successful because there was no statistically significant difference between the groups in age and anthropometric characteristics (Table 1). The mean duration of LBP was 7 years (SD = 7) among the patients who were treated by TBS; it was 11 years (SD = 8) among those who were treated by PT. The patients did not get any other treatment apart from painkillers. Some patients had sick leaves during the study period. They were active in their work life despite their low back problems.

Traditional bone setting is based on manual whole body treatment. A bone setter begins the treatment from the toes and feet up to the hands and head and mobilizes tissues and malocclusions.[11] The aims of TBS treatment are usually to abolish malpositions, to relax the muscles, and to remove excessive muscle contraction and body asymmetry. The patients received 5 TBS treatments with 2-week intervals; these were carried out by experienced bone setters. Physical therapy included massage, therapeutic stretching, trunk stabilization exercise, and exercise therapy. The patients treated by PT received an average of 5 treatments; PT was performed by a fitness center specialist. The patients were also measured before the treatments and 1 month after the last treatment. They were informed of the experimental design of the study and the potential risks of the treatments; they then provided written consent before participating in the study. The study and consent form were approved by the ethics committee of the Kuopio University Hospital.

Upon their arrival at the laboratory, the patients completed questionnaires about their perception of their functional disability (Oswestry Disability Questionnaire),[12] depression (Rimon's Brief Depression Scale Questionnaire),[13] and pain intensity during the study period (100-mm visual analog scale [VAS]).[14] Anthropometric data, finger-floor distance, and lateral bending were measured.[15] The patients assessed their own treatment in a scale that ranged from −1 (no effect) to +10 (high effect) after their last treatment session.

Table 1. *Characteristics of the patients with CLBP*

	TBS group (n = 33)		PT group (n = 28)	
Variable	Men (n = 18)	Women (n = 15)	Men (n = 16)	Women (n = 12)
Age (y)	40.8 (5.5)	40.6 (3.99)	41 (5.9)	42 (6)
Weight (kg)	77 (11)	70 (17)	80 (9)	69 (10)
Height (cm)	176 (3)	165 (6)	177 (6)	167 (5)
Body mass index (kg/m^2)	24.8 (5.6)	25.6 (5.7)	25.5 (2.8)	24.7 (3.6)

Data are presented as mean (SD).

Table 2. *Back pain intensity, functional disability, depression scores, and back mobility parameters of the patients with CLBP*

	TBS group (n = 33)		PT group (n = 28)	
Variable	Pretreatment	Posttreatment	Pretreatment	Posttreatment
Pain intensity (100-mm VAS)	40 (4)	23 (5)**	41 (4)	28 (4)**
Oswestry index (0-100)	18 (2)	12 (2)*	21 (2)	17 (2)**
Depression score (0-21)	3.73 (2.7)	2.64 (3.6)*	4.03 (2.9)	2.92 (3.4)*
Finger-floor distance (cm)	5.8 (1.8)	5.4 (2.2)	5.9 (1.9)	6.3 (1.9)
Lateral bending right (cm)	16.1 (0.7)	17.1 (0.6)	16.5 (0.5)	17.1 (0.7)
Lateral bending left (cm)	16.1 (0.6)	17.4 (0.7)	16.3 (0.8)	16.5 (0.8)

Data are presented as mean (SD).
* $P < .01$.
** $P < .001$.

The sEMG activity of muscles was recorded (ME3000P, Mega Electronics Ltd, Kuopio, Finland) from the right and left paraspinal muscles at the L1-2 and L4-5 levels. Bipolar surface electrodes (Ag/AgCl, Medicotest, Olstykke, Denmark) were positioned according to standard procedures.[16] The skin was carefully prepared to reduce impedance by shaving excessive hair and cleaning the skin with an alcohol swab. Electromyographic electric activities were recorded after full-wave rectification of the signals from 20 to 600 Hz and averaging them with a time constant of 0.1 second to obtain the root mean square (RMS) of the values.[17] The patients underwent a dynamic EMG evaluation for which they were asked to stand relaxed and then bend forward as far as possible, stay fully flexed, and return back to standing. In calculating the results, two repetitive cycles during 30 seconds were used. The resting mean values during standing, full flexion, and reextension as well as the maximal EMG values of the eccentric and concentric phases were used in the analyses. An FRR was computed by comparing the maximal activity RMS in 1 second during flexion with that in 1 second during full flexion.[7] The ratio of the maximal EMG activity during extension to the maximal EMG activity during flexion (EFR)[18] was also used in the analyses. The data were normalized by dividing them for a phase by the average EMG activity during standing.[10]

Statistical analysis was conducted with the use of SPSS version 11.5 (SPSS Inc, Chicago, Ill). The comparison of the characteristics of the groups was assessed with independent-samples *t* test. Data for each measurement were analyzed using time (pretreatment and posttreatment or left and right) by group (TBS and PT) repeated-measures analysis of variance. Bonferroni multiple comparisons were carried out as appropriate, and the main effects of group and time were examined. Pearson's correlation coefficient tests were used to examine the relation between pain scores and EMG parameters. Statistical significance was set at the .05 level.

Results

Visual analog scale (F = 15.7; $P < .001$), disability (F = 12.6; $P < .001$; Oswestry index), and depression (F = 8.1; $P < .01$) scores decreased significantly after the treatments, but no significant treatment effect was observed (Table 2). There was no other significant change or left-right side difference after the treatments; neither was there any difference between groups in parameters depicting back mobility.

Electromyographic activity was almost silent at standing (mean RMS <10 μV), and there was no significant change after both treatments. Figure 2 shows normal back muscle relaxation during full flexion and the typical absence of relaxation in patients with LBP. The FRR decreased significantly at the L4-5 level on the right side (F = 6.56; $P = .013$) after the treatments. The FRR at the L1-2 level

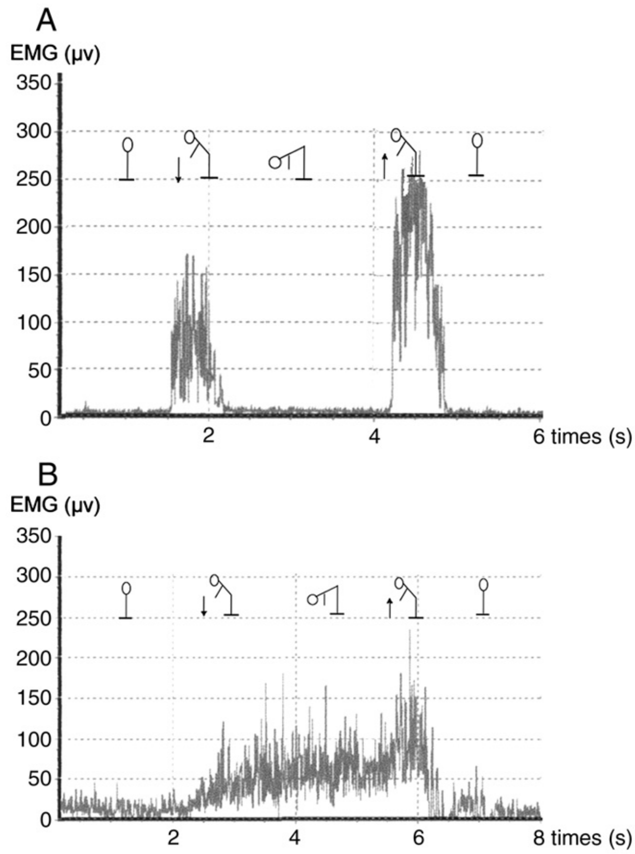

Fig 2. *The RMS EMG activity (time constant, 0.1 second; bandwidth, 20-600 Hz) of the left back muscle at the L4-5 level during standing, flexion, full flexion, and reextension in two patients with nonspecific CLBP. In panel A, normal back muscle relaxation during full flexion is shown. In panel B, typical relaxation during full flexion is absent and the flexion-reextension cycle is slower than normal.*

showed a Right-Left × Group interaction before (F = 8.39; *P* =.005) and after (F = 14.86; *P* = .001; Table 3) the treatments, indicating that left-right FRR differences were greater in the TBS group before and after the treatments as compared with the PT group.

The EFR increased in both groups after the treatments but did not reach statistical significance. Before the treatments, differences between the right and left sides at the L1-2 level approached significance (F = 3.27; *P* = .075), but this difference disappeared after the treatment. The effect of treatments was not significant (Table 3).

Disability scores had a negative but significant correlation with FRR on both sides of the L3-4 level before the treatments ($r = -0.24$; $P < .05$) but did not reach statistical significance after the treatments. Depression scores had a negative but significant correlation with EFR at the right side of the L3-4 level ($r = -0.30$; $P < .05$) before and after the treatments ($r = -0.30$; $P < .05$). Depression scores were significantly correlated with EFR at the left side of the L3-4 level ($r = -0.27$; $P < .05$) after the treatments. Back pain during the study period (VAS) was not significantly correlated with any of the EMG parameters before or after both treatment series.

The patients' own treatment evaluation (−1 to +10) 1 month after their last session was significantly better among those who underwent TBS ($P = .047$). There was a statistically significant difference in the EFR between the self-evaluated results, as high as 8 to 10 (n = 20) and as low as −1 to 2 (n = 10) after the treatment, found among the patients who underwent TBS (2.32 vs 1.69; $P < .05$).

Discussion

In general, EMG activity was high during full flexion, which is typical among patients with LBP; FRP was not observed in most of the patients before reaching maximum flexion.[4,7,8] In addition, the EFR was smaller in our patients than in the healthy control subjects reported on by Sihvonen et al.[18] When the patients were standing at rest, the EMG activity was nearly silent, as has been found in subjects without low back problems.[6,8]

No significant difference between TBS and PT was found in trunk flexibility. Hemmilä et al[11] reported that bone setting improved lateral and forward bending of the spine more than did exercise therapy but that neither bone setting nor exercise differed from physiotherapy. In several studies, exercise-based active back rehabilitation programs have been shown to be effective in reducing LBP intensity and to improve back extension strength and mobility.[19-21] Rissanen et al[22] reported that good dynamic trunk extensor performance is predictive of a decreased incidence of work disability as a result of chronic back disorders.

The FRR was calculated to observe its effect on the FRP. Neblett et al[9] suggested that flexion-relaxation was associated with major improvements in range of motion. In the present study, the FRR decreased after both treatments, such that the EMG activity increased during full flexion after the treatments. One possible explanation for this unexpected finding may be that measurements were carried out 1 month after the series of the treatments, when the positive effect of treatments may have already diminished. On the contrary, the pain intensity, disability, and depression scores decreased significantly, although the patients carried on with their regular work. The limited flexion did not explain decreased FRR because the patients reached at least 40° flexion in this study, at which the FRP is believed to begin.[23] DeVocht et al[24] found that EMG activity increased during spinal manipulation treatment and then usually decreased to a level lower than the pretreatment level. However, this phenomenon seemed to disappear several weeks later without a treatment program. The reliability values of sEMG results several weeks apart are high.[7,8,16] Because the subcutaneous tissues can affect EMG amplitudes,[25] the ratio values of EMG were used in the analyses.

Table 3. *The sEMG activity of back muscles at the L1-2 and L4-5 levels in both sides during flexion (eccentric) and reextension (concentric) cycles before and after treatment in the TBS and PT groups*

	TBS group (n = 33)		PT group (n = 28)	
	Pretreatment	Posttreatment	Pretreatment	Posttreatment
Full flexion (μV)				
L4-5 right	19 (19)	13 (14)	22 (20)	23 (18)
L4-5 left	17 (15)	19 (21)	23 (20)	25 (21)
L1-2 right	14 (17)	18 (17)	22 (18)	23 (21)
L1-2 left	14 (17)	16 (17)	23 (21)	24 (22)
Reextension (μV)				
L4-5 right	48 (16)	49 (21)	59 (21)	56 (19)
L4-5 left	53 (23)	51 (23)	64 (24)	57 (19)
L1-2 right	50 (19)	49 (22)	57 (23)	55 (20)
L1-2 left	54 (22)	50 (21)	58 (20)	55 (17)
FRR				
L4-5 right	9.91 (11)	6.42 (10)	8.17(13.2)	7.07 (12)*
L4-5 left	8.27 (10)	6.48 (11)	7.55 (11.4)	6.22 (9)
L1-2 right	7.12 (9)**	5.01 (7.5)***	7.06 (10.8)	7.07 (12)
L1-2 left	10.33 (14)	7.93 (11)	4.81 (6.6)	4.61 (7.6)
EFR				
L4-5 right	1.74 (0.15)	1.8 (0.17)	1.45 (0.11)	1.54 (0.11)
L4-5 left	1.88 (0.16)	2.04 (0.2)	1.56 (0.09)	1.81 (0.12)
L1-2 right	1.78 (0.14)	1.84 (0.2)	1.95 (0.15)	2.13 (0.3)
L1-2 left	1.94 (0.15)	2.01 (0.2)	1.61 (0.13)	1.95 (0.18)

Data are presented as mean (SD).
* Pre-post effect, $P < .05$.
** Left-Right × Group interaction, $P < .01$.
*** Left-Right × Group interaction, $P < .001$.

The sEMG electrode positioning was performed with the same experimenter. These findings provide support for the biomechanical model of chronic pain. It has been suggested that increased EMG activity in full flexion may be a compensatory response to improve spinal stability and to decrease pain during movement.[26,27] Although the mechanism associating muscle function in patients with LBP is not clearly understood, the passive tissues of the spine are stressed with increasing functional muscle insufficiency.[28]

The EFR tended to increase after both treatments, indicating that the treatment series improved back muscle function. Increased EFR may also be a result of the fact that the patients could move faster because their pain intensity decreased after the treatments, and faster speed of movement may be accompanied by increased EMG activity. Otherwise, Peach et al[29] showed that EMG patterns (regardless of amplitude values) do not differ with load and movement velocity.

The EMG findings tended to show left-right differences in the EFR before the treatments, and these differences disappeared after the treatments. This finding indicates an improvement in muscular symmetry after the treatments, perhaps as a result of the lessening of scoliosis. Lessening of the asymmetry of EMG activity might be attributed to the decrease in pain intensity after the treatments, as shown by the decrease in the VAS scores in this study. Marras et al[30] reported that asymmetry of low back muscles is an important risk factor for the development of an LBP problem.

Disability and depression scores were associated with the EFR and FRR, but the relationship was weak ($P = .05$). The subjective pain scores decreased after the treatments, but no relationship between pain and EMG parameters was found. This finding is inconsistent with that by Sihvonen et al.[6] In their study, the lack of flexion-relaxation correlated highly with current LBP. In the present study, the lack of correlation may be a result of the fact that pain scores were relatively low during the study period before and after treatment in both groups. One possible explanation may be that the patients in the present study were active in their work life despite their low back problems. In contrast, in the study by Sihvonen et al,[6] the study sample consisted of patients who were incapable of work because of their LBP. The studies by Ahern et al,[7] Arena et al,[31] and Watson et al[32] also failed to find a relationship between pain state and EMG activity among patients with LBP.

In the present study, the patients with low back problems were a heterogeneous group, and an assessment of the impact of the treatments used is difficult because of the lack of plausible pathophysiologic or pathoanatomical explanations to account for nonspecific symptoms found in CLBP. Our patients seem to be a general sample of people with low back problems, having long-term nonspecific LBP, working despite their pain, and seeking health care for their complaint. However, in the future, it would be beneficial to examine patients with the same type of back problems. In addition, ergonomic measurements in the workplace should be included in the study design.

The fact that the patients felt the improvement of their physical performance should be recognized. In particular, the extent of pain reduced in both groups after the treatment sessions, although EMG parameters and pain were not significantly associated, is of note. Crombez et al[33] and Mannion et al[34] reported that pain and pain-related fear of physical activity cause avoidance of activity and lead to higher disability. In addition, Watson et al[32] reported on changes in the FRR that were independent of the range of motion and pain in patients with CLBP. Furthermore, Estlander et al[35] suggested that patients' belief in their physical capacity is a powerful predictor of isokinetic back muscle performance.

Conclusions

In conclusion, TBS and PT reduce the subjective feeling of pain as indicated by the VAS and alleviate functional disability as shown by the Oswestry Disability Questionnaire. Pain relief and improvement of disability tend to be greater in patients treated by TBS as compared with those treated by PT. However, no positive and statistically significant association between back pain and EMG parameters was found in this study. Regular back exercise seems to positively influence back muscle function, and bone setting may also improve treatment effects with the use of individually tailored exercise therapies at home after treatment sessions are over.

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