Influence of high-velocity low amplitude manipulation of the lumbar spine on the activity of motor units of the erector spinal muscles with functional assessment in healthy young people

Maciej Oleksiewicz[1], **Piotr Czech**[2]

[1] The University of Applied Sciences in Tarnow, Poland

[2] The University of Applied Sciences in Nowy Sacz, Poland

Correspondence to: Maciej Oleksiewicz, email: maciekol417@gmail.com

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Abstract

Background: High-velocity low amplitude (HVLA) manipulation is used worldwide by healthcare professionals. The literature reports that HVLA manipulation improves joint range of motion, reduces joint surface compression, restores muscle-tissue balance, and reduces inflammation. Many possible reports on HVLA have been given in the last three decades.

Aims: This study aimed to assess the impact of HVLA manipulation of the L2-L4 level on the surface electromyography (sEMG) activity and functional efficiency assessed by the Duncan-Ely (D-E) test.

Material and methods: A group of 60 participants was randomized into 30 for the study and the control group. The study group was randomized into two groups of 15 people. The average age of the study group was 23.77, and 23.07 years of the control group. BMI among groups p=0.27. The project was a pre-test-post-test examining the main effects of HVLA between measures and groups. The methodology used sEMG measurement of the erector spinal muscles using the Biering-Sorenson (B-S) test and normalization by maximum voluntary isometric contraction (MVIC). In addition, D-E test was used to assess functional efficiency. Measurements and sEMG processing were supported by MR® 3.16 Noraxon, ISEK, and SENIAM. The analyzes were done in Statistica v.13.1.

Results: After proving the normality of the distributions for the B-S measurements pS-W>0.05 and the homogeneity of the variances from Levene's test p>0.05, repeated measures ANOVA was used. ANOVA of sEMG measurements in two-group and three-group division was p>0.05. Deltas of pre-test-post-test differences of the D-E test performed by M-WU test show the significance of both deltas p<0.05.

Conclusions: HVLA of the L2 to L4 level does not change the amplitude of the myoelectric activity of the erector spinal muscles in the B-S test, but it does improve the knee flexion range of motion in the population of young and asymptomatic people.

Key words

spinal manipulations, high-velocity low amplitude manipulation, adjustment, sEMG, thrust, lumbar roll, short-lever manipulation.

Introduction

The high-velocity low amplitude (HVLA) manipulation is used worldwide by healthcare professionals. The literature reports that HVLA manipulation improves joint range of motion, reduces joint surface compression, stimulates circulation of body fluids, restores muscle-tissue balance, and reduces inflammation [1-4].

HVLA induces a change in the integrity of nerve impulse transmission. The mechanism of these changes involves activation of the mechanoreceptors of the tissues surrounding the spinal region, and then the spinal and supraspinal centers respond by suppressing the excitability of alpha and gamma motoneurons, causing inhibition of muscle activity [5,6].

Many reports on HVLA have been given in the last three decades. Surface electromyography (sEMG) studies on the neurophysiological effects of HVLA have shown increases, no changes, as well as decreases in myoelectric amplitude values after its application [7-10]. Nevertheless, this evidence still remains limited and requires further investigation.

Aims

This study aimed to evaluate the effect of HVLA manipulation of the L2-L4 spine on sEMG recordings and functional performance as assessed by the Duncan-Ely test.

Material and methods

The experiment was a randomized, controlled, simple trial with a pretest and posttest to highlight the main effects of the set intervention. The study was conducted at the University of Applied Sciences in Tarnow in 2022. The study involved 60 asymptomatic subjects, who were randomized in numbers of 30 each to a control group (17 women and 13 men) and a study group (25 women and 5 men). The mean age of the study group was 23.77 years, while that of the control group was 23.07 years. The BMI between the groups was p=0.27. In addition, the study group was randomized, taking into account the side of the body given the manipulation first, which resulted in two subgroups of 15 subjects each. All volunteers gave written consent to participate in the study, and there were no contraindications excluding them from the experiment.

The study used HVLA manipulation of the lumbar, the so-called "lumbar roll," targeting the joints of the L2 to L4 level. The manipulation was performed to both sides only in the study group by a manual therapist. The methodology for performing measurements using superficial electromyography (sEMG) myoResearch® 3.16 (MR® 3.16) following ISEK and SENIAM guidelines [11]. Volunteers performed a brief trunk warm-up prior to the test. The skin was shaved and cleaned with abrasive paste and alcohol. The L3 level was palpated where electrodes with sensors were taped in pairs on both sides laterally and longitudinally from L3; the electrode pair spacing was 2 cm. Methodology for measuring maximum voluntary isometric contraction (MVIC), the test implementer performed manual resistance on the subject's upper back and instructed the subject to perform an upward trunk lift with maximum power to achieve MVIC [11]. The measurement lasted 6s, and the interval before the Biering-Sorenson Test (B-S) was 2 min.

To verify the purpose of the study, we used measurements of the amplitude of sEMG myoelectric activity while performing a modified B-S test [12]. The test was used to obtain the static working phase of the erector spinal muscles during maximal trunk elevation from the forward lying position. A belt at the height of 1/3 of the lower leg was used for stabilization. The static position was maintained by the subject for 6s. The test was performed three times (B-S1-B-S3) by the volunteer as a separate measurement with a 2 min break between each measurement in the control group, while HVLA manipulation was performed in the test group during this time. For sEMG measurements, the "Ultium EMG System Sensor Noraxon" Model: DTS-8-K MR3 Master Edition was used. No.: 88018095, along with MR® 3.16 software. The device's configuration was characterized by a sampling frequency of 2000Hz, a high-pass filter of 10Hz, and a low-pass filter of 500Hz. The Noraxon system protocol was characterized by setting two sEMG channels to 500 μV for the right (R) and left (L) erector spinal muscles.

Hypoallergenic Ag/AgCl-Kendall Covidien H124SG electrodes were used for the study. In MR® 3.16 digital software, the baseline of the sEMG reading was calibrated each time with the skin impedance between the electrodes. The impedance threshold was 15 kOhm. The MVIC measurement was the reference point for normalizing the B-S measurements for each subject individually. The Peake value algorithm was responsible for finding the highest single μV peak from the entire MVIC measurement, where the algorithm took into account the period of 250ms before and 250ms after the single highest peak by averaging the value from this period. The sEMG signal processing of the B-S measurements was performed by normalizing the amplitude of the measurements against the MVIC measurement. The Smoothing Root Mean Square (RMS) 100 ms algorithm was then applied. The complete recording of the B-S measurement lasted 10s. The raising and lowering phase of the torso was cut off. The 4s period of the static torso maintenance phase was selected for analysis. A report was obtained in the form of the mean amplitude of myoelectric activity during the 4s period expressed in unit %.

The study used a modification of the Duncan-Ely (D-E) test [13]. The test was conducted in the prone position. The examiner grasped the shin and conducted a slow passive knee flexion movement until maximum end resistance of joint mobility was achieved without compensatory pelvic elevation. The measurement was the distance in cm from the heel to the buttock conducted at right angles with the foot placed in dorsiflexion. The test was used to assess muscle tone and the rectus femoris muscle and informed the change in the flexion range of the knee joint - an assessment of functional performance.

The Shapiro-Wilk (S-W) test was used to verify the normality of the distributions. Levene's test was used to verify the homogeneity of variance. The non-parametric Mann-Whitney U (M-WU) test was used to verify the significance of differences between the results in the analyzed groups due to p S-W <0.05. An analysis of variance with repeated measures (ANOVA) was also used to analyze sEMG signals in consecutive measurements in the analyzed groups. A significance level of 0.05 was assumed for all analyses. All analyses were performed using the Statistica v.13.1 package.

Results

After proving the normality of distributions for all B-S measurements, p S-W >0.05 and homogeneity of variance via Levene's p>0.05 test, ANOVA analysis for repeated measures was used (**Table 1**).

Analysis of the results did not warrant rejection of the null hypothesis of no difference p>0.05. These results are confirmed in below **Figure 1**.

Similarly, the same analysis was carried out for the variable grouping of the three-group division due to the manipulation side and its absence. The analysis of the results did not give grounds to reject the null hypothesis of no difference p>0.05. These results are confirmed by the following **Figure 2**.

Subsequent analyses aimed to verify the significance of differences between the effects of the conducted experiment in the analyzed groups. For this purpose, the deltas of differences between post-test and pretest results were calculated (**Table 2**).

Table 1. Comparison of sEMG results for the B-S test.

Variable	Comparative groups										P Levene test
	Study					Control					
	M	Me	SD	V	p S-W	M	Me	SD	V	p S-W	
B-S1 L (%)	55.57	52.30	13.21	23.77	0.74	59.92	56.85	13.39	22.34	0.94	0.81
B-S1 R (%)	55.13	55.15	13.65	24.75	0.65	58.60	57.75	12.01	20.50	0.71	0.54
B-S2 L (%)	55.77	56.45	13.52	24.23	0.70	58.04	56.60	13.38	23.06	0.32	0.96
B-S2 R (%)	54.99	54.50	13.13	23.89	0.73	56.85	55.40	11.21	19.72	0.34	0.26
B-S3 L (%)	55.76	54.25	14.27	25.59	0.63	59.42	57.15	12.80	21.54	0.61	0.97
B-S3 R (%)	55.78	52.40	14.45	25.91	0.66	58.56	57.60	11.87	20.27	0.49	0.17

Abbreviations: *L, left; P, right; B-S, Biering-Soersen test; M, mean; Me, median; SD, standard deviation; V, coefficient of variation; p S-W, Shapiro-Wilk test; p Levene, homogeneity of variance test.*

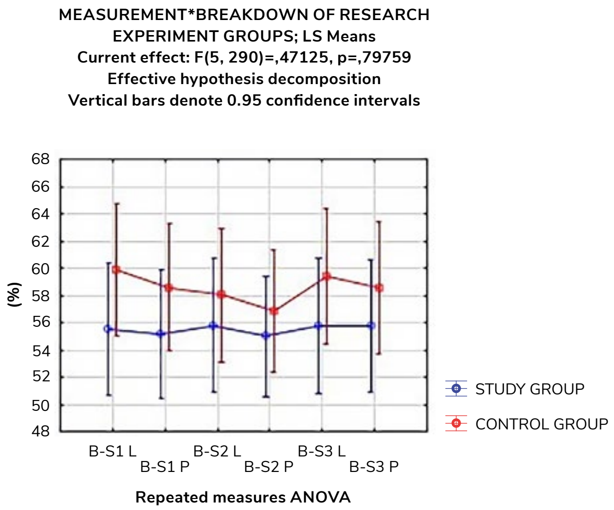

Figure 1. Comparison of B-S1-B-S3 due to two groups.

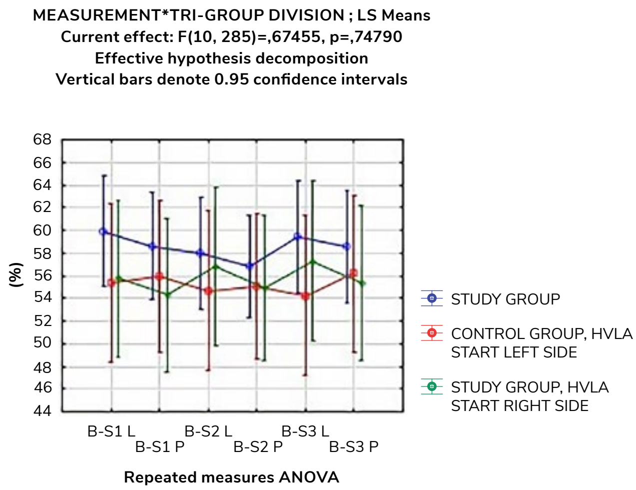

Figure 2. Comparison of B-S1-B-S3 due to the three groups.

Table 2. Delta comparison of results for the D-E test.

Variable	Comparative groups										P UM-Wtest
	Study					Control					
	M	Me	SD	V	p S-W	M	Me	SD	V	p S-W	
Delta D-E L posttest-pretest (cm)	-1.17	-0.75	1.29	-110.47	<0.0001	0.23	0.00	0.86	367.87	<0.0001	<0.0001
Delta D-E R posttest-pretest (cm)	-1.88	-2.00	1.38	-73.02	<0.008	0.08	0.00	0.63	757.04	<0.0001	<0.0001

Abbreviations: *L, left; P, right; D-E, Duncan-Ely test; M, mean; Me, median; SD, standard deviation; V, coefficient of variation; p S-W, Shapiro-Wilk test; p M-WU, Mann-Whitney U test.*

The analysis of the results in **Table 2** revealed statistically significant differences between the analyzed groups ($p<0.05$) for all calculated deltas. Thus, it can be concluded that the effects that occurred in the study group are statistically significantly different from the control group, which is confirmed by the following **Figures 3** and **4** and **Table 2**.

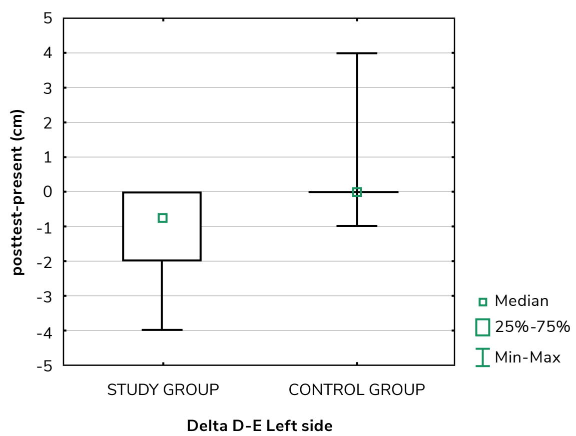

Figure 3. Comparison of delta effects for the D-E L and D-E P test in the analyzed groups.

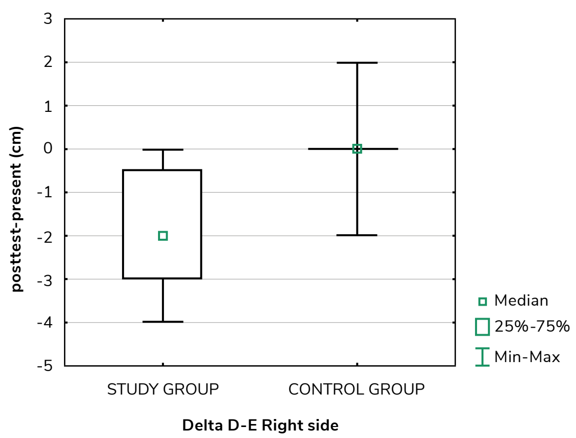

Figure 4. Comparison of delta effects for the D-E L and D-E P test in the analyzed groups.

Discussion

The methodology evaluated a slice of the normalized and averaged 4-second static sEMG measurement phase of the B-S test. Studies report that joint manipulation has been associated with changes in myoelectric sEMG activity [7-10,14,15] both in muscles directly connected to the manipulated spinal joint segments and in remote muscles with only a neuroanatomical connection to the manipulated joint segment [6,16].

However, the ANOVA analyses performed do not present statistical significance between measurements and groups $p>0.05$. The results suggest that HVLA manipulation does not change the amplitude of myoelectric activity of the superficial spinal muscles in the B-S test. For the erector spinal muscles of the superficial layer, it would be appropriate in the evaluation of the test to sample the spinal muscles lying in the deep layer, for example, the multifidus muscles using thin-needle EMG measurement. Using a different sEMG muscle assessment report/parameter than in this study would have been more accurate.

SEMG measurements are sensitive to temperature changes [11,17], so a short warm-up was performed before the measurements to negate the risk of catching differences in muscle warmth between sEMG measurements. Evaluation of the study should consider whether a longer and more intense warm-up would have influenced better sEMG recordings. Studies have noted that the thickness of adipose tissue may hinder sEMG signal collection [11,18]. The groups did not differ significantly in BMI ($p=0.27$), and there was a skin impedance set to 15 kOhm, so its effect on the sEMG results obtained can be excluded. In future studies, it would be necessary to draw the average of several MVIC measurements to obtain greater reliability of MVIC measurement.

It has been reported that HVLA of the lumbosacral (L-S) region leads to improved activity and muscle strength of the quadriceps muscle of the thigh [19,20]. However, little is known about the effect of L-S manipulation on the muscle tone of the quadriceps muscle of the thigh and the range of flexion of the knee joint. Since there is an improvement in muscle strength and activity, it means that the manipulation has a neurophysiological effect on the distal muscles [16,19,20].

Significant differences were noted between the groups $p<0.05$ in the D-E test. This suggests that the HVLA intervention led to improved knee joint mobility due to a probable change in coactivation of the alpha-gamma loop resulting in inhibition of the tonus of the rectus thigh muscle (L2-L4 innervation) [5].

In the evaluation, to exclude subjects with dysfunction, it would be necessary to include an exclusion criterion for volunteers with significantly increased tension of the rectus femoris muscle and set a reference point for the degree of knee joint flexion range.

Conclusions

HVLA manipulation of the L2 to L4 level does not change the amplitude of myoelectric activity of the erector spinal muscles in the B-S test, while it improves the range of motion of the knee flexion Duncan-Ely test in a young and asymptomatic population.

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