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Article

Biomechanical effects of non-specific low back pain kneading manipulation in TCM based on surface electromyography technology

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Abstract: Background: Non-specific back pain (NLBP) is one of the common musculoskeletal disorders, which can seriously affect the patient's life. As one of the methods for treating low back pain, the kneading manipulation in TCM has shown unique advantages in relieving muscle tension and pain. **Method:** 70 NLBP patients were selected as the research subjects. The surface electromyography technology was used to test hardness value, pain value, surface electromyography during complete flexion, surface electromyography during dorsiflexion, and flexion extension ratio. **Result:** The hardness value before treatment was 47.84% ± 4.33%, which decreased to 44.56% ± 4.08% after treatment, with a *P*-value of 0.0017, indicating a significant effect of treatment on reducing hardness values. The average pain threshold before treatment was 25.45 ± 5.23 N. After treatment, the pain threshold increased to 26.78 ± 4.08 N, with a *P*-value of 0.2397, demonstrating that the treatment effect on pain values was not significant. **Conclusion:** The study reveals the therapeutic effect and mechanism of action of the kneading manipulation in TCM on NLBP patients. It is expected to provide scientific basis for the application of the kneading manipulation in TCM technique in the treatment of NLBP, and provide reference for optimizing treatment plans and improving efficacy.

Keywords: surface electromyography technology; NLBP; kneading manipulation in TCM; biomechanical effects; pain threshold

1. Introduction

From 1990 to 2015, the proportion of patients with back pain worldwide increased by 54%, with approximately 540 million people worldwide suffering from back pain. Back pain has become a globally challenging health issue [1]. Low back pain has specific or non-specific, with non-specific low back pain (NLBP) accounting for approximately 80% to 90% of all low back pain cases [2]. Low back pain (NLBP) is a global health challenge, and its incidence has increased significantly over the past decades, severely affecting patients' quality of life. Traditional Chinese Medicine (TCM) manipulation, as a common method of treating NLBP, has received much attention due to its unique efficacy. However, the specific biomechanical effects of TCM manipulation have not been fully clarified, which limits the scientific and effectiveness of its clinical applications. Therefore, understanding the biomechanical effect of TCM manipulation is of great significance to optimize the treatment and improve the clinical efficacy. The kneading manipulation in Traditional Chinese medicine (TCM) refers to the skillful manipulation of the patient's meridians, acupoints, or specific areas using hands or other parts to bone injuries and other diseases. It is a commonly used external treatment method in TCM orthopedics [3,4]. The kneading manipulation in TCM can effectively relieve pain and improve lumbar function through various mechanisms. Therefore, it is widely used in the treatment of NLBP. Analyzing the biomechanical effects of the kneading manipulation in TCM can provide objective scientific evidence, explain traditional treatment mechanisms, optimize treatment techniques, and improve clinical efficacy. Surface electromyography signals are the combined effect of superficial muscle electromyography signals and nerve stem electrical activity on the skin surface. When muscles contract, electrical activity is generated. It is conducted through adjacent tissues and bones, and recorded by electrode pads on adjacent skin areas. These signals can to some extent reflect the activity status of neuromuscular systems [5]. Surface electromyography is a safe, easy to master, non-invasive method, which can objectively quantify muscle energy and is a frequently used method for collecting electromyography signals [6]. To improve the therapeutic effect of kneading manipulation in TCM, surface electromyography technology is used to detect the biomechanical effects of NLBP kneading manipulation in TCM. The aim is to reveal the scientific mechanism of kneading manipulation in TCM through objective quantification methods, and provide scientific basis for optimizing kneading manipulation treatment plans and improving clinical treatment effectiveness. The innovation of the research lies in the combination of modern biomechanical techniques and traditional Chinese medicine techniques. The surface electromyography is used to measure the surface electromyography signals of target muscles. The soft tissue hardness and pain threshold are combined to comprehensively evaluate the biomechanical effects of kneading manipulation techniques from multiple dimensions.

2. Related works

In order to evaluate the efficacy of low back pain treatment techniques, more researchers are paying widespread attention to the biomechanical effects of different techniques in treating low back pain [7,8]. Wu et al. aimed to explore the kinematic and dynamic characteristics of thumb kneading. By analyzing the parameters scored by experts and students, the biomechanical characteristics of thumb kneading operations were explored. The results showed that the operation cycles of kneading the thumb by expert and student groups were mainly concentrated at (0.476 ± 0.117) and (0.990 ± 0.259) seconds [9]. Bíró et al. evaluated the biomechanical effects of traction in adolescent idiopathic scoliosis. Based on Computed Tomography images, two different boundaries and loads were applied to simulate two traction methods. The multi-point traction could better lower the stress on the vertebral body, concentrated the tension on the concave side, and achieved greater deformation [10]. Duarte et al. aimed to determine the effectiveness of thoracic spinal massage therapy on blood inflammatory biomarkers in healthy adults with varying levels of force. A force plate embedded in the treatment table was used to determine the magnitude of the applied spinal massage therapy power. The method contributed to explore the potential relationship between the spinal massage therapy power and blood cytokines [11].

Lin et al. compared the direct effects of chest activity and soft tissue relaxation on trunk movement, and pain sensation in patients with low back pain. Before and after two interventions, the trunk movement, tissue hardness, pressure pain threshold, and erector spinae muscle activity during the lightweight weightlifting task were immediately measured. The above indicators were improved [12]. Tamartash et al. [13] evaluated the effect of myofascial release on low back pain. The biomechanical properties of soft tissue were evaluated by ultrasound. Compared with conventional electrotherapy treatment, myofascial release technique could reduce the elastic modulus of lumbar fascia and further alleviate the patient's low back pain [13]. Quirk et al. measured the kinematics of the patient's trunk and thighs to determine the perceptual effects of back augmentation techniques on soft active back exoskeletons. The back exoskeleton reduced peak back extensor torque by 9% and muscle amplitude by 16% during weightlifting. Compared to weightlifting without outerwear, there was also a slight reduction in maximum trunk flexion [14].

Although some progress has been made in the above research, there are still some common limitations, such as the small sample size selected, neglecting the non-linear characteristics of soft tissues such as muscles and ligaments, as well as the complex mechanical behavior of intervertebral discs, which will affect the universality and representativeness of the results. Therefore, a non-specific biomechanical effect detection method for low back pain muscle manipulation based on surface electromyography technology is proposed. The research aims to provide new treatment methods and evaluation tools for the field of rehabilitation medicine, and promote innovation and development of NLBP rehabilitation treatment technology.

3. Experimental materials and methods

3.1. Experimental materials and equipment

3.1.1. Experimental materials

The surface electromyography technology is used to monitor muscle electromyography signals before and after NLBP treatment with the kneading manipulation in TCM. The instruments, materials, and sources are presented in **Table 1**.

Table 1. Experimental instruments, materials and sources.

Instrument name	Supplier	Instrument name	Supplier
Soft tissue hardness tenderness tester	Ito Ultra Short Wave Co., Ltd., Japan	Check the bed	Nantong Liwei Medical Equipment Technology Co., Ltd
Surface electromyography	Anhui Aili Intelligent Technology Co., Ltd	Marking pen	Guangzhou Mingjia Medical Equipment Manufacturing Co., Ltd
ECG electrode	Shanghai Shenfeng Company	Analog-to-digital converter	Suzhou Mingzhang Semiconductor Technology Co., Ltd
Alcohol cotton ball	Shanghai Chigong Information Technology Co., Ltd	Surface electromyography analysis software	Anhui Aili Intelligent Technology Co., Ltd
Fine sandpaper	Anjichang Grinding Technology Co., Ltd	Hardness tester probe	Ito Ultra Short Wave Co., Ltd., Japan
Portable Bluetooth printer	Shenzhen Datong Youlian Technology Co., Ltd	Tenderness gauge probe	Ito Ultra Short Wave Co., Ltd., Japan

3.1.2. General information

Experimental data were obtained from the Department of Rehabilitation, Dongzhimen Hospital, Beijing University of Traditional Chinese Medicine. The patients were hospitalized between June 2022 and May 2024. The study was primarily divided into two groups of 70 samples each, which were able to provide a modest sample size sufficient to reveal the potential effects of the treatment, as well as to avoid experimental complexity and cost increases due to excessive sample sizes. At the same time, 70 samples were able to ensure data diversity and representation, making the results more general and reliable, and as shown in **Table 2**, there were no statistically significant differences between the two groups in terms of gender, age, pain threshold, course of disease, soft tissue hardness values, etc. ($P > 0.05$), which were comparable. This study used a single blind design. Patients in the experimental group received traditional Chinese medicine manipulation treatment, while patients in the control group did not receive the treatment, but both groups received the same test and evaluation process. The control group served as a key baseline in this study. They were not treated with traditional Chinese medical manipulation, but underwent the same test and evaluation process as the study group, including measurements of soft tissue stiffness, pain threshold, surface EMG signals, etc. Data from the control group were used to compare with those from the study group after treatment to assess the specific efficacy and biomechanical effects of traditional Chinese medical manipulation on patients with nonspecial low back pain. The study has been approved by the ethics committee and ensures that all patients participating in the study are fully aware of the purpose and processes of the study and sign an informed consent form. The ethical approval and patient consent processes are in compliance with relevant regulatory requirements.

Table 2. General information comparison of research subjects.

Content	**Control group (*n* = 70)**	**Experimental group (*n* = 70)**	***P***
Male/(*n*/%)	40 (57.00)	40 (57.00)	> 0.05
Female/(*n*/%)	30 (43.00)	30 (43.00)	
Age/Year	38.5 ± 5.2	39.1 ± 4.8	0.66
BMI/(kg/m^2)	24.5 ± 2.3	23.8 ± 2.1	0.60
Disease duration/(months–years)	3–1	3–1	> 0.05
Pain threshold/*N*	25.45 ± 5.23	26.12 ± 5.54	0.46
Soft tissue hardness value/%	47.84 ± 4.33	46.95 ± 4.12	0.35

3.2. Experimental methods

3.2.1. Soft tissue hardness and pain threshold testing method

Preparation phase: The operator gently touches the paraspinal muscles in the waist and back with both hands to confirm that the muscles are relaxed [15,16]. In the center of the waist, mark the most prominent position of the erector spine muscles with a marker pen (model: MJ-MP-01) as the test point. Survey settings: Mount a 10 mm diameter durometer probe (Model: IT-PROBE-10) and a 75 mm contact plate, ensuring that the durometer probe and contact plate are in the same horizontal line.

The probe should be accurately placed on the marked point and maintained perpendicular to the direction of the muscle. Measuring process:

The operator holds the durometer in his hand and presses vertically at a constant speed. When the pressure reaches the set scale, the instrument will sound an alarm, and the number on the screen is the hardness value. This process is repeated three times, and the device will automatically calculate and display the average of the three measurements. Export recorded data using a portable Bluetooth printer (Model: DT-BP-01). Pain threshold measurements: Using a pressure probe, mark the points in the same way. The experiment subjects held a button in their hand. During the test, if they felt unbearable pain, they pressed a button, and the value displayed on the device screen was the pain threshold. The test process was also run three times in succession, with the device automatically calculating the average and output the recorded data via a portable Bluetooth printer. Data recording: The hardness values and pain thresholds for each measurement were printed using a portable Bluetooth printer (Model: DT-BP-01). Data processing: Record the average of the three measurements in the experiment data sheet for subsequent analysis.

3.2.2. Measurement of muscle surface electromyography signals

The experiment uses a surface electromyography instrument to measure the surface electromyography signals of the target muscle. The principle is to place electrodes on the surface to record the weak potential difference generated by muscle contraction on the skin surface, and then amplify and convert it into surface electromyography signals that can be used for processing through electromyography acquisition circuits [17,18]. The principle of collecting surface electromyography signals in the target muscle area is shown in **Figure 1**.

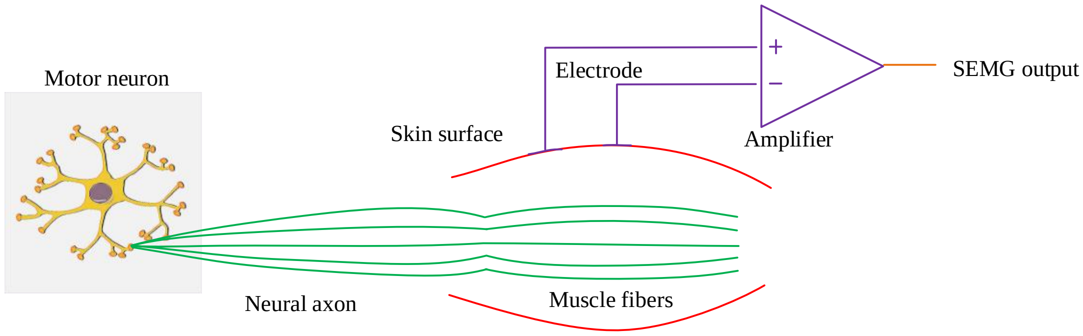
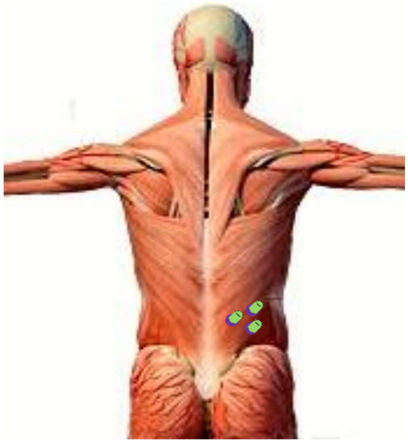


Figure 1. Principle of surface electromyography signal acquisition in target muscle area.

The steps for measuring the surface electromyography signal of the target muscle are as follows. Firstly, the subject is required to expose their waist. Determine the position of the fourth lumbar vertebra through the line connecting the posterior superior iliac spine, and mark the spinous process of the fourth lumbar vertebra using methyl violet. Secondly, gently rub the protrusion of the spinous process of the fourth lumbar vertebra with fine sandpaper to peel off the epidermis. Wipe and disinfect with alcohol, then place a replaceable ECG electrode. The electrodes should be placed in the main muscle area, and the two measuring electrodes should be closely arranged in the direction of the muscle fibers, forming an equilateral triangle relationship with the reference electrode. The specific electrode placement position is shown in **Figure 2**.

(a) Placement position of left abdominal electrode



(b) Placement position of right abdominal electrode

Figure 2. Specific electrode placement diagram.

During the test, the subject's position is set based on their waist flexion and extension movements. Firstly, the subjects maintain a standing posture, with their eyes looking straight ahead and their feet shoulder width apart. Secondly, the subjects slowly bend forward until they reach their maximum tolerance, maintain the bending posture for 3 s, and then slowly return to an upright position. The entire movement process needs to be repeated 3 times [19,20]. When performing waist flexion and extension movements, the operator marks three time periods during the subject's waist flexion and extension process based on computer-generated sound prompts, namely flexion, maximum flexion position, and extension period. Before and after the treatment with the kneading manipulation in TCM, measurements are taken according to the above methods. Finally, the raw electromyography signals obtained are converted into digital signals using an analog-to-digital converter, and the signals are processed using surface electromyography analysis software. Through this processing, the average electromyography values of the three specific stages of flexion and extension movements can be obtained. The flexion extension ratio of the paraspinal muscles on both sides can be calculated. The flexion extension ratio F is shown in Equation (1).

$$F = \frac{G}{g} \times 100\% \tag{1}$$

In Equation (1), G represents the average electromyography value at maximum flexion. g represents the average electromyography value when extended.

3.2.3. Kneading manipulations in TCM for non-specific low back pain

The operation steps for treating NLBP using the kneading manipulation in TCM in the experiment are as follows. Firstly, the therapist presses the first thoracic spinous process to the sacral region in sequence from top to bottom with overlapping hands, performing three rounds of pressure with increasing intensity. The pressure should be controlled to the extent that the patient does not feel significant pain when the palm contacts the spinous process, and the operation time should be 1 to 2 min. Due to the thickness of the sacrococcygeal muscles, in addition to pressing, it is necessary to combine kneading techniques and follow the same sequence from top to bottom to complete three rounds of operation. When operating, first focus on one side and then switch to the other side. Repeat three rounds on each side, with a duration of 2 to 3 min. Secondly, the therapist uses the palmar root to push the lumbar spine spinous process, based on the therapist's own perception of spinous process movement. Three rounds in total are performed, gradually increasing the strength from light to heavy, and requiring gentle movements to give the spinous process a slight sense of movement. The operation time is 2 to 3 min. Finally, after ensuring that the spine and small joints are fully relaxed, the three transverse processes of the waist is accurately located and kneading operations are performed. The thumb should be firmly attached to this point. The force should be adjusted from light to heavy, so as to be able to touch the tendons at the three transverse processes of the waist. The operation time is 6 to 8 min.

Surface Electromyography Signal Acquisition: The sEMG signals are collected using the sEMG device (Model: AL-EMG-01) with a sampling frequency of 1000 Hz, input impedance of 10 GΩ, gain of 1000, and common mode rejection ratio of 110 dB. The signals are processed using surface electromyography analysis software (Model: AL-EMG-SW-01) with an analysis window of 1024 points and an overlap degree of 50%. Statistical Analysis: Data are analyzed using SPSS 22.0. Measurement data are expressed as mean ± standard deviation ($x \pm s$). The independent sample t-test is carried out, and the biomechanical effects of physical therapy on NLBP are explored and expressed using Pearson correlation. Statistically, when $P < 0.05$, the results show significant differences.

3.2.4. Statistical method

Statistical analysis is performed using SPSS 22.0. Measurement data is expressed as mean ± standard deviation ($x \pm s$). The independent sample t-test is carried out. The biomechanical effects of physical therapy on NLBP were explored and expressed using Pearson. Statistically, when $P < 0.05$, the results show significant differences.

4. Experimental results

4.1. Optimization analysis of key parameters for surface electromyography and software

The acquisition frequency, input impedance, gain, and common mode rejection ratio of surface electromyography are key parameters that affect signal quality and measurement accuracy. The study adjusted the experimental parameters of surface electromyography to improve its measurement accuracy [21,22]. Parameters were optimized using one-way analysis of variance (ANOVA) with F range 12–35 ($P < 0.001$). The optimized test results of the experimental parameters are shown in **Figure 3**.

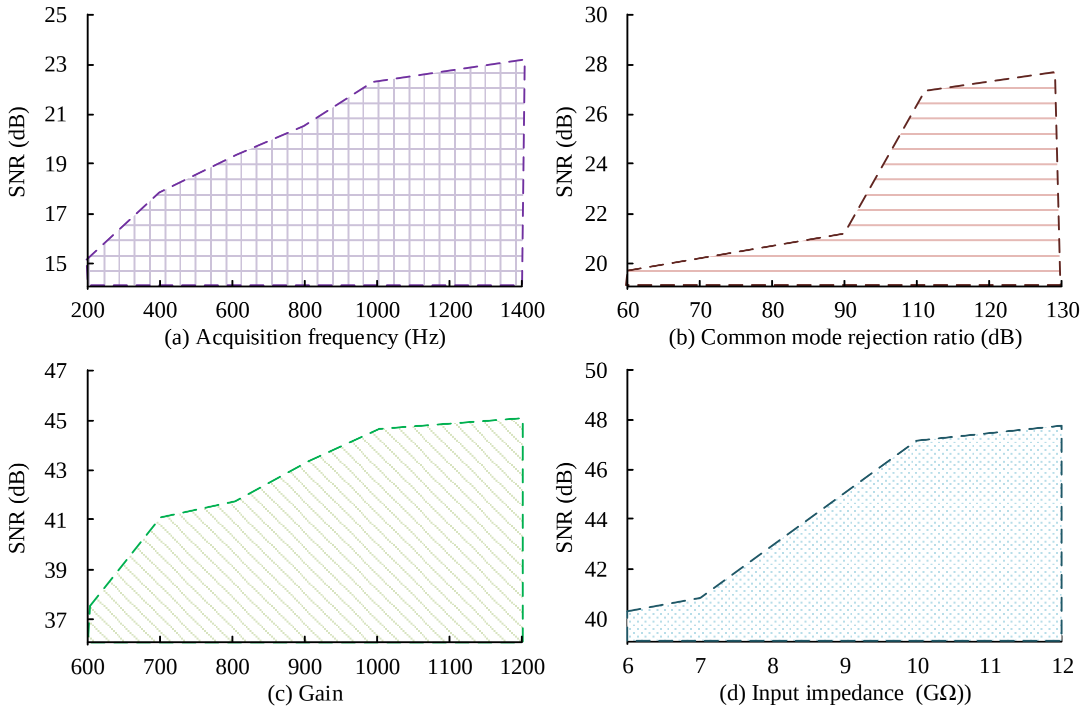


Figure 3. Optimization of key parameters for surface electromyography.

As shown in **Figure 3a**, the acquisition frequency had a significant impact on the Signal-to-Noise Ratio (SNR). When the acquisition frequency was 1000 Hz, the SNR of the signal tended to stabilize. When the acquisition frequency was greater than 1000 Hz, it significantly increased the data volume and processing cost. Therefore, the optimal acquisition frequency for surface electromyography was 1000 Hz. As shown in **Figure 3b**, as the common mode rejection ratio gradually increased, the SNR gradually increased and tended to stabilize at around 110 dB, indicating that 110 was the optimal common mode rejection ratio. In **Figure 3c**, the SNR of the signal significantly improved with increasing gain and tended to stabilize after 1000. The optimal gain was 1000. As shown in **Figure 3d**, the input impedance was positively correlated with the SNR of the signal, and the SNR of the signal tended to stabilize at 10 GΩ, indicating that the optimal input impedance was 10 GΩ. To improve the efficiency of signal processing in surface electromyography analysis software, the optimization test results of experimental parameters are shown in **Figure 4**.

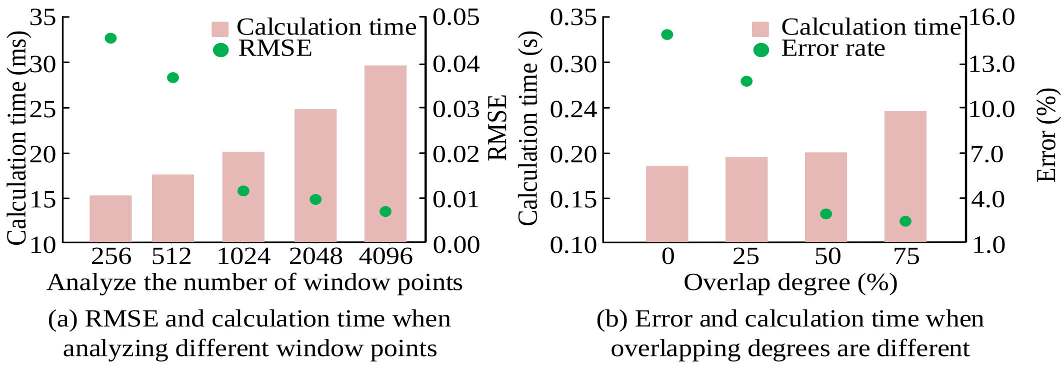


Figure 4. Optimization of software parameters for surface electromyography analysis.

As shown in **Figure 4a**, as the number of analysis window points increased, the Root Mean Square Error (RMSE) of surface electromyography analysis software processing signals decreased, and the calculation time was positively correlated with the quantity of analysis window points. When the number of analysis window points was 1024, the software had low computational complexity, fast operation speed, and small RMSE, indicating that 1024 was the optimal number of analysis window points. As shown in **Figure 4b**, the error of software processing signals significantly decreased with increasing overlap and tended to stabilize after 50%. The time for software to process signals significantly increased after an overlap degree of 50%. Therefore, the optimal overlap degree was 50%.

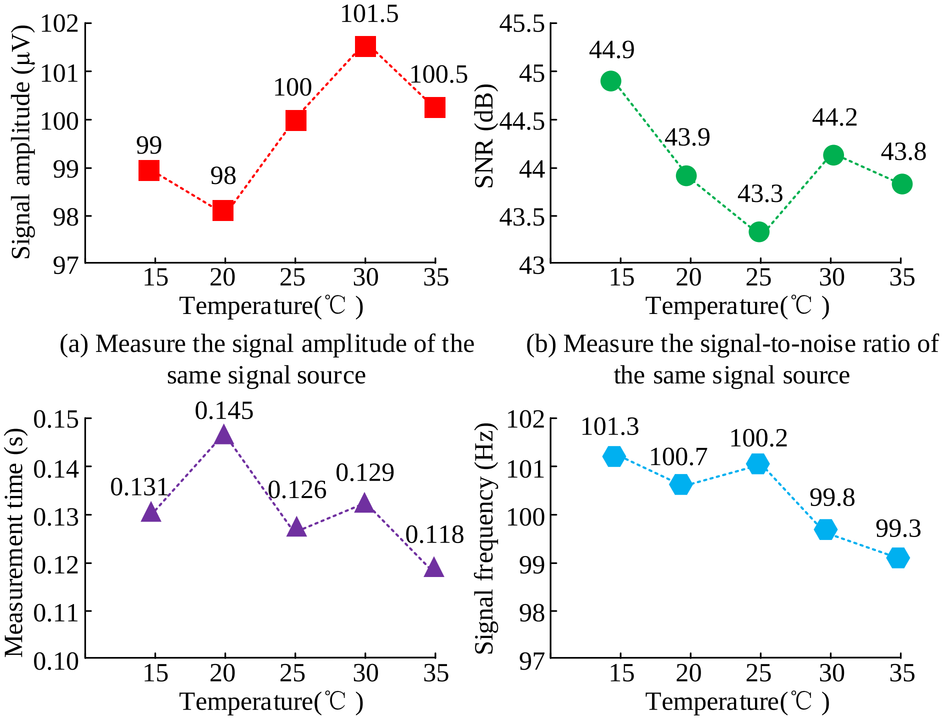
4.2. Stability and efficiency analysis of surface electromyography

To evaluate the performance of surface electromyography, electromyography signal acquisition is performed under different sample sizes. **Table 3** shows the effectiveness of surface electromyography signal acquisition.

Table 3. Efficiency of surface electromyography signal acquisition.

Number of samples	Accuracy (%)	SNR (dB)	RMSE
10	93.4	38.1	0.012
20	92.8	38.6	0.014
30	93.7	37.5	0.0098
40	94.5	39.4	0.015
50	93.5	38.1	0.013
60	92.9	37.9	0.0094
70	94.3	38.5	0.0099
80	95.1	39.2	0.0097
90	94.8	39.6	0.011
100	93.6	38.3	0.0096

According to **Table 3**, when the sample size was between 10 and 100, the accuracy range of the collected signals by the surface electromyography was 92.8% to 94.8%, with a relatively high average accuracy. The RMSE range was 0.0094 to 0.015, and the difference between the maximum RMSE and minimum RMSE was only 0.0056, indicating that the surface electromyography had strong signal acquisition capabilities. The SNR of the collected signal was within 38.1 to 39.6, indicating that there was less noise mixed in the output signal of the device. Overall, the surface electromyography shows high efficiency in collecting surface electromyography signals of the target area. **Figure 5** displays the stability test results of the surface electromyography.



(a) Measure the signal amplitude of the same signal source

(b) Measure the signal-to-noise ratio of the same signal source

(a) Measure the measurement time of the same signal source

(b) Measure the signal frequency of the same signal source

Figure 5. Stability of surface electromyography signal acquisition.

According to **Figure 5a**, the signal amplitude fluctuation range of the surface electromyography was 98–101 μV at 15 °C to 35 °C, with a variation range within ± 2%, and the fluctuation range was relatively small. According to **Figure 5b**, the fluctuation range of SNR of the surface electromyography instrument at 15 °C to 35 °C was 43.3–44.9 dB, with a variation range within ± 1.1%, indicating that the equipment still maintained a high SNR at different temperatures. According to **Figure 5c**, the fluctuation range of the surface electromyography measurement time was 0.118–0.146 s, indicating that the device could still maintain a fast measurement speed at different temperatures. According to **Figure 5d**, the frequency fluctuation range of the surface electromyography signal was 99.3–101.3 Hz, with a variation range within ± 2%. The results verify that the surface electromyography has good stability and small numerical fluctuations under different temperature conditions.

4.3. Analysis of biomechanical effects

For statistical analysis, the independent sample *t*-test was used to compare various biomechanical indexes between the control and experimental groups. The independent sample *t*-test was chosen because it was suitable for the comparison of the means of two independent sample groups and was able to effectively assess the specific efficacy of TCM massage manipulation therapy in patients with NLBP. When surface EMG was used to detect the paraspinal muscles of the control group, various indexes are shown in **Table 4**.

Table 4. Results of paraspinal muscle testing on both sides of the control group.

Index	Number of cases	Left	Right	*T*-value	*P*-value
Hardness value (%)	35	40.12 ± 3.85	40.35 ± 3.72	0.189	0.8509
Pain value (N)	35	34.20 ± 6.45	34.00 ± 6.10	0.113	0.911
Complete flexion AEMG (μV/s)	35	7.45 ± 3.71	7.00 ± 3.50	0.675	0.500
AEMG during dorsiflexion (μV/s)	35	106.30 ± 18.22	105.80 ± 18.50	0.150	0.881
Flexion extension ratio (%)	35	7.50 ± 3.85	7.20 ± 4.20	0.625	0.534

According to **Table 4**, when testing the left paraspinal muscle of the control group, the hardness value was 40.12% ± 3.85%, the pain value was 34.20 ± 6.45 N, the surface electromyography during complete flexion was 7.45 ± 3.71 μV/s, the surface electromyography during dorsiflexion was 106.30 ± 18.22 μV/s, and the flexion extension ratio was 7.50% ± 3.85%. When testing the right paraspinal muscle of the control group, the hardness value was 40.35% ± 3.72%, the pain value was 34.00 ± 6.10 N, the surface electromyography during complete flexion was 7.00 ± 3.50 μV/s, the surface electromyography during dorsiflexion was 105.80 ± 18.50 μV/s, and the flexion extension ratio was 7.20% ± 4.20%. No significant difference existed in hardness and pain values, surface electromyography during complete flexion, surface electromyography during dorsiflexion, and flexion extension ratio between the two sides of the control group, and the differences are not obvious. The surface electromyography results of the paraspinal muscles on both sides of the patient with NLBP are shown in **Figure 6**. Differences between the groups were determined by the Mann-Whitney U test (Z = 2.89, P = 0.004).

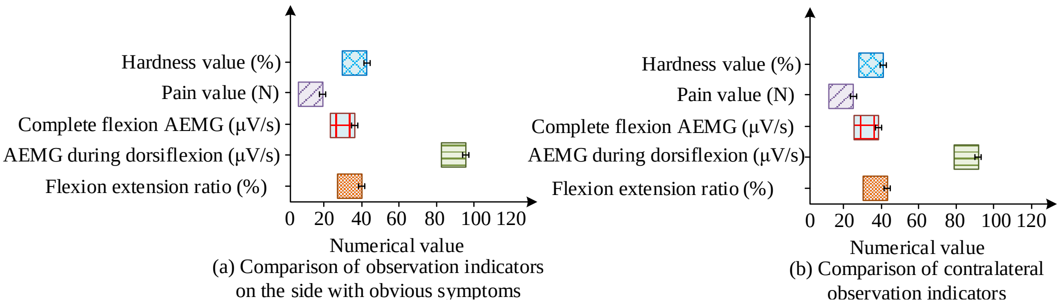


Figure 6. Comparison of observation indicators for the lateral spinal myofascial tissue in non-specificity backache.

According to **Figure 6a**, on the side with obvious back pain symptoms, the hardness value was 46.78% ± 4.12%, the pain value was 25.10 ± 5.02 N, the surface electromyography during fully flexion was 39.82 ± 17.23 μV/s, the surface electromyography during dorsiflexion was 93.45 ± 20.34 μV/s, and the flexion extension ratio was 42.30% ± 19.01%. As shown in **Figure 6b**, the contralateral side with obvious back pain symptoms had a hardness value of 45.50% ± 3.89%, a pain value of 27.80 ± 5.43 N, a surface electromyography of 37.50 ± 16.54 μV/s when complete flexion, a surface electromyography of 95.00 ± 23.21 μV/s when dorsiflexed, and a flexion extension ratio of 41.00% ± 18.87%. The results show that there are differences in hardness and pain values between the side with obvious symptoms before treatment and the contralateral side. The differences in surface electromyography during complete flexion, surface electromyography during dorsiflexion, and flexion extension ratio are not significant. The results of surface electromyography indicators of paraspinal muscles in the NLBP group and the control group are presented in **Figure 7**. NLBP group and control group used analysis of covariance (ANCOVA) to control BMI and duration factors, and the adjusted mean difference of hardness value was 4.12% ($F = 6.72$, $P = 0.011$).

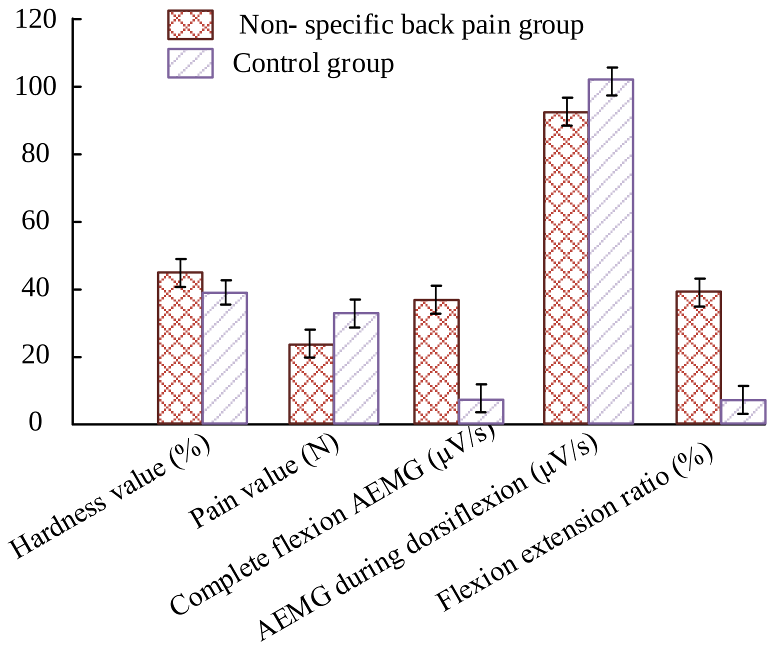


Figure 7. Comparison of observation indicators of bilateral paraspinal muscles between non-specific low back pain group and control group.

According to **Figure 7a**, the hardness value of the NLBP group was 42.89% ± 3.56%, while the hardness value of the control group was 38.47% ± 3.89%, and the difference between the hardness values was not obvious. The pain values of the NLBP group were significantly low than those of the control group, at 26.15 ± 5.32 N and 31.78 ± 6.23 N, respectively, indicating a significant difference in pain perception in the NLBP group. The significant difference existed in surface electromyography signals between the NLBP group and the control group during complete flexion, with values of 41.52 ± 15.58 µV/s and 9.87 ± 4.08 µV/s, respectively. The surface electromyography signals of the control group during back extension were higher than those of the NLBP group, at 100.67 ± 19.42 µV/s and 90.45 ± 22.34 µV/s, respectively. The flexion extension ratio of the NLBP group exceeded that of the control group, at 42.98% ± 17.5% and 9.56% ± 4.78%, respectively, indicating a significant difference in this indicator between the NLBP group and the control group. The significance level was set to 0.05, meaning that the differences between the two groups were considered statistically significant when the *P*-value was less than 0.05. The results of surface EMG measurements of the NLBP group are shown in **Table 5**.

Table 5. Efficiency of surface electromyography signal acquisition.

Index	Number of cases	Before treatment	After treatment	Difference	*P* value
Hardness value (%)	35	47.84 ± 4.33	44.56 ± 4.08	3.28 ± 1.79	0.0017
Pain value (N)	35	25.45 ± 5.23	26.78 ± 4.08	−1.33 ± 1.85	0.2397
Complete flexion AEMG (μV/s)	35	39.76 ± 17.45	31.58 ± 9.87	8.18 ± 15.72	0.0087
AEMG during dorsiflexion (μV/s)	35	96.47 ± 23.21	92.34 ± 18.56	4.13 ± 9.72	0.3865
Bending to extension ratio (%)	35	43.21 ± 19.82	34.56 ± 10.45	8.65 ± 13.97	0.0638

According to **Table 5**, the hardness value before treatment was 47.84% ± 4.33%, which decreased to 44.56% ± 4.08% after treatment, with a *P*-value of 0.0017, indicating an obvious effect of treatment on reducing hardness values. The average pain threshold before treatment was 25.45 ± 5.23 N. After treatment, the pain threshold increased to 26.78 ± 4.08 N, with a *P*-value of 0.2397, demonstrating that the treatment effect on pain values was not significant. Before treatment, the complete flexion electromyography value was 39.76 ± 17.45 μV/s, which decreased to 31.58 ± 9.87 μV/s after treatment, with a *P*-value of 0.0087, demonstrating that treatment had a significant effect on reducing electromyography activity during complete flexion. Before treatment, the surface electromyography value during dorsiflexion was 96.47 ± 23.21 μV/s, which decreased to 92.34 ± 18.56 μV/s after treatment, with a *P*-value of 0.3865, indicating a slight decrease in electromyography activity during extension after treatment. The flexion extension value before treatment was 43.21% ± 19.82%, which decreased to 8.65% ± 13.97% after treatment, with a *P*-value of 0.0638, demonstrating a reduction in muscle fatigue and improvement in muscle function after treatment. For results that do not reach statistical significance, such as pain threshold (P = 0.2397) and flexion to extension ratio (P = 0.0638), these results may be influenced by multiple factors, such as the relatively short duration of the intervention, which may not be sufficient to significantly alter the patient's pain threshold; Or inadequate sensitivity of measuring tools, resulting in subtle changes not being accurately captured.

5. Conclusion

Although there are many treatment methods for NLBP, the efficacy is often unsatisfactory. As one of the treatment methods for NLBP, the kneading manipulation in TCM has shown significant advantages in treating low back pain. However, the mechanism of action of the kneading manipulation in TCM is not fully understood and further scientific research is necessary to clarify it. To elucidate the mechanism of action of the kneading manipulation in TCM, a non-specific biomechanical effect detection method for back pain kneading manipulation based on surface electromyography technology was proposed. The results showed that the surface electromyography value before treatment was 96.47 ± 23.21 μV/s, which decreased to 92.34 ± 18.56 μV/s after treatment, with a *P*-value of 0.3865. This indicated a slight decrease in electromyography activity during extension after treatment. The flexion extension value before treatment was 43.21% ± 19.82%, which decreased to 8.65% ± 13.97% after treatment, with a *P*-value of 0.0638, exhibiting a reduction in muscle fatigue and improvement in muscle function after treatment. The pain values of the

NLBP group were significantly below those of the control group, at 26.15 ± 5.32 N and 31.78 ± 6.23 N, respectively, indicating a significant difference in pain perception in the NLBP group. Key findings included: Massage maneuver significantly reduced patients' waist muscle stiffness values (P = 0.0017), and significantly reduced EMG activity during full flexion (P = 0.0087), indicating that the manipulation had a significant effect in reducing muscle tension and pain. Although the improvement of pain threshold did not reach statistical significance (P = 0.2397), the manipulation of manipulation still showed some tendency of pain relief. These results support the effectiveness of traditional Chinese medicine manipulation in NLBP treatment, and provide new treatment methods and evaluation tools for this field, which help optimize the treatment scheme and improve clinical efficacy. The results of this study have important clinical relevance. Traditional Chinese medical manipulation, as a non invasive treatment, has shown significant effect in the relief of nonspecial lower back pain (NLBP). This study revealed the specific effects of manipulation on waist muscle activity and biomechanical properties by surface electromyography, providing scientific basis for the application of manipulation in NLBP. These results may prompt clinicians to consider manipulation as an effective adjunct in the development of NLBP regimens. In addition, this study also found that manipulation can significantly reduce waist muscle stiffness, reduce muscle activity, thus helping to alleviate muscle tension and pain, and provide important reference for optimizing manipulation treatment.

The proposed method can significantly improve the detection efficiency and accuracy, providing important support for the treatment of NLBP with kneading manipulations in TCM. However, the stability of surface electromyography is easily affected by external interference, and its long-term performance needs further verification. Future research will combine more sample data to optimize its anti-interference ability and explore its potential applications in other chronic diseases. In order to verify the effect of traditional Chinese manipulation on nonspecial low back pain (NLBP) more comprehensively, the following aspects could be considered for future research. First, it is suggested to expand the sample size to further improve the representation and reliability of the results. Secondly, a long-term follow-up study was conducted to observe the long-term efficacy and potential side effects of manipulation therapy. In addition, the biomechanical effects of manipulation on other muscle groups, such as the hip and abdominal muscles, could be explored to more fully understand the mechanism of manipulation in easing muscle tension and pain. These future research directions will help to further optimize the treatment of manipulation, improve clinical efficacy, and provide new perspectives and ideas for research in this field.

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