THE IMPACT OF NANOTECHNOLOGIES ON THE RANGE OF MOTION IN THE CERVICAL AND LUMBAR REGIONS: A PILOT STUDY

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Abstract: The aim of this study is to investigate changes in the range of motion in the cervical and lumbar regions following the application of Taopatch® nanotechnological applicators. The working hypothesis was that the applicators would improve the range of motion. This study is part of a Grant project funded by the Council of Medical Science at the Medical University of Sofia. A total of 33 students from the Y. Filaretova Medical College, Medical University of Sofia, participated in the study. Lateral neck and torso inclinations, as well as head rotation, were measured before and after the application of the nanotechnological devices.
In the cervical spine, mobility assessment included measuring maximum flexion (chin touching the sternum in normal mobility), maximum extension (parietal region in a horizontal position), and lateral tilt (distance from the chin to the acromial process, equal on both sides in normal mobility). Additionally, maximum head rotation was assessed by measuring the distance from the tragus to the acromial process, which should also be equal bilaterally. In the lumbar spine, lateral flexibility was evaluated by observing the reach of the middle finger toward the lateral knee crease during lateral torso bending and the distance to the floor. The results demonstrated improvements in the range of motion across all tests. The greatest average increase (0.89 cm) was observed in the right lateral torso inclination, while the smallest increase (0.47 cm) was measured in head rotation to the right. Statistically significant improvements were found in left and right cervical lateral inclinations, head rotation to the left, and right lateral torso inclination. The differences in motion range between the left and right sides were balanced in the cervical region but increased in the lumbar region as a result of the applicators. The application of Taopatch® nanotechnology led to an improvement in the range of motion in the cervical and lumbar regions. Additionally, the devices contributed to enhanced muscular balance between the left and right sides of the body, with the most pronounced effect observed in head rotation. The application of Taopatch® applicators may support the restoration of muscular balance and hold clinical potential for addressing various conditions, diseases, and pain symptoms associated with the function of the musculoskeletal system.
Keywords: nanotechnology, Taopatch®, posturology, posture

1. INTRODUCTION

Human posture is determined by the condition of the musculoskeletal and nervous systems. It results from muscle tone in response to gravity, as well as neurological, biochemical, and psychological factors. Numerous factors can influence regulatory mechanisms, leading to postural changes.
Centrally mediated disturbances in muscle regulation, combined with the sedentary lifestyle of modern humans and static overload in seated and standing positions, are primary causes of muscular imbalance. These imbalances play a key role in the pathogenesis of functional vertebrogenic disorders, often accompanied by pain symptoms [6]. Additionally, forced working postures, chronic spinal conditions, and pain syndromes can trigger, maintain, or

exacerbate muscular dysfunction [11]. Prolonged immobilization or monotonous posture leads to weakening of dynamic (phasic) musculature, resulting in instability within the kinematic chain and reduced joint mobility. Static (tonic-postural) musculature, on the other hand, tends to exhibit increased tone and shortening, impairing chondro-synovial metabolism and overloading the joints due to uneven muscle mass distribution [1, 5].

Pain syndromes, muscular imbalances, and altered postural alignment result in various spinal deformities, reduced range of motion in the cervical and lumbar regions, and thoracic rigidity. These disturbances interfere with movement and daily activities. The degree of functional impairment can be assessed using specialized tests, measurements, and investigations [7]. Spinal movements are measured in three planes of motion: sagittal (flexion and extension), frontal (left and right lateral tilt), and horizontal (left and right rotation).

Scientific literature reports the positive effects of nanotechnology on posture. The application of nanotechnological devices enhances postural tone and control, even in healthy individuals [4, 8]. One of the most well-known products in this field is the Taopatch® applicators.

Taopatch® is a relatively new nanotechnological medical device. It consists of a 16 mm diameter, approximately 1 mm thick disc containing nanocrystals and hydrogen nanotubes [10]. The nanocrystals are activated by body heat, infrared radiation, and sunlight to emit electromagnetic radiation at wavelengths ranging from 200 to 600 nm [9]. This mechanism resembles low-energy laser therapy. Photon emission stimulates specific receptors, acting on dermatomes to reduce muscle tension, activate photosensitive proteins, and improve cellular communication and oxidative protection [2]. The application of the devices is based on energy meridians and points known from traditional Chinese medicine.

Taopatch® applicators have indications for use in routine orthodontic practice to increase maximum mouth opening and improve patient comfort during dental procedures [10]. They are also effective in patients with multiple sclerosis, improving baropodometric parameters and positively affecting body balance [9].

The use of Taopatch® in combination with an occlusal splint or as a standalone intervention improves masticatory muscle movements and strength [3].

The existing scientific literature demonstrates the positive impact of nanotechnology on posture control, muscle strength, and balance. However, no data were found on the effects of nanotechnological devices on the range of motion in various body regions, except for mandibular opening.

The aim of this study was to investigate changes in the range of motion in the cervical and lumbar regions following the application of Taopatch®. The working hypothesis was that the applicators will improve the range of motion.

2. MATERIALS AND METHODS

This study was conducted as part of a project funded by the Council of Medical Science at the Medical University of Sofia. A total of 33 students from the Y. Filaretova Medical College, Medical University of Sofia, participated in the study. Participants were randomly selected, with the primary exclusion criteria being recent injuries or significantly impaired overall physical condition. Baseline measurements of the following ranges of motion were performed at the beginning of the study:

Cervical Spine Measurements

Maximum Head Flexion: In normal mobility, the chin touches the sternum.

Maximum Head Extension: In normal mobility, the parietal region of the head assumes a horizontal position.

Maximum Lateral Head Tilt (Left and Right): The distance from the chin to the acromial process is measured. In normal mobility, the distances on the left and right sides are equal.

Maximum Head Rotation (Left and Right): The distance from the tragus of the ear to the acromial process is measured. In normal mobility, the distances on the left and right sides are equal.

Lumbar Spine Measurements

Lateral Flexibility: From a standing position with feet together and arms relaxed along the sides of the body, the torso is bent laterally to the left and right. In normal mobility, the middle finger of the hand reaches the lateral crease of the knee. Greater flexibility is recorded as positive values (+ cm), while limited mobility is recorded as negative values (- cm).

The Taopatch® applicators were placed on the skin of the participants at the apophysis of the seventh cervical vertebra (C7) and the *proc. xiphoideus* of the sternum for 5 minutes. The above-mentioned range of motion assessments were repeated after the application of the devices. All measurements were recorded in centimeters relative to the respective reference points, both before and after the intervention.

The data were statistically analyzed using Excel. A paired t-test was applied to determine statistical significance, with a threshold of $p<0.05$.

This study was approved by the Ethics Committee for Scientific Research at the Medical University of Sofia.

3. RESULTS

An increase in the range of motion was observed in all tested movements following the application of the Taopatch® applicators. The greatest average increase (0.89 cm) was recorded for the right lateral torso inclination, while the smallest increase (0.47 cm) was observed in head rotation to the right. Statistically significant differences in the range of motion were found for most of the tested movements. Exceptions were head rotation to the right and lateral torso inclination to the left, where improvements were noted but without statistical significance. The results of the study are presented in Tables 1 and 2.

Table 1: Mean values and standard deviations (in cm) before and after the application of Taopatch® applicators.

Indicator	Mean Value (cm)	Standard Deviation
Lateral Inclination - Left (Before)	10.15	2.47
Lateral Inclination - Left (After)	9.53	2.43
Difference (Left Lateral Inclination)	**0.62**	**0.94**
Lateral Inclination - Right (Before)	9.89	2.32
Lateral Inclination - Right (After)	9.39	2.29
Difference (Right Lateral Inclination)	**0.50**	**1.17**
Rotation - Left (Before)	10.47	2.33
Rotation - Left (After)	9.71	2.57
Difference (Left Rotation)	**0.76**	**1.44**
Rotation - Right (Before)	10.12	2.46
Rotation - Right (After)	9.65	2.88
Difference (Right Rotation)	**0.47**	**1.45**
Lateral Torso Inclination - Left (Before)	44.50	4.20
Lateral Torso Inclination - Left (After)	43.76	4.47
Difference (Left Lateral Torso Inclination)	**0.74**	**2.21**
Lateral Torso Inclination - Right (Before)	44.18	4.55
Lateral Torso Inclination - Right (After)	43.29	4.74
Difference (Right Lateral Torso Inclination)	**0.89**	**2.01**

Source: Author research

Table 2: Pearson correlation and p-value for each test, indicating the presence or absence of statistical dependence in different movements based on the application of Taopatch® applicators.

Category	Pearson Correlation	p-value
Lateral Inclination - Left	0.927	**0.0007**
Lateral Inclination - Right	0.870	**0.0219**
Rotation - Left	0.831	**0.0055**

Rotation - Right	0.865	0.0754
Lateral Torso Inclination - Left	0.872	0.0663
Lateral Torso Inclination - Right	0.907	**0.0169**

Source: Author research

The results of the study on head flexion and extension demonstrated normal values for all participants.

4.DISCUSSION

The relationship between muscles with increased tone and weakened muscles follows a strict pattern, with imbalance manifesting clinically through improper load distribution and fatigue. This trend is further exacerbated by hypodynamia and the forced working postures characteristic of modern lifestyles. Muscular imbalance alters the glide-to-roll ratio in joints, thereby hindering their movement. Disrupted muscle equilibrium affects the entire kinematic chain, leading to joint and spinal overload.

Prolonged maintenance of altered postural alignment impacts the thoracolumbar transition, cervical segment, and lower structures of the musculoskeletal system. These changes result in displacement of the load axis and center of gravity, alterations in posture, and uneven loading of the lower extremities.

Our study revealed an increase in the range of motion following the application of Taopatch® applicators. This improvement is likely attributed to enhanced communication between the muscles and nervous system, balanced muscle tone, and overall regulatory improvements. In this context, the analysis of movement balance between the left and right sides, as presented in Table 3, is of particular interest.

Table 3. Comparison of asymmetry between left and right movement ranges before and after the application of Taopatch® applicators.

Test	Before (cm)	After (cm)
Lateral Neck Tilt	0.26	0.14
Neck Rotation	0.35	0.06
Lateral Torso Tilt	0.32	0.47

Source: Author research

The difference in movement ranges between the left and right sides improved in the cervical region but increased in the lumbar region. The imbalance between the two sides of the body, measured in centimeters, decreased by nearly 50% for lateral neck tilt. The most significant improvement was observed in neck rotation, where the difference in movement range between the left and right sides was reduced to 0.06 cm—a clinically negligible value. On the other hand, lateral torso movements showed a slight increase in the difference between the left and right sides following the application of the Taopatch® applicators. This phenomenon might be explained by the location of the applicators' placement, primarily in the cervical region, and potential compensatory mechanisms within the kinematic chains, temporarily amplifying the imbalance in the lower segments of the body.

The application of Taopatch® medical devices may support the restoration of muscular balance and hold clinical potential for managing various conditions, disorders, and pain symptoms associated with the normal, balanced function of the musculoskeletal system.

5.CONCLUSIONS

The application of Taopatch® nanotechnology led to an improvement in the range of motion in the cervical and lumbar regions. Additionally, it enhanced muscular balance between the left and right sides of the body, with the most pronounced effect observed in head rotation.

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