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ORIGINAL PAPER

KINESIOLOGY TAPING IN CERVICAL SPINE PAIN SYNDROMES. THE EFFECTIVENESS OF THE METHOD BASED ON PILOT CLINICAL NEUROPHYSIOLOGICAL STUDIES

METODA KINESIOLOGY TAPING W ZESPOŁACH BÓLOWYCH KRĘGOSŁUPA SZYJNEGO. OCENA SKUTECZNOŚCI W OPARCIU O PILOTAŻOWE BADANIA NEUROFIZJOLOGII KLINICZNEJ

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ABSTRACT

Introduction

Neck pain is mainly caused by soft tissues pathologies affected by prolonged, static work. Kinesiology Taping method is one of the treatments for soft tissue trauma.

Purpose

Ascertaining of normative values for ENG and sEMG studies in selected muscles and nerves of the shoulder girdle and cervical spine in healthy volunteers to compare with values recorded in patients treated because of neck pain syndrome. Evaluation of Kinesiology Taping (KT) effectiveness on pain relief range and changes in cervical spine motion and activity of selected muscle.

Material and methods

Research involved two Groups: I (N = > 7) with cervical spine pain syndrome and II (N = > 10) of healthy volunteers. I Group was studied by the Copenhagen Scale of Functional Disability of the cervical spine. Also Lovett's muscle strength test as well as measurement of range of cervical spine motions (ROM): flexion, extension, lateral flexion, and rotation were applied. Electroneurography (ENG) and surface electromyography (sEMG) in three observation periods were done. II Group was examined by ENG and sEMG tests once. Neural transmission of the musculocutaneous, axillaris and accesorius nerve were performed. Muscle activity at rest and maximum contraction of the trapezius, paraspinal muscles, deltoid and biceps brachii muscles were studied in both groups. Only I Group was treated by KT application. Statistical analysis used the W Shapiro-Wilk for dependent and independent variables, U Mann-Whitney test for statistical significance for independent and dependent samples. Wilcoxon test was used for the analysis of related variables.

Results

VAS scale showed a reduction of pain intensity from a median 4 in the first period to a median 2 in the last period of observation. The ROM underwent normalization and became symmetric in every type of examined move. ENG results in Group I were within the standard of Group II. sEMG showed no statistically significant differences between muscle activity of trapezius

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and paraspinal muscles before and after KT ($p > 0.05$). Despite no significant differences, muscle activity varied mainly in amplitude values during three periods of observation. Skin and fascia were more movable according to palpation studies, local hyperemia occurred at the KT application site was inspected visually.

Conclusions
sEMG showed no statistically significant differences between muscle activity after KT. KT reduced the level of pain and an increased ROM in the cervical spine. Based on the pilot studies, it can be assumed that the effectiveness of the KT method is based mainly on the impact on the fascia, without causing significant changes in muscle bioelectrical activity. Confirmation of this assumption requires increasing the size of the research group. KT can be used as rehabilitation support therapy, effective especially in myofascial pain in the cervical spine.

Keywords: physiotherapy, neck pain syndrome, Kinesiology Taping, sEMG, myofascial pain syndrome.

STRESZCZENIE
Wstęp
Zespoły bólowe kręgosłupa szyjnego są generowane głównie przez tkanki miękkie poddane długiej statycznej pracy. Jednym ze sposobów wpływania na zaburzone tkanki miękkie jest metoda Kinesiology Taping (KT).

Cele
Ustalenie wartości normatywnych dla badań ENG i sEMG wybranych mięśni i nerwów obręczy barkowej i kręgosłupa szyjnego u zdrowych ochotników w celu porównania z wartościami zarejestrowanymi u pacjentów z zespołem bólowym kręgosłupa szyjnego. Ocena skuteczności KT w zakresie łagodzenia objawu bólu i zmian w zakresie ruchu kręgosłupa szyjnego oraz czynności wybranych mięśni.

Materiał i metody
Badaniami objęto dwie grupy: I (N = > 7) z zespołem bólowym kręgosłupa szyjnego i II (N = > 10) zdrowych ochotników. I Grupa była badana za pomocą Kopenhaskiej Skali Niesprawności Czynnościowej Części Szyjnej Kręgosłupa, skali VAS, testu Lovetta oraz pomiaru zakresu ruchów (ROM): zgięcie, wyprost, zgięcie do boku oraz rotacja. Wykonano elektroneurografię (ENG) i elektromiografię powierzchniową (sEMG) w trzech okresach obserwacji. W Grupie II wykonano jednokrotnie badanie ENG i sEMG. Oceniono przewodnictwo impulsów w nerwach: mięśniowo-skórnym, pachowym, dodatkowym. Analizowano czynność następujących mięśni w warunkach spoczynku i maksymalnego skurczu: mięśnie czworoboczne, przykręgosłupowe szyjne, naramienne i dwugłowe ramienia w obu grupach. Tylko w I Grupie zastosowano KT. W analizie statystycznej zastosowano test W Shapiro-Wilka dla zmiennych zależnych i niezależnych, test U Manna-Whitneya dla istotności statystycznej próbek niezależnych i zależnych. Test Wilcoxona wykorzystano do analizy zmiennych powiązanych.

Wyniki
Skala VAS wykazała zmniejszenie intensywności bólu z wartości mediany 4 w pierwszym okresie do mediany 2 w ostatnim okresie obserwacji. Parametry ROM uległy normalizacji i był symetryczny dla każdego badanego ruchu w odcinku szyjnym kręgosłupa. Wyniki ENG w Grupie I były tożsame z Grupą II. sEMG nie wykazało istotnych statystycznie różnic między

aktywnością mięśni czworobocznych i mięśni przykręgosłupowych przed i po KT ($p > 0.05$). Pomimo braku istotnych różnic aktywność mięśni była zróżnicowana głównie w wartości amplitudy w trzech okresach obserwacji. Skóra i powięź były bardziej ruchome zgodnie z oceną palpacyjną, wystąpiło miejscowe przekrwienie w miejscu aplikacji KT oceniane wzrokowo.

Wnioski
sEMG nie wykazało istotnych statystycznie różnic między aktywnością mięśni po terapii KT. KT zmniejszyło poziom odczuwania bólu i zwiększyło ROM w odcinku szyjnym kręgosłupa. Na podstawie badań pilotażowych można założyć, że skuteczność metody KT opiera się głównie na oddziaływaniu na powięź, nie powodując istotnych zmian aktywności bioelektrycznej mięśni. Potwierdzenie tego założenia wymaga zwiększenia liczebności grupy badawczej. KT może być stosowany jako terapia wspomagająca rehabilitację, szczególnie skuteczna w bólu mięśniowo-powięziowym kręgosłupa szyjnego.

Słowa kluczowe: fizjoterapia, zespół bólowy kręgosłupa szyjnego, Kinesiology Taping, sEMG, ból mięśniowo-powięziowy

Introduction

Chronic cervical spine pain globally affects 34% of the total population, with more frequent use in women (Dvorak, 1998), aapplies to 20–50% of professionally active people (Wilson, 2002) and in countries with highly developed technical infrastructure up to 67%. Changing lifestyle, not only professional, cause that an increasing amount of time is spent statically, in a forced body position, which includes the decrease of physical activity generating back pain (Fella *et al.,* 2004). Osteoarthritis, which is one of the leading causes of back pain syndromes, found quite early, because in the second decade of life, at the age of 65, it affects 90–95% of the patients. However, pain in the cervical spine occurring in the population of young people are mainly located in soft tissues and result from muscular imbalance. Myofascial syndromes caused by this may be the primary source of pain in this group of patients (Kemwendo *et al.,* 1991, Zejda *et al.,* 2009).

Many therapeutic ways are affecting soft tissues, including dynamic plastering, also called Kinesiology Taping. The creators of the method (Csapo *et al.,* 2014) attribute it to the analgesic effect that has been present since the patch was applied and long after. This patch has properties like human skin, including weight, thickness, and extensibility at the level of 130–140%. It is waterproof, permeable to air, which does not disturb the heat exchange between the body and the environment. The acrylic used as an adhesive material reduces the occurrence of skin irritations and allergies. The patch maintains its therapeutic properties for many days without restricting the patient's daily functioning.

The analgesic effect of the plaster is associated with a decrease in pressure on nerve endings and improvement of blood and lymph circulation at the application site. Wavy structure of adhesive and the pulling forces of the patch to its original length, which increases the space in the subcutaneous tissue and thus reduces the pressure in it (Slomka *et al.,* 2018). The effectiveness of therapy is based on a mechanism of proprioceptive stimulation, activation of mechanoreceptors, and increased recruitment of motor units, which generates muscle strength (Yahia *et al.,* 1992, Cools *et al.,* 2002). This method uses the phenomenon of targeted self-healing of the body.

The purpose of the pilot study was to establish normative values for clinical neurophysiology tests (ENG, sEMG) in a group of healthy volunteers to perform a comparative analysis in a group of patients with cervical spine pain syndrome. Assessment of the impact of the Kinesiology Taping method on the bioelectrical activity of selected muscles in a group of patients with pain in the cervical spine at two stages compared with the first study before application of the patch and with the normative values of the group of healthy volunteers. Assessment of the impact of the patch application on the range of cervical spine movement, and pain sensation in a group of patients with cervical spine pain syndrome at two stages of the test (on the third and sixth day of patch application) compared to the first test before patch application.

Material and method

The research group (Group I) consisted of 7 people, six women, and one man, with the cervical spine pain syndrome, aged between 23 and 37, where the average age was 25 years. The studies of the patient from the Group I consisted of a survey and clinical examination. These tests were performed three times: before the start of Kinesiology Taping therapy and after the first and second application of the patch, i.e., on the third and sixth days of treatment. Neurophysiological examinations, including the electroneurography (ENG) and surface electromyography (sEMG), were performed before the start of therapy. Control tests after the first and second applications of the patch included only the EMG test for the same group of muscles.

A control group (Group II) consisting of 10 healthy volunteers, including seven women and three men aged 19 to 25 years with an average age of 23 years, was used to determine the normative values of clinical neurophysiological studies. Healthy volunteers from Group II were examined once and did not undergo Kinesiology Taping. The neurophysiological studies performed in the control group were identical to those in Group I. Anthropometric features of both groups are shown in Table 1, and the inclusion criteria for both groups in Table 2. Both groups seem to be similar according to the anthropometric properties and the daylily activities according to the performed reviews.

Table 1. Anthropometric features of both examined groups. Range, median (shown in parentheses), values of lower and upper quartile (bolded) as well as analysis of significant statistical differences between the groups regarding height and weight parameters assuming p < 0.05 were analyzed.

Features	Group I (N = > 7)	Group II (N = > 10)
Growth (cm)	157–185 (168), **165–174**	160–186 (169), **165–183** p = > 0.84
Weight (kg)	47–92 (55), **52–57**	54–105 (62), **55–73** p = > 0.11
Handness	Right-handness (N = > 7)	Right-handness (N = > 10)

Table 2. Inclusion criteria for both examined groups.

Inclusion criteria	
Group I	no previous neurological or cardiovascular diseases no injuries to the head, spine or shoulder girdle ordinary lifestyle and young age also pain in the cervical spine and shoulder girdle whiplash syndrome without injuries to the head, spine or shoulder girdle confirmed in clinical and X-ray examination
Group II	no previous neurological or cardiovascular diseases no injuries to the head, spine or shoulder girdle ordinary lifestyle and young age

Before studies, the patients (Group I) and healthy volunteers (Group II) signed permission for their tests. Helsinki Declaration of the ethical principles for biomedical research was respected.

The survey for Group I contained questions about the characteristics of pain experienced: the type of pain, its intensity, measured using the pain visual scale (VAS) and the location, radiation of the pain, its frequency and duration, as well as situations and movements that promote pain. Also, patients from Group I answered questions included in the Copenhagen Scale of Functional Disability of the cervical spine.

Clinical studies of both research groups concerned the assessment of muscle strength using the Lovett scale of the following muscles: trapezius muscle, sternocleidomastoid muscle, deltoid muscle, and biceps brachii muscle on both sides. Also, assessed compression tenderness in the areas of the right and the left side of the spine within the trapezius muscle or sub-occipital region, as well as cervical spine movement, ranges, i.e., flexion, extension, lateral flexion, and rotation. Measurement of the range of motion concerned the analysis of the distance between relevant points (in centimeters).

Electroneurographic studies (*ENG*)
For the evaluation of nerve conduction was used diagnostic unit Keypoint (Medtronic A / S, Skovlunde, Denmark) and a corresponding set of electrodes (Figure 1).

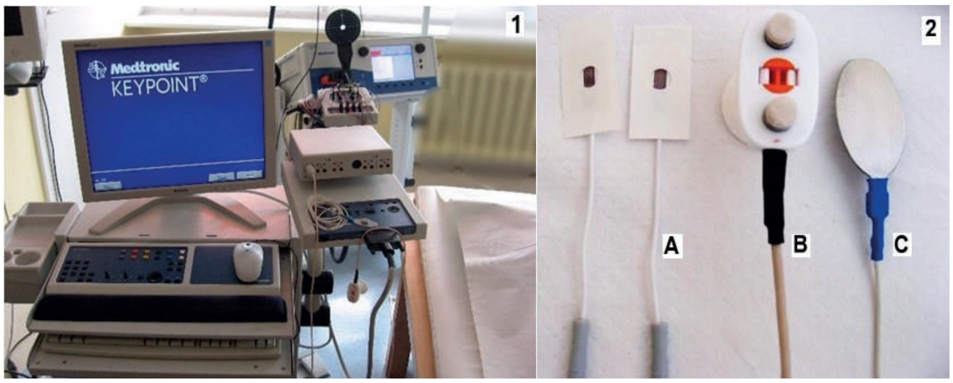

Figure 1. KeyPoint diagnostic system (1) with equipment (2): silver-chloride surface recording electrodes used in ENG and surface EMG (A), bipolar stimulating electrode used in ENG (B), grounding electrode (C).

Disposable chloride-silver surface electrodes were used to record the compound motor action potential (CMAP). The active electrode (cathode) was applied on the muscle belly while the reference electrode (anode) on the olecranon or acromion depending on the examined nerve. For nerve stimulation, a bipolar electrode was used. The grounding electrode was placed on a sternum. The place of application of the electrodes on the skin was cleaned with an abrasive paste, which reduced the skin's resistance. Impedance did not exceed 5kΩ. The time base was set on 5ms/D, the sensitivity of recordings on 10mV/D while 20Hz upper and 10kHz lower filters of recorder amplifier were used during ENG tests. Selected nerves were stimulated with a single rectangular stimulus of 0.2MS duration, frequency 1Hz, and intensity 100 mA (Lee *et al.,* 2005). The ENG examination was performed in a sitting position with the relaxation of the upper extremity muscles. Table 3 presents a summary of selected nerves evaluated in the ENG study.

The following parameters of CMAPs were analyzed:

- the amplitude of negative deflection (measured in mV)
- latency (measured in ms)
- standardized latency (expressed in ms/cm).

Surface electromyographic studies (*sEMG*)
Surface electromyography studies concerned the muscles, which are the effectors of the evaluated nerves (Merletti *et al.,* 2004). They were trapezius (descending part), deltoid muscles, and biceps brachii muscles. The above muscles were activated in a sitting position,

Table 3. Specification of CMAP registration methodology from selected nerves.

Nerves	Active electrode (Cathode – C)	Reference electrode (Anode)	Stimulation point (S)	Distance between C/S (cm)
Accessory Nerve	Trapezius Muscle (upper part)	Acromion	Posterior border of Sternocleidomastoid Muscle	10
Axillary Nerve	Deltoid Muscle	Olecranon	Erb point	17
Musculocutaneous Nerve	Biceps Brachii Muscle	Olecranon	Erb point	25

comfortable for the patient. The function of the cervical paraspinal muscles was also bilaterally assessed. The patient was lying forward, with the head supported on the forehead, in an intermediate position between extension and flexion in the cervical spine.

The same diagnostic system was used for sEMG tests. The time base was set on 80ms/D, the sensitivity of recordings the activity of girdle muscles at rest was set on 50μV/D and during maximal contraction at 1–2 mV/D. For cervical paraspinal muscles, the sensitivity was established on 10μV/D and 0.2 mV/D, respectively. 20Hz upper and 10kHz lower filters of recorder amplifier were used during sEMG tests. The methodology of the sEMG study is in Table 4.

second stage of the research was to assess muscle activity during its maximum contraction.

The following parameters were analyzed in the sEMG study:

- the amplitude of the muscle activity at rest (measured in μV) and during maximal contraction (measured in mV)
- frequency of recruitment of the motor units action potentials (MUAP) during the maximum contraction of the examined muscle (Hz)
- the symmetry of the bioelectrical activity of the muscle at rest and during maximal contraction.

The on-line assessment of the muscle at rest-activity and motor unit recruitment dur-

Table 4. Location of recording electrodes (active and reference) and positioning of the upper extremity or cervical spine in subsequent stages of recording the bioelectrical activity of the assessed muscles in the sEMG test.

Muscle	Electrodes application		Upper extremity / neck position during:		
	Active electrode on the muscle belly	Reference electrode	Resting record	Before muscle activity	During maximal muscle contraction
Tr	Halfway between the spinous process of the 7th cervical vertebra and the acromion	2 cm laterally from the active electrode	Sitting position	Upper limbs arranged along the thorax	Maximum shoulder elevation
DP	Middle muscle acton 4 cm below the acromion	2 cm distally from the active electrode	Sitting position	Elbows flexted to 90˚	Arms abducted to 45˚, elbows flexted to 90˚
BB	Half the length of the humerus	2 cm distally from the active electrode	Sitting position, elbows flexted to 90˚	Elbows flexted to 90˚, supine position of the forearm	Elbows flexted to 90˚, supine position of the forearms
CPS	Lateral from the spinous processes of the C4 vertebra.	2 cm distally from the active electrode	Lying forward, with the head supported on the forehead, in an intermediate position between extension and flexion in the cervical segment.	Like when resting record	Lying forward, maximum neck extension

Abbreviations: Tr – trapezius muscle, DP – deltoid muscle, BB – biceps brachii muscle, CPS – cervical paraspinal muscle.

The sEMG study consisted of two stages. In the first stage, resting activity with full relaxation of the examined muscle was analyzed. The ing the maximum contraction is a subjective analysis of the classification presented by Buchtal (1991). The correct pattern of MUAP recruitment (interference) during the maximum muscle contraction ranges from 70–90 Hz. The pathological pattern of MUAP recruitment ranges from 40–60 Hz (incomplete interference), and below 30 Hz (poor/straight recording) characterizes the neurogenic muscle. The values of the amplitudes of the muscle activity at rest and during maximum contraction were calculated by the oscilloscope program of the Keypoint diagnostic system.

Kinesiology Taping

The method of application of the patch was adjusted individually depending on the location of pain symptoms assessed based on the results of the subjective and physical examination. The form of the plaster preceded by neurophysiological diagnostics (ENG, sEMG). During therapy, original K-Active patches 5 cm wide were used (Figure 2 A, B). Each application consisted of a base and tails, glued with a different degree of extension to the skin surface.

Two types of patch application were used in the study. The first type has been adapted to the trapezius muscle dysfunction. The application base was glued without stretching, while the tails to 25% of maximum stretch. Base fixed above the scapula crest with tails directed to the cervical spine, joining on spinous processes (Figure 2 D). The second type of application has concerned with disorders of the cervical paraspinal muscles and erector spinae muscle. After fixing the base without stretching, the patient made a cervical spine flexion, and tails were glued to maintain this position without stretching the patch. (Figure 2 C).

Statistical analysis

Data were analyzed with Statistica 10 software version (StatSoft, Poland). Descriptive statistics were reported as minimal and maximal values (range), mean or median, and standard deviations (SD). The Shapiro-Wilk test was used to assess the normality of distributions in the test score. Statistical significance was calculated using the U Mann-Whitney for independent samples as well as for dependent samples. P-values of less than 0.05 were considered statistically significant. Wilcoxon test was used for the analysis of related variables.

Results

Survey and clinical study

In the first observation period, the pain in the patients of Group I was located on the posterior surface of the neck. It was extending from the occiput to the descending part of the trapezius. Pain episodes appeared several times a week, and their duration varied from 1 to 4 hours. In the second observation period, the location of the pain did not change. In the last observation period, there was a decrease and centralization of pain in 5 people from Group I. In the other two patients, the above changes were not observed (Figure 3). Changing the tenderness of painful areas was analogous to reducing the painful area.

The results of the VAS scale in Group I (N = > 7), taking into account the median value in individual observation periods, were:

- the first observation period: Med. = > 4; Max = > 9; Min = > 2; (Q1-Q3): 3–8
- second observation period: Med. = > 6; Max = > 7; Min = > 1; (Q1-Q3): 2–7
- third observation period: Med. = > 2; Max = > 7; Min = > 1; (Q1-Q3):1–6

There were no statistically significant differences in the VAS scale results between the first and second tests. On the other hand, between the first and the third study, the difference was statistically significant (z = > 2.20; p = > 0.028), which indicates a decrease in patients' pain perception and thus an analgesic effect of KT.

At all stages of observation, the assessment of the strength of the examined muscles (deltoid muscle, biceps brachii muscle, trapezius – descending part and cervical paraspinal muscles) was the same and classified according to the Lovett scale at 5 (there were no statistically significant differences in the Lovett scale between the tested muscles of the right and left side).

At the third stage of observation, six days after the application of the patch,

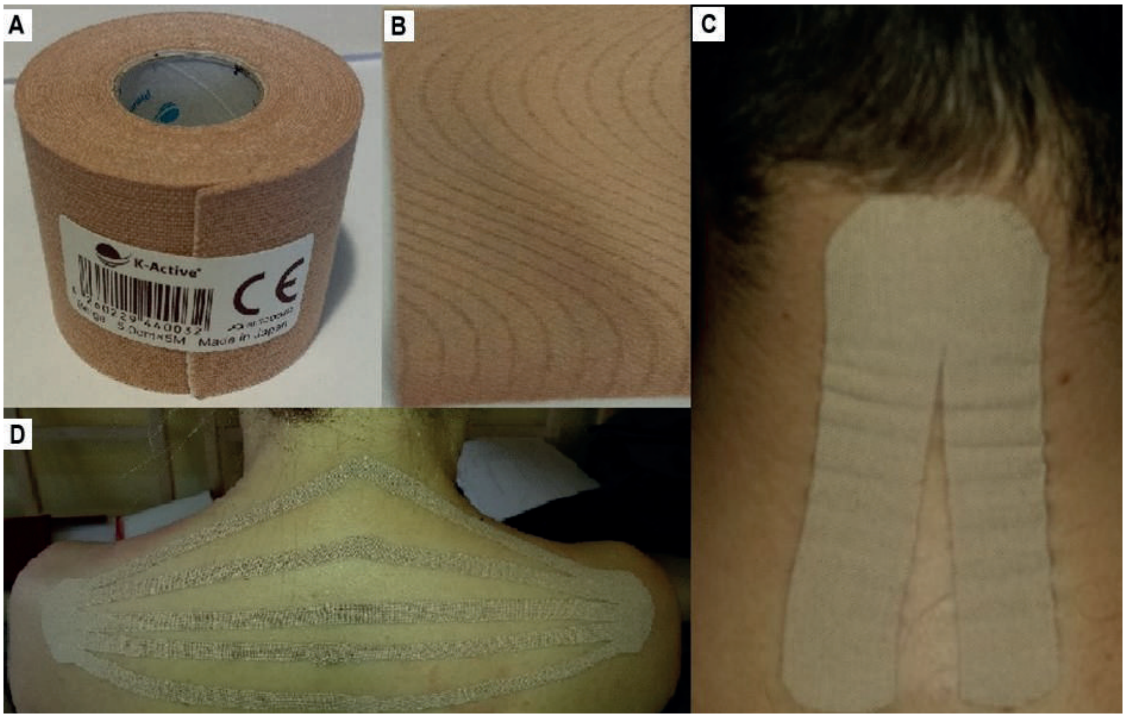

Figure 2. The type of the plaster used in therapy (A, B) and examples of its application within the cervical paraspinal muscles, erector spinae muscle (C) and trapezius muscle (D).

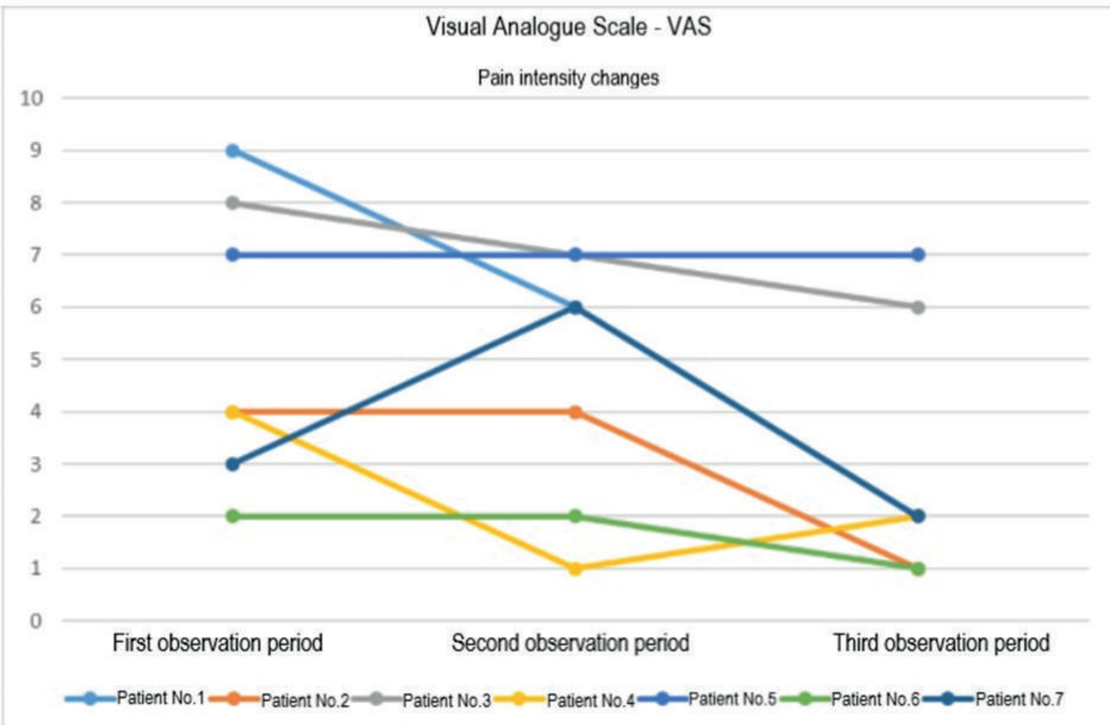

Figure 3. Changes in pain sensation measured by VAS scale during three periods of observation in patients from Group I.

symmetrization of the cervical spine movement ranges was observed in the assessed sequences (Figure 4).

The analysis of the Copenhagen Scale of Functional Disability of the cervical spine showed that pain in the cervical spine does

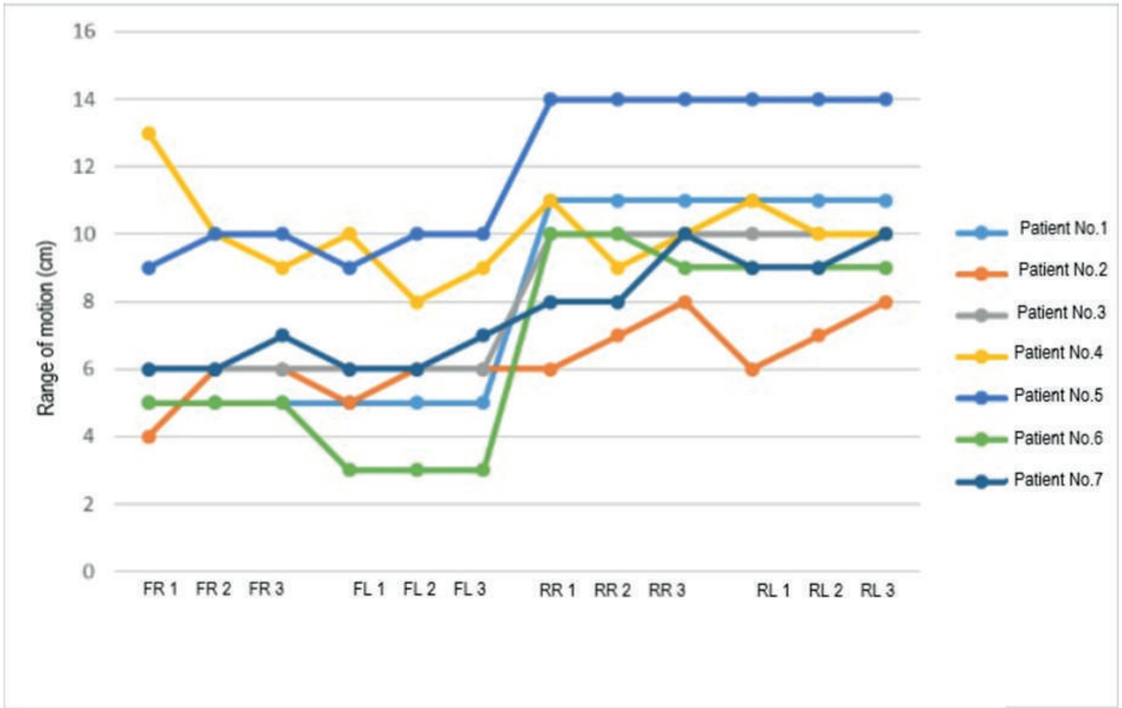

Figure 4. Changing the range of cervical spine motion in 7 patients from Group I at three stages of observation. Flexion to the right (FR), flexion to the left (FL), rotation to the right (RR), rotation to the left (RL) at first, second and third periods of observation (1, 2, 3).

not affect the daily activity of patients, but may hinder daily functioning in the future.

Electroneurography examination (*ENG*)
Based on the results of the ENG study of the control group (Group II N = > 10), normative values were determined. The range and mean value of the CMAP amplitude, latency, and standardized latency in the examinated nerves were presented in Table 5 and Figure 5. Statistically significant differences in the value of conduction time in the examined nerves between the right and left side in the control group were shown. For the musculocutaneous nerve, axillary nerve and accessory nerve, they were p = > 0.02, p = > 0.04 and p = > 0.01, respectively, pointing to longer conduction time in the examined nerves on the left side. Below is a summary of median, range, and lower and upper quartile values for the conduction time parameter for the nerves on both sides.

Musculocutaneous nerve:
Right side – median: 0.14; range: 0.14–0.18; Q1-Q3: 0.14–0.16
Left side – median: 0.15; range: 0.14–0.18; Q1-Q3: 0.15–0.17
Axillary nerve:
Right side – median: 0.18; range: 0.16–0.21; Q1-Q3: 0.18–0.18
Left side – median: 0.18; range: 0.16–0.22; Q1-Q3: 0.18–0.19
Accessory nerve:
Right side – median: 0.20; range: 0.17–0.21; Q1-Q3: 0.20–0.20
Left side – median: 0.21; range: 0.18–0.25; Q1-Q3: 0.20–0.23

The lateralization of conduction parameter, possible minimal differences in the distance measurement or setting the latency markers can explain the above. Therefore, taking into account the added value of the standard deviation, further analysis of the ENG results in the Group I refers to the number of tests performed on both sides in Group II (N = > 20).

The results of the ENG study of the musculocutaneous nerve, axillary nerve, and accessory nerve in Group I (N = > 7) are in Table 6, Table 7, and Table 8, respectively. Only the parameter of the amplitude of the musculoskeletal and axillary nerve showed statistically significantly lower values on the left side compared to the right side.

Table 5. The range and mean value of the CMAP amplitude, latency, and standardized latency in ENG studies in Group II (N = > 20). Ranges, mean values and standard deviations are presented.

Nerves	CMAP parameters (N = > 20)		
	Latency (ms)	Amplitude (mV)	Standardized latency (ms/cm)
Musculocutaneous(N = > 20)	3.45 – 4.7 4.08 ± 0.38	8.75 – 17.313.03 ± 2.64	0.14 – 0.18 0.16 ± 0.01
Axillary(N = > 20)	2.8 – 3.653.23 ± 0.3	12.65 – 19.215.93 ± 2.5	0.16 – 0.220.19 ± 0.01
Accessory (N = > 20)	1.77 – 2.32.04 ± 0.25	6.35 – 10.98.63 ± 2.22	0.18 – 0.230.2 ± 0.01

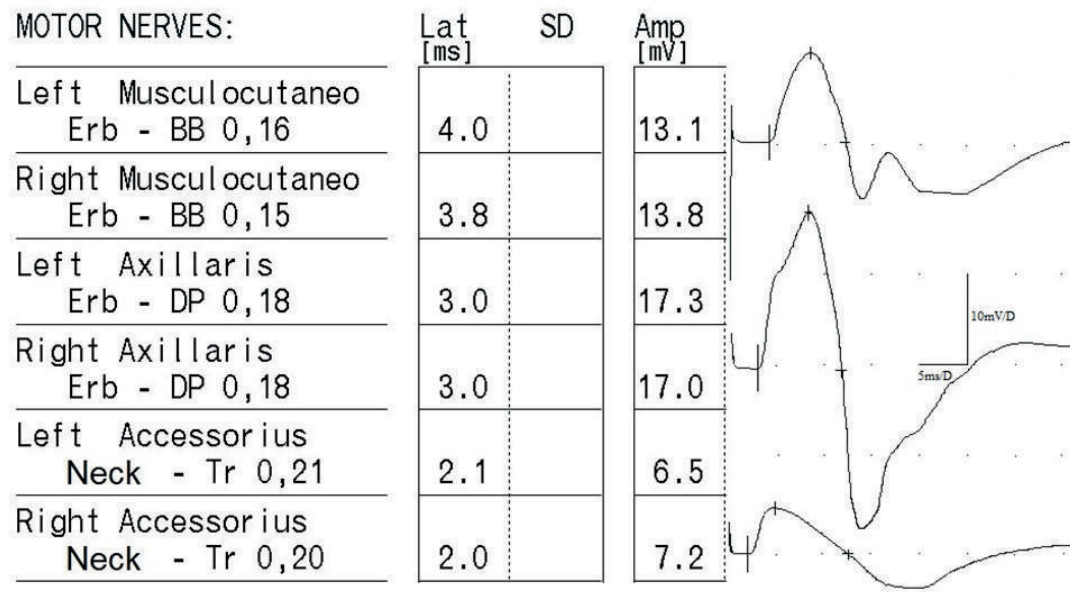

Figure 5. Examples of CMAP registration of examined nerves with correct latency, amplitude, and standardized latency parameters.

The p values for the nerves listed above are respectively p = > 0.04 and p = > 0.01. These results may result from similar considerations, as discussed in the analysis of the conduction time differences in the control group.

The results of the ENG study for individual nerves in patients in Group I were within the normative values of Group II, i.e., healthy volunteers, there were no statistically significant differences in the ENG study between

Table 6. Results of ENG studies of the musculocutaneous nerve in Group I (N = > 7) showing the absolute values of the amplitude and latency of the CMAP as well as standardized latency in ENG studies in Group II (N = > 20).

CMAP parameters recording from the musculocutaneous nerve						
	Right side			Left side		
Patient N = > 7	Latency [ms]	Amplitude [mV]	Standardized latency (ms/cm)	Latency [ms]	Amplitude [mV]	Standardized latency (ms/cm)
1	3.8	12.8	0.15	3.8	11.4	0.15
2	3.5	13.1	0.14	3.5	12.2	0.14
3	3.7	15.7	0.15	4.0	15.0	0.16
4	3.8	12.1	0.15	3.8	10.4	0.15
5	4.0	16.1	0.16	4.2	12.0	0.17
6	4.2	11.3	0.17	3.4	11.9	0.14
7	4.1	11.4	0.16	3.7	11.1	0.15

Table 7. Results of ENG studies of the axillary nerve in Group I (N = 7) showing the absolute values of the amplitude and latency of the CMAP as well as standardized latency.

CMAP parameters recording from the axillary nerve						
Patient N = 7	Right side			Left side		
	Latency [ms]	Amplitude [mV]	Standardized latency (ms/cm)	Latency [ms]	Amplitude [mV]	Standardized latency (ms/cm)
1	3.2	14.5	0.18	3.1	13.1	0.18
2	3.0	15.4	0.17	2.9	15.1	0.17
3	2.8	20.5	0.16	2.7	17.0	0.16
4	3.2	13.8	0.19	3.4	11.3	0.2
5	3.2	18.2	0.19	3.2	16.0	0.19
6	3.0	16.7	0.18	3.1	12.0	0.18
7	2.8	15.2	0.16	2.9	13.6	0.18

Table 8. Results of ENG studies of the accessory nerve in Group I (N = > 7) showing the absolute values of the amplitude and latency of the CMAP as well as standardized latency.

CMAP parameters recording from the accessory nerve						
Patient N = > 7	Right side			Left siade		
	Latency [ms]	Amplitude [mV]	Standardized latency (ms/cm)	Latency [ms]	Amplitude [mV]	Standardized latency (ms/cm)
1	2.3	6.8	0.23	2.4	9.5	0.24
2	2.0	9.0	0.2	2.1	7.9	0.21
3	1.83	7.6	0.18	1.83	8.3	0.18
4	1.83	6.3	0.18	2.2	7.3	0.22
5	2.0	9.5	0.2	2.9	7.4	0.3
6	2.2	8.6	0.22	2.2	11.4	0.22
7	2.2	7.1	0.22	1.96	8.6	0.2

the groups. The above result excludes the axonal or demyelinating type of nerve damage that would affect the function of examined muscles.

Surface electromyography (*sEMG*)
Based on the sEMG test in the control group (Group II, N = > 10), amplitude norms were determined for the tested muscles at rest and during maximum contraction (Table 9). Due to the lack of statistically significant differences ($p = > 0.05$) in the values of the amplitude of the bioelectrical activity of individual muscles recorded on the right and the left, the value N = > 20 refers to the number of tests performed on both sides in Group II.

The results of the sEMG study in Group I were divided into three observation periods.

The EMG study did not show any statistically significant differences in the muscle function compared to the control group tested at rest or maximum contraction. The comparisons included periods 1–2 and 1–3, as well as the evaluation of muscle function and the correlation between the right and left side at three stages of observa tion. Only in the trapezius muscle, the mean value of the amplitude parameter at rest was higher. At maximum contraction, it was lower compared to the control group at all stages of observation. The above results indicate increased resting tension of the trapezius muscle and reduced bioelectrical activity during maximal contraction. This outcome proves that the dysfunction of this muscle can be associated with the overloading of soft tissues and

Table 9. Normative values of the amplitude of muscle bioelectrical activity at rest and during maximum contraction containing its minimum value, maximum value, and average with standard deviation assessed in the sEMG test.

Muscles	sEMG	
	Amplitude at rest (μV)	Amplitude during maximum contraction (mV)
DP (N = > 20)	5.0 – 10.0 5.5 ± 1.58	1.13 – 3.0 2.23 ± 0.57
BB (N = > 20)	5.0 5 ± 0	1.0 – 4.5 2.58 ± 0.94
Tr (N = > 20)	5.0 – 10.0 5.5 ± 1.58	0.88 – 3.0 1.94 ± 0.72
CPS (N = > 20)	5.0 – 10.0 6.25 ± 2.12	0.1 – 0.75 0.45 ± 0.18

be a source of pain in the cervical spine and shoulder girdle.

The analysis of the variability of activity of the trapezius and cervical paraspinal muscles at rest and maximum contraction conditions was made. The study took into account statistically significant changes in its value between test periods – the analysis concerned only for these two muscles due to the pain and application of patches in their area. The results of the above study are in Table 10 and Table 11. The level of statistical significance was p = > 0.05.

at the third stage of observation, i.e., after the sixth day of applying the patch. Also, note the increase in the amplitude of trapezius muscles at maximum contraction at the second and third stages of observation compared to the values recorded before the patch was applied.

The results of the symmetry the amplitude of bioelectrical activity of the examined muscles between the left and right sides, respectively in the 1, 2 and 3 periods of observation at rest and during its maximum

Table 10. Assessment of statistical significance (p = > 0.05) of amplitude changes between the periods of the trapezius and paravertebral muscles at rest.

Sides	Compared periods	Trapezius Muscle	Cervical Paraspinal Muscle
Right	1st vs. 2nd study period	p = > 0.06	p = > 0.76
	2nd vs. 3rd study period	p = > 0.35	p = > 0.22
Left	1st vs. 2nd study period	p = > 0.09	p = > 0.26
	2nd vs. 3rd study period	p = > 1.0	p = > 0.93

Table 11. Assessment of statistical significance (p = 0.05) of amplitude changes between the periods of the trapezius and paravertebral muscles during maximum contraction.

Sides	Compared periods	Trapezius Muscle	Cervical Paraspinal Muscle
Right	1st vs. 2nd study period	p = > 0.57	p = > 0.77
	2nd vs. 3rd study period	p = > 0.53	p = > 0.36
Left	1st vs. 2nd study period	p = > 0.5	p = > 0.36
	2nd vs. 3rd study period	p = > 1.0	p = > 0.17

The above results were not statistically significant. However, despite the lack of statistical significance, variation in amplitude was observed, as illustrated by the following figures (Figure 6, Figure 7).

Notice the decrease in the amplitude of cervical paraspinal muscles function at rest

contraction also did not show statistical significance.

Notice the decrease in the level of pain perception (clearly observed at the third stage of observation) with a relatively stable value of the trapezius muscle activity at rest and maximum contraction (except for

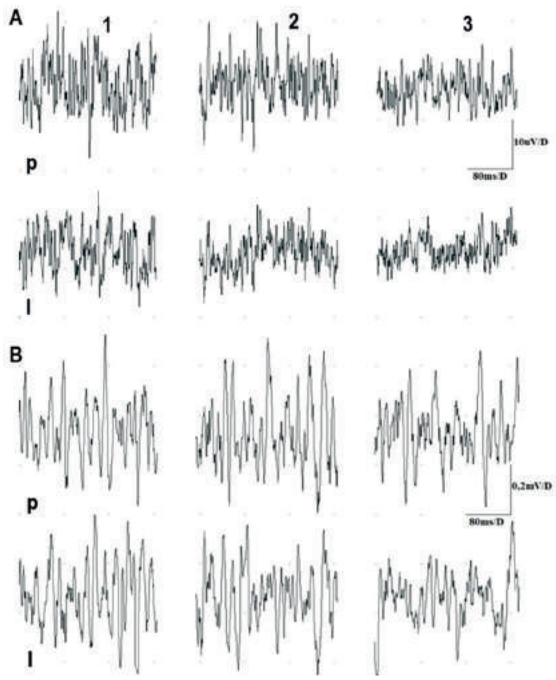

Figure 6. An example of bilateral recording of bioelectrical activity of the cervical paraspinal muscles at rest (A) and during maximum contraction (B).

Abbreviations: A – cervical paraspinal muscle at rest, B – cervical paraspinal muscle at maximum contraction, p – recording of right side, l – recording of left side, 1 – first observation period before therapy, 2 – second observation period on the third day after the patch application, 3 – third observation period on the sixth day after the patch application.

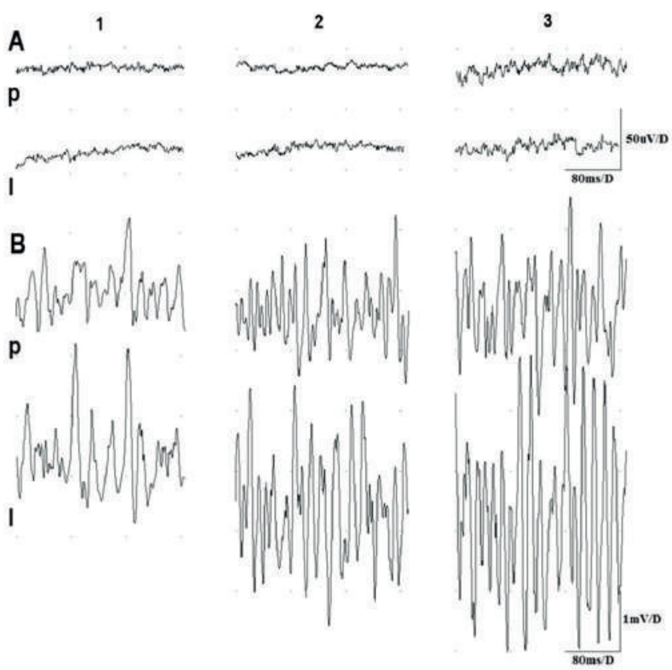

Figure 7. Example of bilateral recording of bioelectrical activity of the trapezius in resting conditions (A) and during maximum contraction (B).

Abbreviations to Figure 7 are the same to those presented in Figure 6.

Patient 1 and 5). The above is evidence of the significant impact of Kinesiology Taping on reducing pain (Figure 8).

adapted to the needs of a particular patient. By placing the patch within the disturbed structure, the reaction concerns the cause,

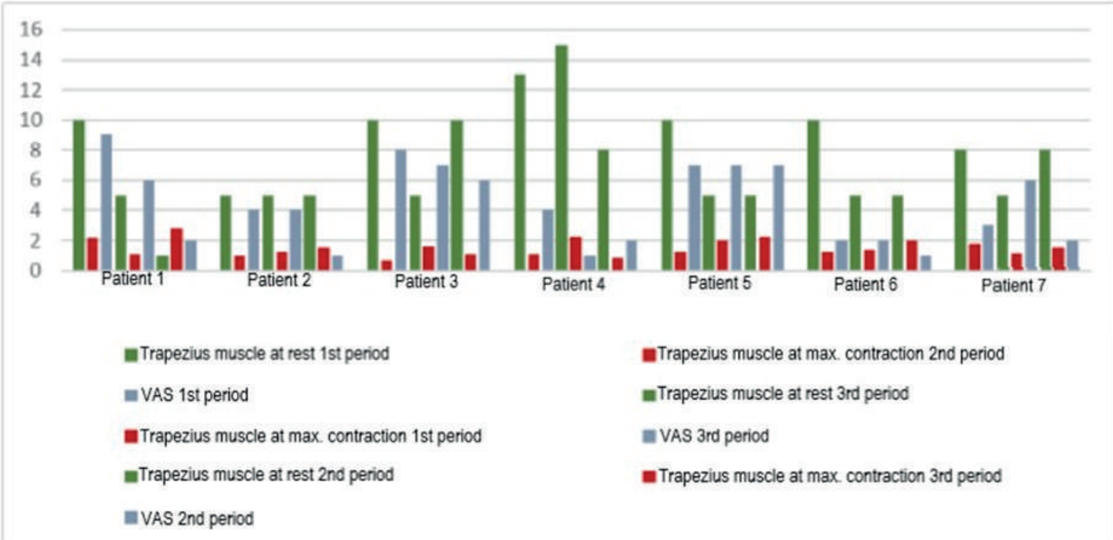

Figure 8. Comparison of the variability of the trapezius muscle bioelectrical activity and the level of pain perception in three stages of observation. Y-axis: for the assessment of muscle at rest, it determines the amplitude in μV; for the evaluation of muscle in maximal contraction, it determines the amplitude in mV; individual points for the VAS scale.

Kinesiology Taping

As a result of Kinesiology Taping therapy, palpation revealed a change in skin tissue and fascia mobility. These tissues became more flexible and moved with each other more easily. At the site of the application of the patch on the skin, a reaction with a wavy surface remained, indicating stimulation of blood and lymph circulation in this area (Figures 9 and 10).

Discussion

Kinesiology Taping (KT) is a therapeutic method that uses a special patch to affect an disturbed body structure. The technique uses the astringent properties of the plaster to reduce pressure in the subcutaneous tissue, allowing increased blood flow and reducing pressure on nerve endings. In most cases, the application of the patch does not force mechanical but sensory correction, which improves the locally functioning of the disturbed tissue. The patch application is in accordance with the dysfunction localization test, based on fascia and soft tissue displacement disorders. This therapy is individualized and not the location of the symptoms of the dysfunction with which the patient reports (Thelen *et al.,* 2008).

The main goals of this study were ascertaining of normative values for ENG and sEMG studies in selected muscles and nerves of the shoulder girdle and cervical spine in healthy volunteers to compare with values recorded in patients treated because of neck pain syndrome and evaluation of Kinesiology Taping (KT) effectiveness on pain relief range and changes in cervical spine motion and activity of selected muscle.

As indicated by Kenzo Kase, the creator of the Kinesiology Taping method, the patch's mechanism of action is to mechanically increase the space between the skin tissue and the fascia, which reduces pressure on the nerve endings and improves blood and lymph flow at the application site (Slomka *et al.,* 2018). KT, therefore, reduces pain, swelling, increases the stability of the locomotor system at the site of application of the patch (Gonzalez-Iglesias *et al.,* 2009). It also improves deep sensation due to the stimulation of skin mechanoreceptors, which determines

Figure 9. Photographs illustrating the state of the KT patch in the trapezius muscle during the last observation period (A) and the skin reaction after the therapy (B).

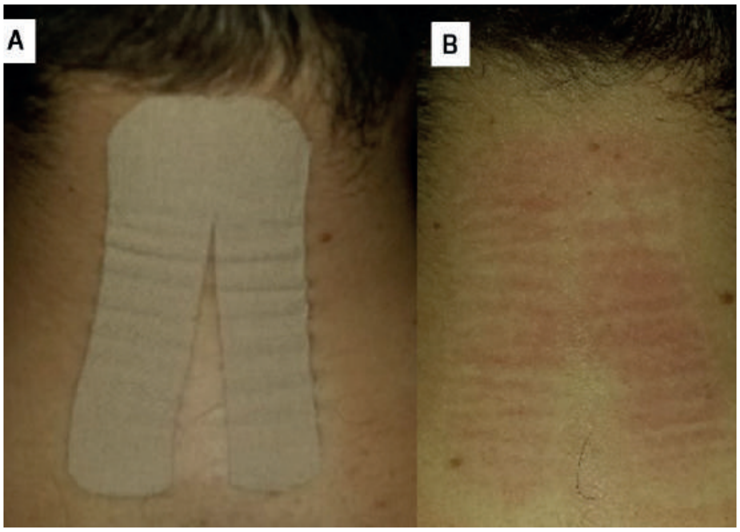

Figure 10. Photographs illustrating the state of the KT patch in the cervical paraspinal muscles and erector spine muscles during the last observation period (A) and the skin reaction after the therapy (B).

the recruitment of motor units and muscle function (Yahia *et al.*, 1992, Cools *et al.*, 2002) .

The above reports regarding changes in the area of pain sensation confirm the work of other authors (Gonzalez-Iglesias *et al.*, 2009, Youngsook, 2014). The VAS scale examination in this study also confirmed the abolition, reduction of the level of pain felt after the application of the patch. An essential element of the effectiveness of the therapy was increasing the range of motion of the cervical spine in its specific sequences and affecting the symmetrization of the relative movement after six days of treatment. Similar observations were in the works of Thelen *et al.* (2008), Gonzalez-Iglesias *et al.* (2009) and Youngsook Bae (2014), contrary to the work of Saavedra-Hernandez *et al.* (2012), who do not confirm statistically significant changes in ranges cervical spine movement.

The change in the bioelectrical activity of muscles during resting conditions and maximum muscle contraction seems to be debatable. Analysis of the results obtained showed no significant statistical difference in the tension of the trapezius and cervical paraspinal muscles and the symmetry of recording after application of the patch. Ryan and Rowe (2006) and Cai *et al.* (2015) indicate that there is no significant change in muscle tonus both at rest and during muscle contraction. Whereas Cools *et al.* (2002) and Ackermann *et al.* (2002) showed changes in muscle bioelectric activity in the sEMG study under the influence of KT, but it was not statistically significant. Lin *et al.* (2011) indicate a statistically significant effect of KT on muscle bioelectrical activity. The trapezius muscles were assessed in two bands: descending and ascending as well as serratus anterior and deltoid muscles. According to the authors, TK reducing the hyperexcitable descending part of the trapezius muscle. However, it does not affect the increase of motor unit activity in the weakened ascending part of the trapezius muscle.

Similarly, Selkowitz *et al.* (2007) suggest in their studies a decrease in the function of the hyperactive descending part of the trapezius muscle under the influence of KT. He also notes the statistically significant increase in the activity of the weakened ascending part of this muscle. Despite some similarities to the research of Lin *et al.* (2011), the obtained research results are different in the abovementioned authors. They may be a consequence of different methods of applying the patch. The mechanism of the analgesic effect of KT and affecting the range of motion most likely concerns the modulation of subcutaneous tissue and fascia surrounding the muscles. It relieves excessively strained or blocked fascia structures, and thus, the self-healing mechanism is activated. Stimulation of this mechanism is associated with increased blood flow and lymph as well as the change in skin temperature (Slomka *et al.* 2018) at the site of application of the patch. The mechanism consisting of the removal of muscle metabolism products through tissue congestion, can explain the effect of analgesia, and fascia tension modulation have a direct impact on the range of motion. Similar results were obtained in this work, i.e., hyperemia on the skin and visible changes with the surface reflecting the structure of the patch after its application. In contrast, palpation showed increased mobility of the fascia in the patch application area, which may support above mentioned hypothesis.

Despite many years of research by various authors on the impact of KT on muscle bioelectrical activity and muscle tone, the data presented are still not conclusive. The results of the above pilot studies require an extension of the number of neurophysiological studies (what constitutes the study limitation) to be able to objectively assess a possible change in the activation of motor units. On the other hand, the results obtained in this study suggest the use of the KT method as rehabilitation support therapy, effective in myofascial pain in the cervical spine.

Conclusions

The therapeutic method of Kinesiology Taping does not significantly affect the bioelectrical activity of the examined muscles in the group of patients with pain in the cervical spine, both at rest and in the maximum contraction compared to the results of sEMG studies of the group of healthy volunteers. There were also no changes in the symmetry of muscle bioelectrical activity at three stages of observation in the group of patients. The types of patch application affect changing the range of motion of the cervical spine, causing its symmetrization six days after the first application in the group of patients. Kinesiology Taping reduces the level of pain perception (Vas scale) after six days in a group of patients. Based on the pilot studies, it can be assumed that the effectiveness of the KT method is based mainly on the impact on the fascia, without causing significant changes in muscle bioelectrical activity. Confirmation of this assumption requires increasing the size of the research group. KT can be used as rehabilitation support therapy, effective especially in myofascial pain in the cervical spine.

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