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The Influence of Physiotherapy on the Range of Motion and Kinesthetic Sensation of Movement in the Radiocarpal Articulation in Patients with Carpal Tunnel Syndrome

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Abstract

Background

Range of motion (ROM) and kinesthetic differentiation of movement (KDM) significantly influence hand functions during work and while performing everyday activities. Because to date ROM and KDM in carpal tunnel syndrome (CTS) patients and its changes following different forms of physiotherapy have not been thoroughly assessed, they became the objective of our study. The aim was to assess the influence of two physiotherapeutic programs on the ROM and KDM in patients with CTS.

Methods

140 people participated in the experiment, including 122 (87,15%) women and 18 (,85%) men. Each person who was not excluded and fulfilled the inclusion criteria to the study was randomly assigned to a group rehabilitated by means of either manual therapy including neurodynamic techniques (MT) or physical therapy including electrophysical modalities (EM). ROM and KDM were assessed. The therapy in MT group was based on manual therapy including neurodynamic techniques and in the EM group on laser therapy and ultrasounds.

Results

Statistically significant improvement was observed in flexion and extension ROM in upper extremities with CTS only in the MT group (p<0.001). Similar effects were obtained in KDM. Similar results distribution occurred while comparing extremities with CTS and healthy extremities. Statistically significant improvement in assessment of ROM and KDM were observed only in the MT group (p<0.001).

Conclusions

Therapeutic program using manual therapy including neurodynamic techniques improves ROM and KDM in patients with CTS. The cycle of therapy improved the status of symptomatic limbs. A decreased difference in terms of ROM and KDM in the symptomatic limb in relation to the asymptomatic limb was observed.

Keywords: carpal tunnel syndrome; radiocarpal joint; neurodynamic technique; treatment

Introduction

Carpal tunnel syndrome (CTS) is a peripheral neuropathy with a very highest incidence. The incidence reported by different authors varies from 1.5% to 3.8% [1-3]. This condition frequently affects persons of working age and may lead to absences at work and marked decline in performance with a significant economic impact.

Currently, surgery is believed to be the most effective treatment method. In nonsurgical treatment, splinting, corticosteroid injections or orally administered steroids or nonsteroidal anti-inflammatory drugs are used. However, the effectiveness of this type of therapy is more controversial compared with surgical treatment [4,5]. The use of physiotherapy for treatment of this mononeuropathy is not often recognized. This results from poorly documented data of the effectiveness of such treatment, and therefore physiotherapy is frequently overlooked as a potential treatment of CTS [6]. Physiotherapy usually includes various electrophysical modalities, such as laser therapy or ultrasounds, massage [7,8] or alternative

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therapies (acupuncture, yoga, cupping) [9-11]. However, therapeutic procedures vary widely and their effectiveness is controversial. Therefore, new physiotherapy methods of CTS treatment must be sought and their effectiveness supported by proper scientific experiments. It also seems that simple and inexpensive tools for the assessment of the effectiveness of the therapeutic methods used are lacking.

In recent years, there have been several interesting studies concerning the possibility of using manual therapy including neurodynamic techniques in the diagnosis and treatment of CTS [12,13]. The efficacy of this procedure has not been yet well substantiated, especially in randomised studies. Kostopoulos states that results of few scientific reports referring to the possibilities of using the manual therapy including neurodynamic techniques in the CTS therapy are promising [14]. The neurodynamic techniques are a relatively new field in physiotherapy and it seems that their value and possibility of using in the CTS therapy should be studied more extensively basing on randomised studies.

ROM and ability of KDM have not been assessed in CTS patients. Ability of KDM can be an important variable influencing the efficiency of the hand in everyday activities and occupational life. The ability to KDM can be associated with professions requiring precision of movements. It can play a significant role in the planning and conduction of movement. It can also affect muscle tone and coordination of hand muscle operation, and this will be important in occupations that require high precision movement.

Assessment of the effectiveness of a therapeutic approach usually involves nerve conduction, pain, symptom exacerbation, functional state, muscle strength or discrimination sense [6-9]. Because to date ROM and KDM in CTS patients and its changes following different forms of physiotherapy (especially manual therapy including neurodynamic techniques) have not been thoroughly investigated, they became the subject of a more detailed study here.

Methods

The Bioethics Committe for Scientific Studies at the Academy of Physical Education in Katowice (Decision No. 16/2007) authorised the study. All study procedures were performed according to the Helsinki Declaration of Human Rights of 1975, modified in 1983.

Participants

a total of 236 patients diagnosed with CTS by a physician were initially enrolled in the study. Within this group, 76 patients did not qualify for the next part of the study because of coexisting diseases that excluded subjects from the study. The remaining 160 individuals participated in the next part of the study but 20 did not complete it. A detailed scheme of the study is presented in Figure 1.

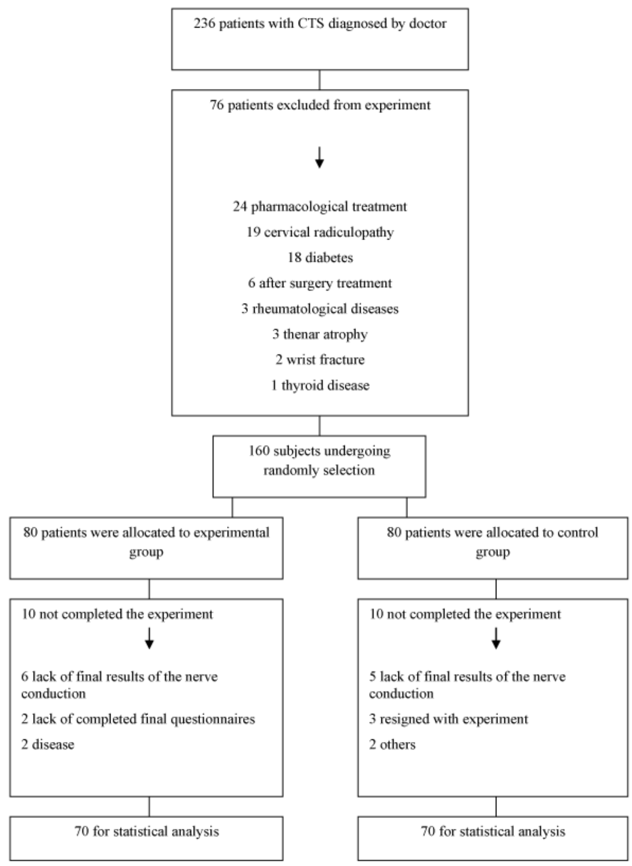

Figure 1: Flow diagram of phases through clinical trial

A total of 140 individuals, including 122 (87.15%) females and 18 (12.85%) males, took part. Characteristics of the participants are presented in Table 1.

	Group MT (n=70)	**Group EM (n=70)**	**p**
Women (%)	62 (88.57)	60 (85.71)	p=0.6135¹
Men (%)	8 (11.43)	10 (14.29)	
Age (SD; min-max) years	53.128 (8.701; 26-72)	51.514(10.348; 28-71)	p=0.1080²
Body mass (SD; min-max) kg	72.27 (11.08; 50.00-97.00)	69.75 (11.84; 43.00-105.00)	p=0.5788²
Height (SD; min-max) cm	164.22 (6.42; 148.00-180.00)	164.85 (5.90; 144.00-182.00)	p=0.1968²
BMI (SD; min-max)	26.98 (4.18; 17.88-41.12)	25.53 (3.85; 18.36-39.04)	p=0.0336*²

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Right dominant hand (%)	65 (92.86)	69 (98.57)	p=0.9509¹
Left dominant hand (%)	5 (7.14)	1 (1.43)	
Asymptomatic hand [right] (%)	7 (13.46)	7 (14.58)	p=0.8716¹
Asymptomatic hand [left] (%)	45 (86.54)	41 (85.42)	
Symptomatic [right] hand (%)	63 (71.59)	63 (68.48)	p=0.6487¹
Symptomatic hand [left] (%)	25 (28.41)	29 (31.52)	
* statistically significant, ¹ Chi² test, ² T-Student test			

Table 1: The participants' characteristics in the studied RNM and RPT groups with p levels of the homogeneity tests (quantitative variables – t-Student test, qualitative variables Chi² test).

Protocols

Diagnostic criteria for CTS: In each case CTS was diagnosed by a physician. Clinical diagnoses were primarily based on the data obtained in interviews and the presence of two or more positive symptoms:

Numbness and tingling in the area of the median nerve

Paraesthesia at night

Positive Phalen's symptom

Positive Tinel's symptom

Pain in the wrist area radiating to the shoulder [15].

The exclusion criteria: earlier surgical treatment, steroid and non-steroid treatment, cervical radiculopathy, tendon sheath inflammation, rheumatoid diseases, diabetes, pregnancy, past traumas to the wrist, muscular atrophy of the thenar eminence.

The diagnostic criterion of inclusion in the experiment did not include electrophysiological test because as it is stated by Nora [16] most authors believe that the clinical symptoms are more useful to accurately diagnose a patient even if disorders in the nerve conduction are not found [17,18].

Randomisation: All patients were informed about the objective and, risks and benefits of the experiment. They could resign from taking part in the experiment at any stage without giving the reasons. Patients diagnosed with mild to moderate CTS who met the diagnostic criteria were included in the study (For mild and moderate forms of CTS those patients were enrolled who received results from 1 to 3 on a Hi-Ob Scale) [19,20]. Each consecutive person who met the inclusion criteria and was not excluded was randomly assigned to either a manual therapy including neurodynamic techniques (MT) group or electrophysical modalities (EM) group. Patients were randomised by drawing lots with the group number. Individuals who drew the number "1" were assigned to the MT group and those that drew number "2" were assigned to the EM group.

Blinding of the study: Next, the patient was directed to a physical therapist who performed a physical examination where they completed the relevant questionnaires and documentation. The examination of nervous conduction was performed by an independent EMG laboratory at an off-site centre by a specialist. The physical therapy procedures were performed by other physical therapists. were not members of the study team. The specialists who performed the conduction examinations were not aware of the therapy administered to the participants. After a cycle of treatment, study participants were examined by the same physical therapist. The second examination of nerve conduction was performed at the same site as the first one by the same specialists. The same procedures and study records were also used in both examinations before and after the therapeutic cycle.

Study method: In assessing the ROM and KDM two analyzes were performed. The first evaluated the effect of therapy in symptomatic limbs. In this case 140 patients were analyzed (180 hands). The second analysis was a comparison of the ROM and KDM in the symptomatic limb in relation to the asymptomatic limb which is why individuals with bilateral CTS were excluded. In this case 100 patients were analyzed (100 hands).

In the analyses concerning the comparison of the ROM and KDM in the symptomatic limb in relation to the asymptomatic limb relative values were used. They were obtained by dividing the values of symptomatic side compared to the asymptomatic side. They pointed out the differences in the considered variables between the analyzed limbs.

The range of motion of bending and straightening in the radiocarpal joint was analyzed [6]. For this purpose the Saunders digital inclinometer was used. The measurements were carried out in accordance with the guidelines set by the manufacturer on the basis of the American Medical Association guidelines [21]. The test was performed in the sitting position, the patient's upper limb was straightened in the shoulder joint, bent to an angle of 90 ° at the elbow with the forearm in pronation, resting on the therapeutic table, and the radiocarpal joint set in an intermediate position. Palmar side of the hand facing towards the substrate was outside the therapeutic table so as to be able to freely obtain the full range of flexion and extension. Fingers were bent to loosen the flexors of the fingers, which could limit the movement of the extension in the radiocarpal joint. An inclinometer was applied on the dorsal side of the hand parallel to the third metacarpal bone and middle finger. In this setting, the display of inclinometer presented a value of 0°, then the subject actively fully straightened the radiocarpal joint. After reading the result the 0° position was restored and the measurement of the active bending in the radiocarpal joint was performed. Measurement of the active range of motion was performed three times, and a mean value was used for further analysis. In the case of a unilateral carpal tunnel syndrome a healthy limb was analyzed first, while the affected limb second. Evaluation was performed before and after the completion of the rehabilitation therapy cycle.

During examining the range of motion in the radiocarpal joint, the assessment of the ability to kinesthetically differentiate the sensation of motion was also performed. Measurement methodology was the same as in the measurement of the range of motion with the difference being that after performing the full range active motion, the subject's task was the performance of the active motion to 50% of the maximum range of motion. In this analysis, measurement was performed three times, and a mean value was used for further analysis. In case of a unilateral carpal tunnel syndrome a healthy limb was analyzed first, and the affected one secondly. The evaluations were performed before and after the completion of the rehabilitation therapy cycle.

Examination of the ROM and ability to KDM allowed for the calculation of the error committed by each subject. For this purpose the following formula was used:

(50%ZR – RPZR) / 50%ZR × 100 = %

50%ZR – 50% of the range of motion

RPZR– real measurement value in the measurement of the mid-range of motion.

The obtained percentages allow for an estimation of the severity of error. Lower percentages indicate a less severity of error committed by the subject.

Techniques used for therapy: During a 10-week observation period, patients in each group underwent physical therapy. No other form of treatment was used during the entire therapeutic cycle.

In the MT group, physical therapy was based on manual therapy including neurodynamic techniques for the median nerve. Functional massage of the descending part of the trapezius (duration 3 min.), as well as wrist mobilization techniques described by Shacklock [22] were used. In both techniques, three series with 10 repetitions were used. The duration of one mobilisation was 15 s with a rest period of 10 s. Gliding and tension mobilisations of the median nerve were performed in the median neurodynamic test position (median neurodynamic test 1 – NM 1) with support. One-direction proximal and distal slider mobilisations and one-direction proximal and distal tension mobilisations were performed [22]. The standard approach was to perform three series of 60 repetitions of glide and tension mobilisations. The duration of the inter-series intervals was 15s. The entire course of therapy included all the therapeutic techniques above and 20 therapeutic sessions were performed twice a week.

In the EM group, physical therapy was based on electrophysical modalities therapy. Laser therapy was performed using a contact method at three points on the palmar surface of the wrist in the transverse ligament area [23]. Each procedure started with a red laser (using a R650/50 probe) emitting 658 nm light at 50 mW; the duration of biostimulation was 1 min 40s. The dose was 5J. Next, an infrared laser (with a IR810/400 probe) emitting 808 nm light at 400 mW was used; the duration of the biostimulation was 1 min. The dose was 24J. Thus, each point was stimulated for two minutes 40 s. The entire procedure was eight minutes long. Ultrasound therapy was used to treat the palmar surface of the hand in the transverse ligament area. The following parameters were used: frequency 1 MHz, intensity 1.0 W/ cm and impulse mode with a pulse width factor of 75%. Each procedure was 15 minutes long [24]. Each therapeutic cycle included 20 therapeutic sessions performed twice a week.

Statistical methods: To evaluate the uniformity of the groups, Student’s t-test was used for quantitative variables and a Chi2 test for qualitative variables. An ANOVA model for analysis of variables with repeated measures in which the repeated measures factor was 2 (measurements 1,2) and the independent factor was -2 (MT and EM groups) was used. Analysis of variancewas supplemented by the post hoc Bonferroni’s test. The critical p level was set at 0.05.

Results

Analysis of variance showed no significant intergroup differentiation in the assessment of ROM in radiocarpal joint flexion (p = 0.3017), whereas there appeared a significant effect of treatment (p = 0.0003) and no interaction effect (interaction of ANOVA factors group x measurement: p = 0.0562).

	Examination	Output	Final	differences within group
The range of flexion	group MT n = 70	70.12 ± 9.86 47.00 – 90.00	73.11 ± 8.92 50.00 – 93.00	p=0.0007*
	group EM n = 70	72.57 ± 10.07 40.00 – 92.00	73.51 ± 10.59 29.00 – 90.00	p=0.2498
	differences between groups	p=0.588	p=0.7864	significance level
The range of extension	group MT n = 70	61.94 ± 12.17 30.00 – 90.00	65.87 ± 10.95 30.00 – 90.00	p<0.0001*
	group EM n = 70	61.86 ± 13.64 36.00 – 84.00	61.22 ± 11.13 37.00 – 90.00	p=0.3817
	differences between groups	p=0.9696	p=0.0616	significance level
* statistically significant				

Table 2: Mean values, standard deviations, minimum and maximum values and the significance levels of differences within and between groups (post-hoc Bonferroni test) in the assessment of the range of motion

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The MT group experienced increased range of flexion motion of 4.3% on average, while the EM group experienced average of 1.2% relative to baseline examination. According to the extension ROM of the radiocarpal joint analysis of variance showed no significant intergroup differentiation (p = 0.1716), whereas there appeared a significant effect of treatment (p = 0.0015) and interaction (interaction of ANOVA factors group x measurement: p<0.0001). The MT group experienced increased range of extension motion of 6.3% on average, while in the EM group the range decreased by 1% on average compared to baseline examination. Results of the post hoc Bonferroni examination are presented in Table 2.

Analysis of variance showed no significant intergroup differentiation in the assessment of KDM in radiocarpal joint flexion of the affected limb (p=0.6744) whereas there appeared a significant effect of treatment (p=0.0004) and interaction (interaction of ANOVA factors group x measurement: p=0.0015). The MT group experienced increased range of flexion KDM of 8.5%, while the EM group experienced average of 0.5% relative to baseline examination. Analysis of variance showed no significant intergroup differentiation in the assessment of KDM in radiocarpal joint extension of the affected limb (p=0.3795) whereas there appeared a significant effect of treatment (p<0.0001) and interaction (interaction of ANOVA factors group x measurement: p=0.0233). The MT group experienced increased range of extension KDM of 8.8% on average while the EM group experienced average of 3.4% relative to baseline examination. Results of the post hoc Bonferroni examination are presented in Table 3.

	Examination	Output	Final	differences within group
Kinesthetic differentation of flexion	group MT n = 70	19.26 ± 13.01 0.00 – 55.88	10.74 ± 10.51 0.00 – 54.38	p<0.0001*
	group EM n = 70	15.93 ± 14.42 0.00 – 47.12	15.48 ± 16.94 0.00 – 70.00	p=0.823
	differences between groups	p=0.6638	p=0.1423	significance level
Kinesthetic differentation of extension	group MT n = 70	20.65 ± 16.60 0.00 – 72.41	11.89 ± 13.58 0.00 – 56.66	p<0.0001*
	group EM n = 70	19.77 ± 15.61 0.00 – 57.14	16.35 ± 16.70 0.00 – 74.54	p=0.2234
	differences between groups	p=0.7134	p=0.347	significance level
* statistically significant				

Table 3: Mean values, standard deviations, minimum and maximum values and the significance levels of differences within and between groups (post-hoc Bonferroni test) in the assessment of kinesthetic sensation of movement

	Examination	Output	Final	differences within group
The range of flexion (relative values)	group MT n = 52	0.95 ± 0.06 0.71 – 1.06	1.00 ± 0.83 0.83 – 1.26	p=0.0049*
	group EM n = 48	0.98 ± 0.09 0.71 – 1.15	1.01 ± 0.12 0.47 – 1.36	p=0.577
	differences between groups	p=0.249	p=0.4856	significance level
The range of extension (relative values)	group MT n = 52	0.93 ± 0.07 0.69 – 1.05	0.99 ± 0.07 0.75 – 1.18	p<0.0001*
	group EM n = 48	0.91 ± 0.1 0.54 – 1.11	0.93 ± 0.08 0.67 – 1.11	p=0.5979
	differences between groups	p=0.2033	p=0.0015*	significance level
* statistically significant				

Table 4: Mean values, standard deviations minimum and maximum values and significance levels of differences within and between groups (post hoc Bonferroni test) in the assessment of the range of motion (relative values)

In assessing the flexion ROM in the affected limb compared to the healthy one, the analysis of variance showed no intergroup differentiation (p = 0.0959), a significant effect of treatment (p = 0.0004), and no significant interaction effect (interaction of ANOVA

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factors group x measurement: p = 0.2401). The MT group experienced a reduction of the difference between the range of flexion of the patient's limb as compared to the health of 4.8% on average, while the EM group experienced average of 2.4%. In assessing the extension ROM in the affected limb compared with the healthy one, the analysis of variance showed significant differences between groups (p = 0.0035), a significant effect of treatment (p<0.0001) and a significant interaction effect (interaction of ANOVA factors group x measurement: p = 0.0239). The MT group experienced a reduction of the difference between the ROM of extension of the patient's limb as compared to the healthy one of 6.3% on average, while the EM group experienced average of 2.2%. Results of the post hoc Bonferroni examination are presented in Table 4.

In assessing KDM of flexion in the affected limb compared to the healthy one, the analysis of variance showed no significant intergroup differentiation (p = 0.08), no significant effect of treatment (p = 0.1108), whereas there appeared a significant effect of interaction (interaction of ANOVA factors group x measurement: p = 0.01). The MT group experienced error value of KDM of flexion in the healthy limb of 5.5% on average. Improvement of the diseased limb KDM in relation to the healthy one was 13.8% on average. In the EM group error value of KDM of flexion in the healthy limb was 10.9% on average. Improvement of the diseased limb KDM in relation to the healthy one was 5% on average. In assessing the KDM of extension in the affected limb compared to the healthy one, the analysis of variance showed no significant intergroup differentiation (p = 0.4744) and a significant effect of treatment (p = 0.0268), as well as a significant effect of interaction (interaction of ANOVA factors group x measurement:: p = 0.01). The MT group experienced error value of KDM of extension in the healthy limb of 6.3% on average. Improvement of the diseased limb KDM in relation to the healthy one was 14.3% on average. In the EM group error value of KDM of extension in the healthy limb was 12.8% on average. Improvement of the diseased limb KDM in relation to the healthy one was 6.9% on average. Results of the post hoc Bonferroni examination are presented in Table 5.

	Examination	Output	Final	differences within group
Kinesthetic differentation of flexion (relative values)	group MT n = 52	5.81 ± 5.78 0.00 – 25.2	2.55 ± 2.33 0.00 – 9.59	p<0.0001*
	group EM n = 48	2.24 ± 2.04 0.00 – 8.52	3.4 ± 7.06 0.00 – 41.54	p=0.307
	differences between groups	p=0.0002*	p=0.4359	significance level
Kinesthetic differentiation of extension (relative values)	group MT n = 52	4.44 ± 4.16 0.00 – 19.13	2.11 ± 2.15 0.00 – 8.05	p=0.0002*
	group EM n = 48	2.65 ± 3.6 0.00 – 18.08	2.87 ± 5.63 0.00 – 32.08	p=0.765
	differences between groups	p=0.0325*	p=0.3849	significance level
* statistically significant				

Table 5: Mean values, standard deviations minimum and maximum values and significance levels of differences within and between groups (post hoc Bonferroni test) in the assessment of kinesthetic sensation of movement (relative values)

Discussion

Effectiveness of different methods of conservative treatment of CTS was evaluated several times especially when related to medical treatment [25] but few studies exist evaluating different methods of physiotherapy. Tal-Akabi emphasizes that due to the small number of works documenting the effectiveness of physiotherapy in the conservative treatment of CTS, it is often overlooked. The second reason for the neglecting is very different effectiveness of such proceedings assessed by different authors, which results from significant methodological differences occurring in the experiments carried out [26].

In the CTS there are a number of objective and subjective symptoms, which are the focus of the therapeutic treatment. It is aimed at reducing both pain and paresthesia, improving muscle strength, feeling, as well as hand function which depends inter alia on the existing ROM in the radiocarpal joint and the ability to KDM [27].

In assessing the ROM in the radiocarpal joint it should be noted that in most cases it was within normal limits. There were also no significant differences in comparison of healthy and affected limb in patients with unilateral CTS. At the same time it is important that the treatment was not aimed at improving the mobility of the radiocarpal joint, but only at mobility between the wrist bones in the midcarpal and intercarpal joints in order to increase the cross section of CTS [28]. However, it could also affect the ROM in the radiocarpal joint. The resulting increase in ROM in both flexion and extension especially in the MT group could also have been the result of repetitive motion in the radiocarpal joint during neurodynamic techniques. It seems that increasing the ROM of the joint is not necessary in the CTS so you can consider this effect to some extent as a "side effect" of therapy. However, from the point of view of hand agility KDM is important. This improvement, especially in the MT group, may translate into better hand agility not only during activities of daily life, which in part has been confirmed by the results obtained in the evaluation of the functional status (Boston - FSS) [29,30], but also in working life. KDM and related error severity can affect primarily those professions where high motion precision is important.

The resulting improvement of KDM can be a result of significant reduction in pain after the therapy. Tamburin showed that pain may be one of the factors that contributes to the hand agility disorder [31]. The fact that chronic pain can impair motor control and efficiency with performance of various tasks by hand is also mentioned by Birch [32]. Various models have been proposed to explain the pain - motility relationship [33,34], but so far not a single position was developed. Some researchers suggest the hypothesis of a defense reflex mechanism from the core, others suggest that the pain - motility interaction takes place at the cortical level.

The resulting improvement in the KDM can also be explained by the fact that the pain is such as to change the motion strategy by reducing the agonist muscle activity, resulting in a reduction in speed and strength. Furthermore, impaired nerve function on the perimeter may in time result in neuroplastic changes in the central nervous system and thereby impair proper KDM. Tecchio discovered the existence of changes in the cortex of patients with CTS. Changes in the somatosensory cortex can influence the reduction in motor control, as suggested by some authors. Improvement of physiological processes in the nerve obtained after the therapy [35], especially with neurodynamic techniques, could affect the plastic changes in the central nervous system, and this can be attributed to the improvement in KDM.

The resulting favorable therapeutic effects in the UMN group may result primarily from a different therapeutic approach related to mechanical impact, owing to which it is possible to affect pathomechanics and attempt to reverse the disease to some extent [36,37]. This allows for improvement of both the physiological processes within the nerve, as well as improvement of the impaired neuromechanics. This type of interaction is not present in the passive therapy (laser, ultrasound), even if it exhibits anti-inflammatory, analgesic and antiedema effect. This method of treatment does not take into account one of the most important activities for which the hand is created, namely motion. Therefore, it seems that the therapy using neurodynamic techniques is a more physiological impact similar to the function, which a hand performs.

A limitation of this study is primarily the lack of assessment of the long-term effects of therapy, which in turn does not allow us to draw far-reaching conclusions, since the resultant effects may be reversible. Another limitation may be the lack of a control group in which no treatment was applied, because then it would be possible to assess the influence of spontaneous recovery when compared to the effects of the experimental therapies [38]. There was no control group which would have been a subject to sham therapy, by which it would be possible to determine the placebo effect on the results of treatment, which also may be a limitation of our study. Such a control group would have allowed for assessment of how the therapeutic effect is dependent on the participation in therapy, and what percentage is dependent on the type of treatment.

To summarize all of these considerations, Brininger's statement, who stresses the need of a secure, efficient and cost-effective ways of dealing conservative therapy, especially in mild to moderate CTS, should be supported. This has significant social and economic importance, because it enhances the quality of therapy, reduces the costs associated with poor performance and absenteeism at work. It is important therefore to continue to explore effective methods of conservative therapy, especially physiotherapy, which are based on the most natural, non-pharmacological process and are relatively inexpensive. It is also necessary to standardize such procedures, and then verify them with a number of randomized studies [39].

In conclusions, the therapeutic program using manual therapy and neurodynamic techniques exhibits a beneficial effect on the ROM and KDM in patients with CTS. The ROM and KDM in the radiocarpal joint of symptomatic limbs improved significantly only in the group that used manual therapy including neurodynamic techniques. The ROM and KDM in the symptomatic limb in relation to asymptomatic reduced significantly only in the group that used manual therapy including neurodynamic techniques.

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