ORIGINAL RESEARCH

The Effect of Manual Therapy Including Neurodynamic Techniques on the Overall Health Status of People With Carpal Tunnel Syndrome: A Randomized Controlled Trial

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ABSTRACT

Objective: The purpose of this study was to assess the influence of manual therapy, including neurodynamic techniques, compared with no treatment on overall health status (OHS) in patients with mild to moderate carpal tunnel syndrome (CTS).

Methods: The study included 189 patients with CTS who were randomly assigned to the manual therapy (MT) group (including the use of neurodynamic techniques) or to the control group (CG; without therapy). The CTS diagnosis was made on the basis of nerve conduction studies and clinical examinations. Overall health status was assessed using the RAND 36-Item Short Form Health Survey. Therapy in the MT group was conducted twice weekly (20 therapy sessions). The CG had no therapy.

Results: A baseline assessment revealed no group differences in the physical and mental components of OHS (in all cases $P > 0.05$).There were also no significant differences in the Physical Component Summary or Mental Component Summary on the RAND 36-Item Short Form Health Survey ($P > 0.05$). Immediately after therapy, analysis of variance revealed differences in the physical and mental components in the MT group (in all cases $P < 0.001$) and no differences in the CG (in all cases $P > 0.05$). After therapy, analysis of variance also revealed differences in Physical Component Summary and Mental Component Summary in the MT group (in both cases $P < 0.001$) and no differences in the CG (in both cases $P > 0.05$).

Conclusion: Manual therapy, including neurodynamic techniques, had a positive effect on OHS in this group of individuals with CTS. (J Manipulative Physiol Ther 2018;41:641-649)

Key Indexing Terms: *Carpal Tunnel Syndrome; Health Status; Musculoskeletal Manipulations*

INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common peripheral neuropathy caused by compression of the median nerve in the carpal tunnel.[1] Characteristics and commonly known symptoms are pain,[2-4] disorders of various senses,[3,5-7] and impairment of hand function.[4,8,9]As a result, people affected by CTS have problems in their day-to-day activities and during their professional duties, which undoubtedly has a negative impact on productivity.[10-12] The incidence of CTS in the population varies between 1.5% and 3.8%,[13,14] and the multitude of symptoms (impaired sensory and motor function of the hand) affects the cost of treatment.

The economic aspect (cost of treatment, productivity at work) is not the only consequence of CTS; it has been shown that CTS also has a negative impact on overall health status (OHS).[15,16] Negative OHS contains a number of components (such as avoiding social interaction, reduced vitality, emotional disturbance [depression, anxiety], difficulty in performing basic daily activities, and problems with extraoccupational physical activity), which deteriorate as a result of CTS.[15,16] It is clear that the peripheral neuropathy in question negatively affects many dimensions of human life (professional, economic, community, and social). Therefore, looking holistically at CTS patients, in assessing therapy, one should consider the effects on both the symptoms directly related to the disease and the individual OHS components.[15]

Surprisingly, the direct influence of therapy on OHS in patients with CTS has so far been assessed in only 2 studies in which operative techniques for median nerve decompression

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were used.[16,17] In these works, Atroshi et al[16] and Thomsen et al[17] demonstrated a positive effect of this form of therapy on the Physical Component Summary (PCS) and no effect on the Mental Component Summary (MCS) of the Rand 36-Item Short Form (SF-36) Health Survey. To our knowledge, the literature does not contain other research evaluating the impact of CTS therapy on OHS. Furthermore, not a single study has evaluated the effects of manual therapy (including neurodynamic techniques) on OHS in CTS patients. Considering some positive effects of this conservative treatment on CTS symptoms, it seems important to estimate the impact of the use of these techniques on OHS. Therefore, the purpose of this study was to assess the effect of manual therapy, including neurodynamic techniques, on OHS in patients with mild to moderate CTS.

Methods

Ethics

The study was authorized by the Bioethics Committee for Scientific Studies at the Academy of Physical Education in Katowice on May 31, 2007 (Decision No. 16/2007). All study procedures were performed according to the Declaration of Helsinki. The clinical trial registration number is ACTRN12614000367640.

Study Design

This was a multicenter, randomized controlled, single-blinded, parallel-group design study. The study took place in medical outpatient clinics in the area of Silesia, Poland, from 2014 to 2015. Participants were randomly allocated to the experimental group in which manual therapy (MT), including the use of neurodynamic techniques, was applied or to the control group (CG) in which no therapy was used. Qualification for mild and moderate forms of CTS was based on the historical-objective scale.[18,19] People who received a score of 1 to 3 (1—only nocturnal paresthesia, 2—diurnal paresthesia, 3—sensory deficit) were eligible for further study. The MT group received 20 treatments twice weekly for 10 weeks. At the same time, the CG group had no treatment. All patients were informed about what the study would involve and were told that they could withdraw at any stage without giving a reason. Written informed consent was obtained from all participants.

Participants

A total of 278 patients diagnosed with CTS by a physician were initially enrolled in the study. Within this group, 54 patients were excluded because of coexisting diseases. The remaining 224 individuals participated in the next phase of the study but 35 did not complete it. A detailed scheme of the study is presented in Figure 1. A total of 189 individuals, including 169 (89%) women and 20 (11%) men, took part. The characteristics of the participants are presented in Table 1. The necessary sample size was assessed based on preliminary results for 20 participants, employing an α of 0.05 and statistical power of 0.80. Based on this calculation, we aimed to recruit 98 patients for each group.

Protocols

Diagnostic Criteria for CTS. The CTS diagnosis was made on the basis of nerve conduction studies (NCSs) and clinical examinations. In all cases, CTS was diagnosed by a physician.

NCSs were prescribed by the physician and performed in an independent electromyography laboratory by experienced personnel. Based on the NCS, only participants who had diminished nerve conduction values (below 50 m/s) or increased motor latency (above 4 m/s) were included.

The clinical diagnosis of CTS was based on the following criteria (drawing on the approach of Chang et al[20]): (1) numbness and tingling in the area of the median nerve, (2) night-time paresthesia, (3) positive Phalen's test, (4) positive Tinel's sign, and (5) pain in the wrist area radiating to the shoulder. Presenting 2 or more symptoms was evaluated as positive for CTS.[20]

In addition, pain was assessed using the Numerical Pain Rating Scale (0 = no pain, 10 = maximum pain),[21] and symptom severity and physical capacity were assessed using the Boston Carpal Tunnel Questionnaire (BCTQ).[22]

The exclusion criteria were as follows: prior surgical or conservative treatment for CTS, cervical radiculopathy, tendon sheath inflammation, rheumatoid disease, diabetes, pregnancy, past trauma to the wrist, or muscular atrophy of the thenar eminence.

Randomization. Consecutive patients who met the diagnostic criteria and presented mild or moderate CTS were included in the study. Patients were randomly assigned to either the MT group or CG by drawing lots using group numbers. Individuals who drew the number 1 were assigned to the MT group, and those who drew number 2 were assigned to the CG.

Blinding Procedures. The procedure in which the patient drew his or her group number was supervised by a secretary who was not otherwise involved in the study. The same physical therapist performed pre- and posttreatment assessments but was blinded as to treatment allocation. A physical therapist, other than the examining therapist, was informed by the secretary of the treatment to be performed and completed the regimens without knowledge of the assessment results.

Outcome Measures. Overall health status in both groups was assessed using the SF-36 questionnaire.[23] We used the Polish version of the questionnaire.[24,25] This is a self-assessment questionnaire consisting of 11 questions and a total of 36 responses, allowing the assessment of the 8 components of OHS. The following factors were taken into account: the components contain an appropriate number of questions, and each question is rated on a scale of 0 to 100. By totaling the values selected by the patient and dividing the total by the

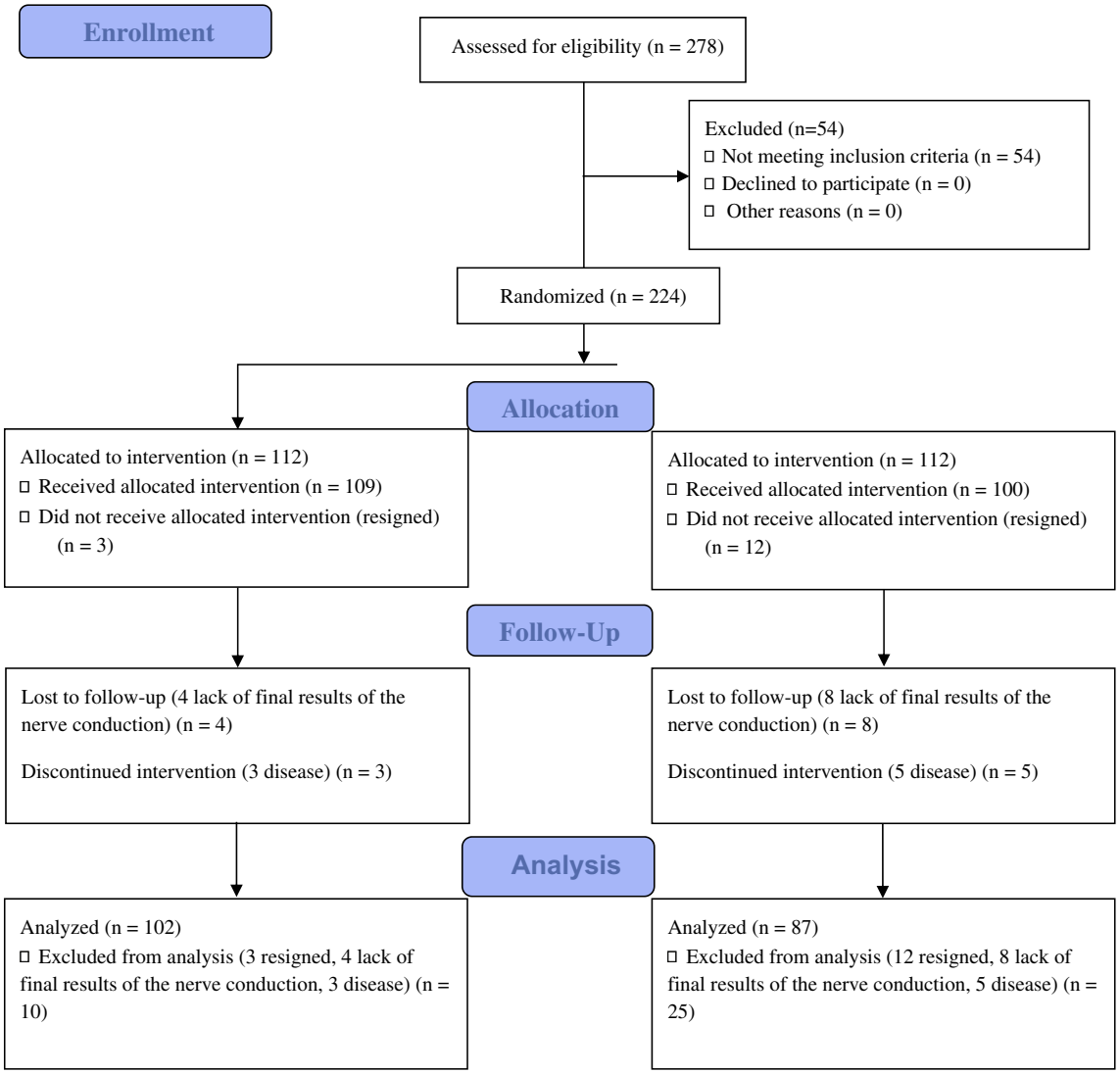

Fig 1. *Flow diagram of phases through clinical trial.*

number of questions, we obtained the value of the indicator for the relevant subcomponent of OHS. Using this method, the values for all 8 components of overall health status were calculated. The physical functioning (PF), role physical (RF), bodily pain (BP), and general health (GH) indicators concerning physical functioning were totaled, allowing us to determine the PCS; and the vitality (VT), social functioning (SF), role emotional (RE), and mental health (MH) indicators concerning mental functioning were similarly summed, allowing us to determine the MCS.[24,25]

$$\mathrm{PCS} = \frac{\mathrm{PF} + \mathrm{RF} + \mathrm{BP} + \mathrm{GH}}{4}$$

$$\mathrm{MCS} = \frac{\mathrm{VT} + \mathrm{SF} + \mathrm{RE} + \mathrm{MH}}{4}$$

Intervention. Physical therapy for the MT group was based on manual therapy including the use of neurodynamic techniques directed at the median nerve. Functional massage of the descending part of the trapezius (duration = 3 minutes) and the wrist mobilization techniques described by Shacklock[26] were also used. Three series of 10 wrist mobilizations were used for both techniques. A single mobilization lasted 15 seconds and was followed by a rest period of 10 seconds. Both gliding and tension mobilizations of the median nerve were performed in the median neurodynamic test position (median neurodynamic test 1 [NM 1]) with support.[26] One-direction proximal and distal slider mobilizations and one-direction proximal and distal tension mobilizations were performed. The standard protocol consisted of 3 series of 60 repetitions of glide and tension mobilizations separated by interseries intervals of 15 seconds. A single therapy session included all of the above therapeutic techniques; therapy sessions were performed twice a week for 20 sessions.[4,7]

Table 1. *Group Means and Between-Group Comparisons for Participant Characteristics at Baseline*

Characteristics	MT Group (n = 102)	CG Group (n = 87)	*P*
Women (%); men (%)	90 (88); 12 (12)	79 (91); 8 (9)	$P = 0.5671$ [a]
Age (SD; min-max)	52.6 (9.3; 26-72)	53.1(8.9; 28-69)	$P = 0.6871$ [b]
Body mass (SD; min-max)	72.1 (10.7; 50-105)	71.5 (10.4; 51-97)	$P = 0.7203$ [b]
Height (SD; min-max)	164 (6.1; 148-182)	163 (7.2; 148-180)	$P = 0.5116$ [b]
BMI (SD; min-max)	26.8 (4.1; 17.8-41.1)	25.9 (3.9; 18.5-38.7)	$P = 0.9815$ [b]
Dominant hand: right; left (%)	97 (95); 5 (5)	82 (94); 5 (6)	$P = 0.7958$ [a]
Asymptomatic hand: right; left (%)	9 (12); 69 (88)	7 (11); 57 (89)	$P = 0.9101$b [a]
Symptomatic hand: right; left (%)	93 (74); 33 (26)	80 (73); 30 (27)	$P = 0.8512$ [a]
Number of carpal tunnels 1/2 (%)	78 (62); 48 (38)	64 (58); 46 (42)	$P = 0.5601$ [a]

BMI, body mass index; *CG*, control group; *MT*, manual therapy; *SD*, standard deviation.
[a] χ^2 test.
[b] Student *t* test.

No treatment was performed in the CG, and the follow-up period was the same as in the MT group.

Statistical Analysis. The basic parameters were compared between groups using an independent *t* test (age, body mass, height, body mass index [kg/m^2]) and the χ^2 test (sex distribution, side of hand dominance, side of asymptomatic and symptomatic hand, 1 or both hands affected).

A 1-way analysis of variance for repeated measurements (independent factor group: MT vs CG; repeated factor time: before therapy vs after therapy) was used to evaluate the differences in the physical components of OHS (PF, RF, BP, GH), the mental components of OHS (VT, SF, RE, MH), PCS, and MCS. For significant differences in the main effect for group, time, or interaction (group × time), Tukey's post hoc test was used. The sample size was determined based on statistical power. The critical *P* level was set to 0.05.

Results

The baseline characteristics presented in Table 1 showed that the groups did not differ in a statistically significant way on basic parameters. There were also no significant differences in the NCS. There were no significant differences in the sensory conduction velocity of the median nerve ($P = 0.9935$). The average sensory conduction velocity was 28.2 m/s in the MT group and 28 m/s in the CG group. There were also no significant differences in the motor conduction velocity of the median nerve ($P = 0.4607$). The average motor conduction velocity was 52.8 m/s in the MT group and 53.4 m/s in the CG group. The average motor latency of the median nerve in the MT group was 5.5 and in the CG group was 5.6 (no significant differences, $P = 0.4952$). There were no significant differences in the pain (average pain in the MT group 5.5 and in the CG group 5.6, $P = 0.8792$). There were also no significant differences in BCTQ (average symptom severity in the MT group 3.03 and in the CG group 3.04, $P = 0.9242$; average physical capacity in the MT group 2.88 and in the CG group 2.91, $P = 0.8218$).

Analysis of variance on all physical components (PF, RF, BP, GH) of OHS revealed a group difference ($P < 0.01$), therapy effect ($P < 0.01$), and interaction between group and therapy ($P < 0.01$). The results of Tukey's post hoc tests are shown in Table 2.

Analysis of variance for the 2 mental components (VT, SF) of OHS revealed a group difference ($P < 0.01$), therapy effect ($P < 0.01$), and interaction between group and therapy ($P < 0.01$), and for the other 2 components (RE, MH) of OHS no group difference ($P > 0.05$), therapy effect ($P < 0.01$), or interaction between group and therapy ($P < 0.01$). The results of Tukey's post hoc test are shown in Table 3.

Analysis of variance on PCS and MCS revealed a group difference ($P < 0.01$), therapy effect ($P < 0.01$), and interaction between group and therapy ($P < 0.01$). The results of Tukey's post hoc test are shown in Table 4.

Discussion

The main purpose of this study was to assess the effect of manual therapy including the use of neurodynamic

Table 2. *Group Means, Standard Deviations, and Ranges for Physical Components of SF-36 Questionnaire; Differences Between Groups and Differences Within Group (Significance Level; Mean Difference; 95% CI)*

Physical Components	Group	Baseline	Final	Differences Within Groups
PF	MT group n = 102	60.7 ± 22.1 5-90	79.1 ± 15.5 30-100	$P < 0.001$ [a] (18.4; -23.1 to -13.6)
	CG group n = 87	64.9 ± 21.1 5-90	64.3 ± 21.3 5-90	$P = 0.9754$ (0.6; -5.1 to 6.2)
	Differences between groups	$P = 0.4171$ (0.2; -4.23 to 8.54)	$P < 0.001$ [a] (14.8; -8.58 to 3.09)	Significance level
RF	MT group n = 102	35.9 ± 32.3 0-100	66.4 ± 34.6 0-100	$P < 0.001$ [a] (30.5; -38.8 to -22.2)
	CG group n = 87	36.5 ± 30.6 0-100	35.6 ± 30.6 0-100	$P = 9759$ (0.9; -7.24 to 9.06)
	Differences between groups	$P = 0.9986$ (0.6; 7.69–25.7)	$P < 0.001$ [a] (30.8; 13.8–34.3)	Significance level
BP	MT group n = 102	42.4 ± 16.3 10-90	61.3 ± 18.7 10-90	$P < 0.01$ [a] (18.9; -23.2 to -14.4)
	CG group n = 87	42.8 ± 16.1 10-90	42.7 ± 16.5 10-90	$P < 0.01$ [a] (0.1; -4.28 to 4.37)
	Differences between groups	$P = 0.2911$ (0.4; -4.49 to 3.82)	$P < 0.01$ [a] (18.6; 13.9 to 23.1)	Significance level
GH	MT group n = 102	43.1 ± 14.5 12.5–79.1	51.2 ± 14.6 25-87.5	$P < 0.001$ [a] (8.1; -11.6 to -4.44)
	CG group n = 87	42.1 ± 13.9 12.5-79.1	41.9 ± 14.1 12.5-79.1	$P = 0.9997$ (0.2; -3.66–3.81)
	Differences between groups	$P = 0.9494$ (1.0; 0.34-8.67)	$P < 0.001$ [a] (9.3; 2.81-11.5)	Significance level

BP, bodily pain; *CG*, control group; *CI*, confidence interval; *GH*, general health; *MT*, manual therapy; *PF*, physical functioning; *RF*, role limitations because of physical health problems; *SF-36*, RAND 36-Item Short Form Health Survey.

[a] Statistically significant.

techniques on OHS in patients with mild to moderate CTS. To our knowledge, this is the first paper to evaluate the effectiveness of physiotherapeutic treatment on OHS in CTS patients. The results of the work provide evidence that manual therapy, including the use of neurodynamic techniques, leads to an improvement in the physical and mental components of OHS in patients with mild to moderate CTS. For all physical components of OHS (PF, RF, BP, GH) and mental components (RE, VT, SF, MH), the treatment yielded significant improvement compared with the CG group, which received no treatment. Evaluation of the PCS and the MCS as a whole showed a 27% and 13% improvement, respectively, after the therapy cycle in the MT group, whereas no changes were found in the CG group. The results of this study indicate that a therapeutic program based on manual therapy including the use of neurodynamic techniques is effective in the treatment of CTS-related OHS disorders.

In previous studies, Wolny et al[4,6,7] investigated the effect of manual therapy including the use of neurodynamic techniques on NCS, pain, BCTQ, 2-point discrimination, ROM, and kinesthetic sensitivity in patients with mild to moderate CTS. The therapy applied had a beneficial effect on the parameters directly related to CTS. The same therapeutic program, used in this study, had a positive effect of improvement in OHS. This both demonstrates the effectiveness of the therapeutic program used and explains to some extent the improvement in OHS. The NCS improvement, pain reduction, improvement of senses, and other objective and subjective symptoms obtained after administering therapy, in addition to increased functional capabilities of the hand, should also affect OHS in terms of its physical and mental components. The greater improvement in the scope of physical components compared with mental components may be because, as shown by previous

Table 3. *Group Means, Standard Deviations, and Ranges for Mental Components of SF-36 Questionnaire; Differences Between Groups and Differences Within Group (Significance Level; Mean Difference; 95% CI)*

Mental Components	Group	Baseline	Final	Differences Within Groups
RE	MT group n = 102	71.4 ± 33.8 0-100	86.5 ± 27.7 0-100	$P < 0.001$ [a] (15.1; -22.7 to -7.37)
	CG group n = 87	74.5 ± 30.5 0-100	73.9 ± 31.3 0-100	$P = 0.9862$ (0.6; -7.61 to 6.82)
	Differences between groups	$P = 0.8775$ (0.1; -11.43 to 5.19)	$P < 0.01$ [a] (12.6; 4.96-20.1)	Significance level
VT	MT group n = 102	52.4 ± 14.4 10-85	62.1 ± 15.9 10-90	$P < 0.001$ [a] (9.7; -12.3 to -4.78)
	CG group n = 87	52.1 ± 14.3 10-85	52.6 ± 13.9 10-85	$P = 8764$ (0.5; -4.39 to 3.11)
	Differences between groups	$P = 0.8847$ (0.3; -2.25 to 5.15)	$P < 0.001$ [a] (9.5; 5.51-12.2)	Significance level
MH	MT group n = 102	66.3 ± 16.4 28-100	72.3 ± 15.4 32-100	$P < 0.001$ [a] (6.0; -10.1 to -1.1)
	CG group n = 87	67.6 ± 14.3 28-100	66.7 ± 14.6 28-100	$P = 0.7795$ (0.1; -2.98 to 4.72)
	Differences between groups	$P = 0.9132$ (1.3; -5.33 to 2.62)	$P < 0.03$ [a] (5.6; 1.69-9.45)	Significance level
SF	MT group n = 102	72.4 ± 20.3 12.5-100	83.2 ± 20.3 25-100	$P < 0.001$ [a] (10.8; -15.4 to -6.01)
	CG group n = 87	72.9 ± 21.1 12.5-100	72.4 ± 20.6 12.5-100	$P = 0.9851$ (0.5; -5.08 to 5.99)
	Differences between groups	$P = 0.9985$ (0.5; -5.74 to 4.89)	$P < 0.001$ [a] (10.8; 5.85-15.6)	Significance level

CG, control group; *CI*, confidence interval; *MH*, mental health; *MT*, manual therapy; *RE*, role limitations because of emotional problems; *SF*, social functioning; *SF-36*, RAND 36-Item Short Form Health Survey; *VT*, vitality.

[a] Statistically significant.

works, physical components are more disrupted than mental components in CTS patients. [11,12,14]

Many other studies have evaluated the effectiveness of various therapeutic programs containing manual therapy or neurodynamic techniques, sometimes supplemented with other physiotherapeutic measures, in the treatment of patients with CTS. [2-7,9,27] In these studies, however, OHS was not evaluated. Thus, the symptoms and the clinical course of CTS are well known and documented, but its impact on the OHS has not been sufficiently studied. This study has demonstrated, for the first time, the positive effects of the therapeutic program administered on OHS assessment. Therefore, further studies should also be supplemented with the SF-36 questionnaire, or other OHS questionnaires, to take into account both the physical and mental components of health. [11,17,27]

For evaluation of the effectiveness of surgical median nerve decompression, studies have been conducted to evaluate the impact of the surgical procedure on OHS. [16,17] Atroshi et al [16] found improvements in all OHS components after surgery. The greatest effect was observed in BP assessment, but the other PCS components also improved significantly. A slightly smaller improvement was observed in the MCS and its individual components. The results obtained in Atroshi et al [16] are very similar to those of our research, in which improvement also occurred in all components of OHS. Moreover, in our study, better results are obtained in the PCS and all its components than in the MCS and all its components. In turn, Thomsen et al [17] found no change in OHS assessment for either the PCS or the MCS after surgical treatment in the CTS patients studied. However, they studied diabetic patients with CTS. Greater, but not significant, therapeutic effects occurred in the PCS and its components (the biggest effect concerned BP), and in the case of the MCS there was even a slight

Table 4. *Group Means, Standard Deviations, and Ranges for SF-36 Questionnaire—Summary; Differences Between Groups and Differences Within Group (Significance Level; Mean Difference; 95% CI)*

SF-36 (Summary)	Group	Baseline	Final	Differences Within Groups
PCS	MT group n = 102	45.8 ± 13.7 21.8-77.1	62.8 ± 17.4 24.8-90	$P < 0.001$ [a] (17; -20.9 to -13.16)
	CG group n = 87	45.4 ± 12.9 21.8-77.2	45.7 ± 12.8 21.8-77.1	$P = 0.9874$ (0.3; -3.72 to 3.13)
	Differences between groups	$P = 0.9977$ (0.4; -3.07 to 3.81)	$P < 0.001$ [a] (17.1; 13.5-21.1)	Significance level
MCS	MT group n = 102	65.9 ± 15.7 23.9-93.2	76.1 ± 15.2 30.5-97.5	$P < 0.001$ [a] (10.2; -13.8 to -6.1)
	CG group n = 87	67.1 ± 14.5 23.9-93.2	66.4 ± 14.4 23.9-93.2	$P = 8511$ (0.7; -3.11 to 4.57)
	Differences between groups	$P = 0.9378$ (1.2; -5.07 to 2.72)	$P < 0.001$ [a] (9.7; 5.77-13.4)	Significance level

CG, control group; *MCS*, mental component summary; *MT*, manual therapy; *PCS*, physical component summary; *SF-36*, RAND 36-Item Short Form Health Survey.

[a] Statistically significant.

deterioration in some of its components (SF, RE, MH). In the Thomsen et al[17] control group, which was nondiabetic patients with CTS, there was improvement in all OHS components, although it is difficult to say whether this was significant because intragroup analyses were not conducted. The lack of improvement in the group of diabetic patients with CTS compared with the group of nondiabetic patients with CTS indicates the strong impact of diabetes on OHS, which is understandable given the significant impact of this disease on the whole body.

Many authors stress the high impact of neuropathic pain on OHS.[28-30] Jensen et al,[28] in a systematic review, analyzed 52 studies and identified a strong correlation between neuropathic pain and OHS. Moreover, Manca et al,[29] in addition to the relation between OHS and neuropathic pain, found an additional dependence of OHS on functional disability. Geelen et al[30] also claim that neuropathic pain increases disability, and this worsens OHS in patients with painful diabetic neuropathy. Putter et al[31] demonstrated a deterioration in OHS in people experiencing upper limb injuries, associated with impaired fitness, and Slatkowsky-Christensen et al[32] pointed to worse OHS in people with hand osteoarthritis compared with the healthy population. The large reduction in pain experienced with manual therapy including the use of neurodynamic techniques in patients with CTS could significantly improve OHS.[4] Moreover, Pinar et al[3] and Akalin et al[5] reported significant reductions in neuropathic pain after treatment including neurodynamic techniques, but OHS was not evaluated in these studies. The functional improvement obtained in many experiments,[4,5,9] also looking at the research of the authors cited above, could have a beneficial effect on OHS. It seems that the improvement in different senses obtained in many experiments[5,6,7] could have contributed to better OHS assessment in the patients studied. Therefore, one can arguably state that the reduction in all symptoms directly related to the underlying condition reduces hand disability, resulting in an improvement in OHS.

Limitations

The limitation of these studies is, first, the absence of a longitudinal evaluation of whether the therapeutic effect associated with the improvement achieved in all components of OHS is sustainable. Assessments were conducted just after the end of therapy when the therapeutic effect is usually greatest. Another limitation is the lack of a control group using a "sham" therapy. In this case, it would be possible to eliminate the placebo effect, which could occur as a result of participating in therapy alone and not because of the therapeutic program used.

Strengths

This study had various strengths. The CTS diagnosis was based on neurophysiological and clinical studies. In addition, pain intensity and disease-specific BCTQ were evaluated. Moreover, this is the first study to assess the impact of a physiotherapy program based on manual therapy including the use of neurodynamic techniques on OHS. This program has been used in previous studies and has been shown to be effective in treating many CTS-specific, objective, and subjective symptoms.[4,6,7] The positive therapeutic effect on both the PCS and the MCS

demonstrates the beneficial effects of this therapeutic program on OHS in the treatment of patients with mild to moderate CTS.

This research may also have some implications for further research. In recent years, it has become increasingly common to discuss the need to assess the patient not only using disease-specific scales, but also addressing subjective patient-reported therapeutic outcomes. Such a combined study can provide a more comprehensive assessment of the patient. Therefore, in subsequent studies on the effectiveness of other physiotherapy programs in CTS treatment, the impact of CTS on OHS and the evaluation of the effectiveness of therapy within the scope of OHS should also be considered. It is increasingly being recommended in studies that pain intensity and OHS be assessed as among the most important measures of the effectiveness of therapy from the patient's perspective.[33,34]

Practical Applications

- Manual therapy and neurodynamic techniques had a positive effect on overall health status in individuals with mild and moderate carpal tunnel sydrome.
- Comprehensive assessment of patients with CTS should also include nonspecific scales (like SF-36) to evaluate possible influence CTS-related disturbances on general health status.

Conclusion

The therapy program based on manual therapy including neurodynamic techniques had a positive effect on overall health status in individuals with carpal tunnel syndrome. Significant improvement was observed in all the OHS components compared with the control group, which did not receive any therapy.

Funding Sources and Conflicts of Interest

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Contributorship Information

Concept development (provided idea for the research): T.W.
Design (planned the methods to generate the results): T.W.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): P.L.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): T.W.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): T.W., P.L.
Literature search (performed the literature search): T.W., P.L.
Writing (responsible for writing a substantive part of the manuscript): T.W.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): P.L.

References

1. Burger M, Kriel R, Damon A, et al. The effectiveness of low-level laser therapy on pain, self-reported hand function, and grip strength compared to placebo or "sham" treatment for adults with carpal tunnel syndrome: a systematic review. *Physiother Theory Pract.* 2017;33(3):184-197.
2. Tal-Akabi A, Rushton A. An investigation to compare the effectiveness of carpal bone mobilisation and neurodynamic mobilisation as methods of treatment for carpal tunnel syndrome. *Man Ther.* 2000;5(4):214-222.
3. Pinar L, Enhos A, Ada S, Güngör N. Can we use nerve gliding exercises in women with carpal tunnel syndrome? *Adv Ther.* 2005;22(5):467-475.
4. Wolny T, Saulicz E, Linek P, Shacklock M, Myśliwiec A. Efficacy of manual therapy including neurodynamic techniques for the treatment of carpal tunnel syndrome: a randomized controlled trial. *J Manipulative Physiol Ther.* 2017;40(4):263-272.
5. Akalin E, El O, Peker O, et al. Treatment of carpal tunnel syndrome with nerve and tendon gliding exercises. *Am J Phys Med Rehabil.* 2002;81(2):108-113.
6. Wolny T, Saulicz E, Linek P, Mysliwiec A, Zajac A. The influence of physiotherapy on the range of motion and kinesthetic sensation of movement in the radiocarpal articulation in patients with carpal tunnel syndrome. *J Nov Physiother.* 2015;5(2):251-259.
7. Wolny T, Saulicz E, Linek P, Myśliwiec A, Saulicz M. Effect of manual therapy and neurodynamic techniques vs ultrasound and laser on 2PD in patients with CTS: a randomized controlled trial. *J Hand Ther.* 2016;29(3):235-245.
8. Brininger TL, Rogers JC, Holm MB, Baker NA, Li ZM, Goitz RJ. Efficacy of a fabricated customized splint and tendon and nerve gliding exercises for the treatment of carpal tunnel syndrome: a randomized controlled trial. *Arch Phys Med Rehabil.* 2007;88(11):1429-1435.
9. Horng YS, Hsieh SF, Tu YK, Lin MC, Horng YS, Wang JD. The comparative effectiveness of tendon and nerve gliding exercises in patients with carpal tunnel syndrome: a randomized trial. *Am J Phys Med Rehabil.* 2011;90(6):435-442.
10. Wolny T, Saulicz E, Linek P, Myśliwiec A. Two-point discrimination and kinesthetic sense disorders in productive age individuals with carpal tunnel syndrome. *J Occup Health.* 2016;58(3):289-296.

11. Provinciali L, Giattini A, Splendiani G, Logullo F. Usefulness of hand rehabilitation after carpal tunnel surgery. *Muscle Nerve.* 2000;23(2):211-216.
12. Riccò M, Signorelli C. Personal and occupational risk factors for carpal tunnel syndrome in meat processing industry workers in Northern Italy. *Med Pr.* 2017;68(2):199-209.
13. Atroshi I, Gummesson C, Johnsson R, Ornstein E, Ranstam J, Rosén I. Prevalence of carpal tunnel syndrome in a general population. *JAMA.* 1999;282(2):153-158.
14. Tanaka S, Wild DK, Seligman PJ, Behrens V, Cameron L, Putz-Anderson V. The US prevalence of self-reported carpal tunnel syndrome: 1988 National Health Interview Survey data. *Am J Public Health.* 1994;84(11):1846-1848.
15. Wolny T, Linek P, Saulicz E. Overall health status in patients with mild to moderate carpal tunnel syndrome: a case-control study. *J Hand Ther.* 2017;30(3):293-298.
16. Atroshi I, Gummesson C, Johnsson R, Sprinchorn A. Symptoms, disability, and quality of life in patients with carpal tunnel syndrome. *J Hand Surg Am.* 1999;24(2):398-404.
17. Thomsen NO, Cederlund R, Björk J, Dahlin LB. Health-related quality of life in diabetic patients with carpal tunnel syndrome. *Diabet Med.* 2010;27(4):466-472.
18. Giannini F, Cioni R, Mondelli M, et al. A new clinical scale of carpal tunnel syndrome: validation of the measurement and clinical-neurophysiological assessment. *Clin Neurophysiol.* 2002;113(1):71-77.
19. Mondelli M, Giannini F, Giacchi M. Carpal tunnel syndrome incidence in a general population. *Neurology.* 2002;58(2):289-294.
20. Chang WD, Wu JH, Jiang JA, et al. Carpal tunnel syndrome treated with a diode laser: a controlled treatment of the transverse carpal ligament. *Photomed Laser Surg.* 2008;26 (6):551-557.
21. Jensen MP, Turner JA, Romano JM, et al. Comparative reliability and validity of chronic pain intensity measures. *Pain.* 1999;83(2):157-162.
22. Levine DW, Simmons BP, Koris MJ, et al. A self-administered questionnaire for the assessment of severity of symptoms and functional status in carpal tunnel syndrome. *J Bone Joint Surg Am.* 1993;75(11):1585-1592.
23. Ware Jr JE, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med Care.* 1992;30(6):473-483.
24. Knapik A, Saulicz E, Plinta R, Kuszewski M. Aktywność fizyczna a zdrowie kobiet w starszym wieku. *J Orthop Trauma Surg Relat Res.* 2011;6(26):27-33.
25. Knapik A, Saulicz E, Kuszewski M, Plinta R. An analysis of relations between a self assessment of health and active life-style. *Med Sportiva.* 2009;13(1):17-29.
26. Shacklock M. *Clinical Neurodynamics. A New System of Musculoskeletal Treatment*. Toronto, Canada: Elsevier; 2005.
27. MacDermid JC. The quality of clinical practice guidelines in hand therapy. *J Hand Ther.* 2004;17(2):200-209.
28. Jensen MP, Marci JC, Dworkin RH. The impact of neuropathic pain on health-related quality of life: review and implications. *Neurology.* 2007;68(15):1178-1182.
29. Manca A, Eldabe S, Buchser E, Kumar K, Taylor RS. Relationship between health-related quality of life, pain, and functional disability in neuropathic pain patients with failed back surgery syndrome. *Value Health.* 2010;13(1):95-102.
30. Geelen CC, Kindermans HP, van den Bergh JP, Verbunt JA. Perceived physical activity decline as a mediator in the relationship between pain catastrophizing, disability, and quality of life in patients with painful diabetic neuropathy. *Pain Pract.* 2017;17(3):320-328.
31. de Putter CE, Selles RW, Haagsma JA, et al. Health-related quality of life after upper extremity injuries and predictors for suboptimal outcome. *Injury.* 2014;45(11):1752-1758.
32. Slatkowsky-Christensen B, Mowinckel P, Loge JH, Kvien TK. Health-related quality of life in women with symptomatic chandosteoarthritis: a comparison with rheumatoid arthritis patients, healthy controls, and normative data. *Arthritis Rheum.* 2007;57(8):1404-1409.
33. Devlin NJ, Parkin D, Browne J. Patient-reported outcome measures in the NHS: new methods for analysing and reporting EQ-5D data. *Health Econ.* 2010;19(8):886-905.
34. Parsons N, Griffin XL, Achten J, Costa ML. Outcome assessment after hip fracture: is EQ-5D the answer? *Bone Joint Res.* 2014;3(3):69-75.