Med. J. Cairo Univ., Vol. 92, No. 4, Accepted 16/7/2024
DOI: 10.22608/MJCU. 1003-1009, December 2024
www.medicaljournalofcairouniversity.net

Effect of Somatosensory Motor Control Training on Patients with Chronic Mechanical Neck Dysfunction: A Randomized Controlled Trial

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Abstract

Background: Somatosensory motor control training (SSMCT) has increased attention in the management of chronic mechanical neck dysfunction (CMND), as well as the usual physical therapy program.

Aim of Study: To determine whether adding SSMCT to a conventional physiotherapy program is beneficial for patients with CMND or not.

Patients and Methods: This randomized controlled trial recruited 56 patients with a moderate score on the neck disability index (NDI) who had been complaining of CMND for at least three months.

Patients and Methods: Patients were randomly allocated to either group A, which received the conventional physical therapy program consisting of hot packs, stretching, and strengthening exercises, or group B, which underwent a combination of SSMCT and the conventional physical therapy program (n= 28 in each group). The treatment program was applied for four weeks, three times a week. The assessment was applied to all patients before and after the intervention, including neck pain severity evaluated by the visual analog scale (VAS), deep neck flexor activation level evaluated by the craniocervical flexion test, and neck function evaluated by the NDI.

Results: There was no significant difference between the two groups in the pre-test of VAS, NDI, or neck flexor activation level. The VAS, NDI, and deep neck flexor activation levels increased significantly in both groups. There was also a significant difference in favor of the study group when comparing the two groups at the post-test (*p*-value <0.05).

Conclusions: From the results of this clinical trial, it can be concluded that SSMCT can be more efficient in managing CMND than a conventional physical therapy program alone.

Key Words: *Neck pain – Mechanical neck dysfunction – Pain – Disability – Somatosensory motor control training.*

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Introduction

NECK Pain (NP) is categorized by pain at the back of the neck that travels to the head, arms, and chest wall **[1]**. There are two types of neck pain: non-mechanical neck pain (NMNP) and mechanical neck pain (MNP). The MNP accounts for 80.0% of NP cases; the discomfort outspreads posteriorly from the nuchal line to the thoracic area without causing neurological symptoms. Globally, NP affects approximately two-thirds of the population, with females more susceptible than males. NP affects up to 78.3% of the world's population, ranging in prevalence from 2.6% to 14.6% **[2]**.

The syndrome known as chronic mechanical neck dysfunction (CMND) affects the cervical spine and is typified by sporadic cervical pain and discomfort when the cervical musculature is palpated without any pathologythat extends from the region between the superior nuchal line and the first thoracic vertebra **[3]**.

Neck dysfunction, or NP, ranks fourth in terms of contributing factors to disability, following joint pain, low back pain, and depression. Neck dysfunction, or NP, has a high chronicity and recurrence rate. Thirty-one percent of patients with NP experience chronic symptoms for longer than six months, and thirty-four percent experience symptoms for more than a year **[4]**.

The pathogenesis of CMND is still unclear. Physical disorders such as neck/shoulder region-related myofascial disorders, genetic and psychosocial predispositions, and/or improper lifestyle postures, as well as changes in the neck muscles, are typically linked to the persistence of pain in patients with CMND [5]. Compared to healthy individuals, those with CMND have weaker and/or worse muscle endurance [6], dysfunction or pain, a restricted cervical range of motion (ROM), exhaustion or fatigue, weakened muscles, impaired eye movement control or coordination, aberrant joint position error, impaired postural control, headache, and dizziness, which is strongly linked to the CMND-induced pain and disability [7].

For the treatment of persistent CMND-associated pain, exercise therapy combined with physiotherapeutic techniques (manual therapy, hot packs, education, and electrotherapy) is thought to be beneficial. It is currently unknown whether a particular kind of exercise is conventional for the management of CMND patients in terms of enhancing proprioception acuity, reducing pain, and reducing disability [8].

Patients with NP who received sensory-motor control training showed improvements in cervical spine ROM, precision, velocity, fine motor control, and coordination. It is thought that in patients experiencing NP, this type of training could simultaneously trigger the vestibular, visual, and sensorimotor control systems [9].

The study aimed to assess the efficacy of adding SSMCT to traditional physiotherapy programs for patients with CMND.

Patients and Methods

Study design: Pre-post test, randomized control clinical trial. All details about the nature of the study (assessment and treatment program) were described to the patients before they signed the consent form. The Ethical Committee of Cairo University's Faculty of Physical Therapy approved this study under the number: PT/REC/012/003765. The study was conducted from July 2023 to March 2024 atphysiotherapy outpatient clinic of the General Medical Center in New Damietta, Egypt.

Inclusion criteria: Fifty-six patients of both genders with an age range of 25 to 45 years old, diagnosed as CMND for more than three months [10], with a BMI between 18.5 and 29.9 [11], and a score of 30-48% on the neck disability index (NDI), were involved in the study. All patients were diagnosed and referred by an orthopedic surgeon.

Exclusion criteria: Patients with acute NP, history of neck fractures, surgery, cervical spondylolisthesis, disc herniation, cervical stenosis or spondylolysis [11], vestibular pathology, vertigo or dizziness, hypertension, migraine, vertebrobasilar insufficiency, congenital anomalies, and balance/stability disorders weren't included in the study [12].

Sample size calculations: G*POWER statistical programming (the German software used for sample size calculation with its version No. 3.1.9.2) detected the effect size (d = 0.76) of the primary outcome (deep cervical muscular activation level) extracted from the craniocervical flexion test (CCFT) at 80% power. For this SSMCT trial, the appropriate sample size was N = 56, 28 for each group.

Randomization and blinding: Sixty patients were assessed for eligibility from the physiotherapy outpatient clinic of the General Medical Center in New Damietta, Egypt. Four patients were excluded (did not meet inclusion criteria), and fifty-six were randomly allocated to equal groups (A and B) (Fig. 1). Both the subjects and the statistical researcher were blinded. The treatment duration was 12 sessions, three times per week [7].

Outcome measures:

All patients in both groups were evaluated before and after the completion of the treatment programusing the following variables:

Visual analogue scale:

The Visual Analogue Scale (VAS) was utilized to quantify pain levels. The linearly scaled VAS marked patients' pain from 0 to 10 (zero indicates no pain, while 10 indicates maximal pain perception) [13].

Neck disability index:

The extent of neck pain-induced disability was assessed in patients by the 10-question neck disability index (NDI). Every question within the NDI was assessed via a 6-point scale. The self-reported NDI examined patients' sleep, pain, headache, daily life, concentration, lifting objects, reading, driving, work, and leisure. A higher NDI score was a marker for a more induced functional disability. NDI scores have been classified into four categories: 0–4 = no disability; 5–14 = mild disability; 15–24 = moderate disability; 25–34 = severe disability; and >35 = total disability [14].

Craniocervical flexion test:

Deep cervical muscular activation level was tested using a craniocervical flection test (CCFT) via a pressure biofeedback device (Chattanooga Group Device, Inc.-Hixson, TN) (Fig. 2). The cuff was positioned behind the patient's neck and inflated to a pressure level equal to 20mmHg. Then, while sustaining stability in the posterior aspect of the head, the patient was instructed to perform craniocervical flexion at a progressed level at five various successive pressure levels (22, 24, 26, 28, and 30mmHg). Each level should be held for 10 seconds, with 10 seconds of rest in between [15].

Intervention:

The treatment duration was 12 sessions, three times per week [7]. Patients in group A received a conventional physiotherapy program (hot packs for 20 minutes [16], stretching for the upper fibers of the trapezius, sternocleidomastoid scalene, and levator scapulae muscles, each stretch was held for 20s and repeated 2 to 3 times with no extra pain [2]. After 5 minutes of rest, they started isometric exercises for extensors, bilateral side bending muscles, and bilateral neck rotators. Each exercise was repeated 5 times for three sets [17], the hold time was 6s, with 6s of rest in between [18]. Patients in group B received the same protocol as in group A as well as SSMCT in the form of proprioceptive, oculomotor, and balance training. The following exercises were performed up to 10 repetitions according to the patient's tolerance without causing extra pain. (1) Proprioceptive training (cervical position sense and cervical movement sense) using a LASER pointer fixed to the patient's head via a head strap (Fig. 3), (2) Oculomotor training such as (a) Eye follow (by moving the laser pointer's light in the right-to-left direction followed by an above-to-down direction across the facing wall and he/she was ordered to follow the light only by eyes with a steady head) and (b) Gaze stability (by maintaining their gaze on a specific target during the active or passive movement of the head in all directions with open and closed eyes and in different body positions such as supine, sitting, standing, or standing on an unstable surface). For more challenge, change the focus point to be more complicated, like written words; (c) Eye-head coordination exercises (movement of the patient's eyes and head simultaneously to a new localized focus point and then advance by starting both-eye movement followed by the patient's head movement in the same direction). To be more challenging, the target and the head are moved into opposite directions while focusing on the target with the eyes, and (3) Balance training progressions including single leg stance/support, tandem stance, and standing on a balance board which were done in conjunction with eye coordination exercises [19]. All patients were told to continue with their regular lifestyle and not to exercise at home [7].

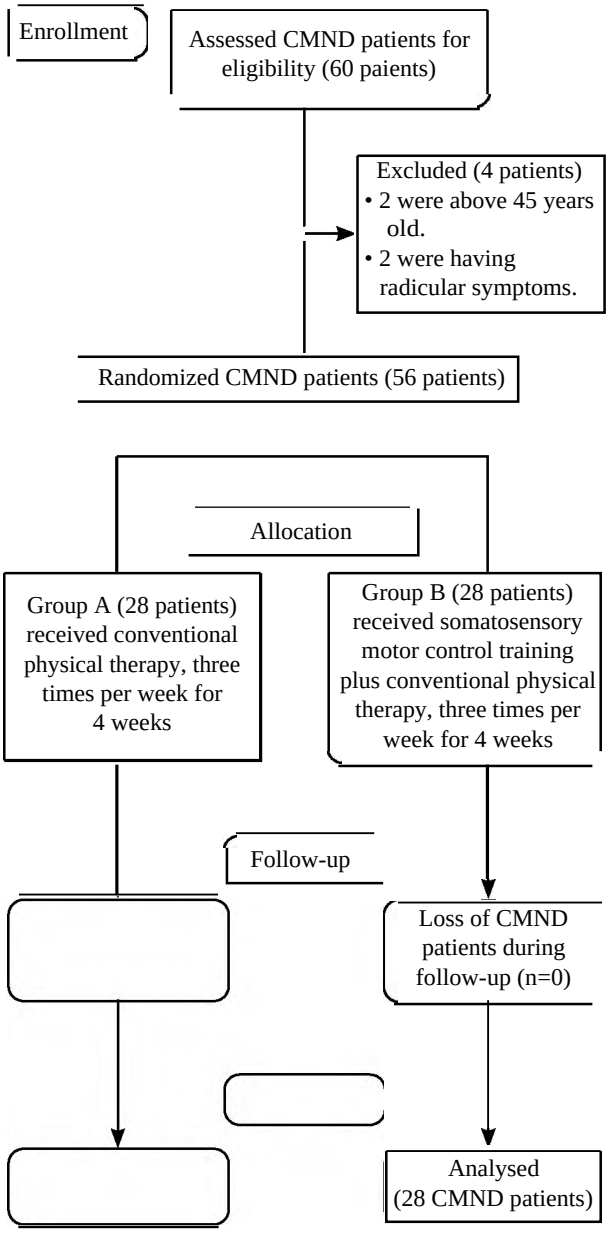

Fig. (1): Flow chart of patients with chronic mechanical neck dysfunction (CMND).

Fig. (2): Craniocervical flexion test.

Fig. (3): Cervical movement sense.

Results

Age, gender, and BMI did not differ statistically significant (*p*-value >0.05), according to the subjects' demographic data (Table 1).

Overall effect:

Between group comparison: Baseline and after four weeks: At baseline, there were no statistically significant changes (*p*-value >0.05) among both groups in any of the evaluated variables; after following a four-week intervention, all evaluated variables showed statistically significant changes between both groups, with group B benefiting more (*p*-value <0.05) (Table 2).

Within-group comparison: The results of the before and post-intervention showed statistically significant differences (*p*-value <0.0001) in all outcome measures within group B (study group) andgroup A (traditional group), with the study group benefiting more.

Table (1): Demographic characteristic of patients (N=56) *.

	Group A ±SD	Group B ±SD	*p*-value
Age (years)	34.54±6.46	35.32±5.97	0.64
BMI (kg/m^2)	24.5±2.87	23.73±2.56	0.29
Gender, n (%):			
Female	17 (60.7%)	15 (53.57%)	0.5
Male	11 (39.3%)	13 (46.43%)	9

* : Data were expressed as mean ± Standard deviation.
N : Number.
P : Probability.
BMI : Body mass index.
a : Non-significance difference.

Table (2): Within and between group analysis for CCFT, VAS and NDI.

Variables	Group B	Group A	MD (95% CI)	*p*-value (between groups)	n2
CCFT (mmHg)					
Pre-treatment	2.2±24.21	1.91±23.57	0.64 (-0.46 to 1.75)	0.25**a**	0.35
Post-treatment	1.83±28.21	25.5±1.93	2.71 (1.71 to 3.72)	0.001**b**	
p-value (within-group)	0.001b	0.001**b**			
VAS (cm)					
Pre-treatment	6.18±1.47	6.82±1.54	-0.64 (-1.45 to 0.16)	0.12**a**	0.3
Post-treatment	4±1.25	5.75±1.48	-1.75 (-2.48 to -1.02)	0.001**b**	
p-value (within-group)	0.001**b**	0.001**b**			
NDI (Score)					
Pre-treatment	37.86±5.1	39.43±5.78	-1.57 (-4.49 to 1.35)	0.29**a**	0.19
Post-treatment	19.64±4.29	24.57±6.06	-4.93 (-7.74 to -2.12)	0.001**b**	
p-value (within-group)	0.0001**b**	0.001**b**			

CCFT : Craniocervical flexion test.
mmHg : Millimeter of mercury.
VAS : Visual analogue scale.
NDI : Neck disability index.
p-value: Probability.
a : Non-significance difference.
b : Significance difference.
CI : Confidence interval.
MD: Mean difference.
n2 : Partial eta squared.

Discussion

Both groups (group A received a conventional physiotherapy program) and (group B received the same regimen as group A plus SSMCT) showed significant effects on pain intensity, neck function, and deep neck flexor activity level, with group B benefiting more.

The study's findings agree with the following studies regarding pain intensity, neck function, and deep neck flexor strength.

Oculomotor training and joint position sense maneuvers (as part of SSMCT) further improve the sensitivity and response of the deep cervical muscles' spindles, maximize the effectiveness of the neuromuscular control system, mediate the reflexive interaction between cervical-ocular and vestibular-ocular reflexes that elevates patients' endurance of deep neck muscles, decreases over-activation of superficial long muscles, and thereby decreases pain **[7].**

As a primary component of sensorimotor control training, balance training concentrated on various static and dynamic balance exercises that required anticipatory whole-body postural reactions and changes. Balance training enhances neuroplasticity in various brain regions, including the sensory-motor and vestibular systems (the putamen and hippocampal regions) **[20].**

The enhanced deep neck flexor activation shown in the combined exercise group (receiving proprioceptive training as part of SSMCT) may be associ-

ated with highly expressed fine control of neck motion throughout various joint position exercises. The numerous tasks performed in joint position exercises were delicate, precise motions with a relatively low force and high execution that were appropriate for repeatedly discharging the deep neck muscles of patients' various motor units that are below the threshold. Lower threshold motor units supply small muscle fibers, which are rich in capillary beds that can withstand fatigue. Consequently, SSMCT may enhance patients' deep neck flexor activation by activating small muscle fibers [21].

Our results are linked with those of Humphreys et al. [22]. We found that 4-week eye-head-neck coordination exercises could help lower the chronic NP-related impairment level and the rates of functional impairment in patients with chronic NP.

Patients with chronic neck pain experienced significant improvements in pain, functional disability (measured by NDI), and endurance of deep neck flexors after completing a 2-month cervical proprioceptive training program that comprised exercises like head relocation, eye-follow training, gaze stability, eye-head coordination, and oculomotor exercises spread over six sessions [21].

Neck disability indexand pain intensity (measured by VAS) significantly improved when patients with chronic NP were randomly allocated to a group of 3-week conventional physical therapy (n = 20 patients) or a group of the conventional program plus gaze-directing recognition exercise (as proprioceptive training). According to the proprioceptive training group's results, NDI and pain levels were shown to be higher than those of the traditional physical therapy group [11]. Also, individuals with cervical radiculopathy who received an 8-week program of SSMCT experienced a significant reduction in both their NDI and pain perception, which is matched with our study's results of VAS and NDI [23].

Patients with persistent non-specific NP showed improved endurance of deep neck muscles, VAS, and NDI with a combination of SSMCT and physical therapy exercises, as compared with conventional exercises separately [7].

Outcomes of chronic NP patients were found to be significantly improved by adding 6-week SSMCT to traditional physiotherapy procedures. This was found to be more effective than a conventional physical program in terms of both pain severity (measured by VAS) and disability (measured by NDI) [19].

Individuals with chronic NP often exhibit deficits in sensorimotor control, especially in head and eye motion control and postural balance, despite the onset of symptoms. Changes in cervical input and subsequent alterations to sensorimotor incorporation of integrated visual, vestibular, and proprioceptive inputs are thought to be the cause of the problems. The patient's symptoms appear to be somewhat influenced by these changes. As such, it is recommended that managing difficulties related to neck pain involves acknowledging and resolving these deficiencies. Research has shown that targeted instruction for correcting problems related to head and eye movement control enhances sensorimotor function and reduces complaints from patients [24].

However, due to the low-quality evidence of the analyzed studies, a 2014 systematic review did not recommend adding proprioceptive training to a traditional physiotherapy program for treating chronic neck or back pain. This contrasts with the current positive findings of proprioceptive training as an adjunct to sensorimotor control training in this trial [25]. Future research is necessary to assess the activation level of deep neck flexors, pain, and disability in CMND patients with a severe score of NDI, across various age groups, and to evaluate the long-term follow-up to the presented results of this study.

Conclusions:

From the findings of this clinical trial, it can be concluded that there is more efficient improvement in neck function, pain intensity, and deep neck flexor activation level with a 4-week combination treatment of SSMCT and conventional physiotherapy program than with conventional physiotherapy program alone in CMND patients.

Financial support and sponsorship:

Nil.

Conflicts of interest:

No conflicts of interest.

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تأثير التدريب على التحكم الحركى الحسى الجسدى على المرضى الذين يعانون من خلل ميكانيكى مزمن فى الرقبة: تجربة عشوائية محكمة

مقدمة: أدى التدريب على التحكم الحركى الحسى الجسدى (SSMCT) إلى زيادة الاهتمام بعلاج الخلل الميكانيكى المزمن فى الرقبة (CMND) وذلك بإضافته إلى برنامج العلاج الطبيعى التقليدى.

الهدف من الدراسة: تحديد ما إذا كانت إضافة تدريب التحكم الحركى الحسى الجسدى إلى برنامج العلاج الطبيعى التقليدى مفيدًا للمرضى الذين يعانون منخلل ميكانيكى وظيفى مزمن فى الرقبة.

المرضى والطرق: إشتملت هذه الدراسة على بتجنيد ٥٦ فردًا لديهم درجة معتدلة من مؤشر إعاقة الرقبة والذين كانوا يشتكون من الخلل الميكانيكى المزمن فى الرقبة لمدة ثلاثة أشهر على الأقل. تم توزيع المرضى بشكل عشوائى إما على المجموعة أ التى تلقت برنامج العلاج الطبيعى التقليدى الذي يتكون من كمادات ماء ساخن ' تمرينات استطالة وتقوية أو مجموعة بالتى خضعت لتدريب التحكم الحركى الحسى الجسدى بالإضافة إلى برنامج العلاج الطبيعي التقليدى (ن = ٢٨ فى كل مجموعة). تم تطبيق برنامج العلاج لمدة أربعة أسابيع، ثلاث مرات فى الأسبوع. اجرى التقييم على جميع المرضى قبل وبعد التدخل بما فى ذلك شدة آلام الرقبة (التى تقاس بالمقياس التناظرى البصرى)، ومستوى تنشيط عضلات الرقبة العميقة (يقاس باختبار انثناء القحفى العنقى)، ووظيفة الرقبة (تقاس بمؤشر إعاقة الرقبة).

النتائج: لم يكن هناك فرق كبير بين المجموعتين فى المقياس التناظرى البصرى ومؤشر إعاقة الرقبة ومستوى تنشيط عضلات الرقبة فى الاختبارات القبلية، لكن ضمن تحليل المجموعة، كانت هناك زيادة كبيرة فى المقياس التناظرى البصرى ومؤشر إعاقة الرقبة، ومستوى تنشيط عضلات الرقبة العميقة فى كلا المجموعتين، لكن بالمقارنة بين المجموعتين فى الاختبار البعدى كان هناك فروق ذات دلالة إحصائية لصالح مجموعة الدراسة (قيمة p <٠,٠٥).

الاستنتاجات: استنادا إلى نتائج هذه التجربة السريرية، يمكن أن نستنتج أن تدريب التحكم الحركي الحسي الجسدي يمكن أن يكون أكثر كفاءة فى علاج المرضى الذين يعانون من خلل ميكانيكى وظيفى مزمن فى الرقبة من برنامج العلاج الطبيعى القياسى وحده.

التوصيات: هناك حاجة لإجراء دراسات مستقبلية من أجلتقييم استجابة مستوى تنشيط عضلات الرقبة العميقة والألم والإعاقة لدى مرضى CMND الحاصلين على درجة شديدة من NDI وفى الفئات العمرية المختلفة لمرضى CMND. تقييم المتابعة طويلة المدى للنتائج المقدمة لهذه الدراسة.