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PREVENTION & REHABILITATION: Randomised Clinical Trial

Effects of an integrated neuromuscular inhibition technique program on neck muscle strength and endurance in individuals with chronic mechanical neck pain

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A B S T R A C T

Background: The aim of this study was to investigate whether the application of the integrated neuromuscular inhibition technique (INIT) combined with therapeutic exercise (TE) can provide faster and greater improvement in maximum isometric strength and isometric endurance of the neck muscles in patients with chronic mechanical neck pain (CMNP).
Methods: In this 10-week, single-blind clinical trial, 40 participants (men and women) with CMNP were divided into two groups. The intervention group (IG) followed a TE program in combination with the INIT, while the control group (CG) followed the same TE program without the INIT technique. Changes in maximum isometric strength and isometric endurance of the neck muscles were evaluated before, during, and after the intervention, with follow-up measurements taken at 1, 3, and 6 months after the intervention. Analysis of variance with repeated measures was applied.
Results: Both groups showed a significant improvement in all dependent measures after the intervention ($p < .05$). These changes were maintained for both groups 6 months after the intervention. However, the IG showed a greater improvement in the maximum isometric strength of neck flexion and an improved craniocervical flexion test score compared with the CG.
Conclusion: The combination of TE and INIT had a positive effect on neck muscle strength and endurance in individuals suffering from CMNP as compared with TE alone.

1. Introduction

Neck pain is one of the most common and costly musculoskeletal disorders, with a high rate of recurrence and chronicity (O'Riordan et al., 2014; Childs et al., 2008). According to the International Association for the Study of Pain, chronic neck pain is defined as neck pain with a duration of symptoms longer than 3 months (O'Riordan et al., 2014). Many authors have reported that the persistence of symptoms is associated with changes in the biomechanics of the neck region (Falla et al., 2004; Hakkinen et al., 2004). The main contributing factor seems to be the muscular imbalance between the neck muscles and specifically between the deep and superficial neck flexors (Falla et al., 2004; Hakkinen et al., 2004; Ylinen et al., 2003), which is confirmed by electromyography (Halvorsen et al., 2014; Jull et al., 2008; Falla et al., 2003, 2006).

Numerous studies have demonstrated a reduction in neck muscle strength and endurance capacity of neck flexor muscles in people with chronic neck pain compared with healthy adults (Falla et al., 2006; Ylinen et al., 2004). Researchers have suggested that decreased neck muscle strength is highly associated with neck pain (Hakkinen et al., 2004). Similarly, isometric neck flexor strength has been linked to the severity of symptoms of chronic tension-type

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headache (Castien et al., 2015). Using electromyography, Falla et al. (2003) reported greater myoelectric manifestations of sternocleidomastoid and anterior scalene muscle fatigue in people with chronic neck pain compared with healthy individuals.

Therapeutic exercise (TE) plays a vital role in the restoration of this muscular imbalance (Blanpied et al., 2017; Gross et al., 2016; Bertozzi et al., 2013; Childs et al., 2008). According to recent guidelines (Blanpied et al., 2017; O'Riordan et al., 2014; Gross et al., 2009), the implementation of a combined (resistance and endurance) exercise program, three to five times per week for 6–12 weeks, increases neck muscle strength, reduces pain, and improves functionality (O'Riordan et al., 2014; Andersen et al., 2011; Hakkinen et al., 2008; Chiu et al., 2005; Ylinen et al., 2003).

The intensity of exercise programs for chronic neck pain depends on the type of exercise. Resistance programs are designed using 1 repetition maximum subdivisions (most commonly 12–15 repetitions maximum) (Chiu et al., 2005; Viljanen et al., 2003; Ylinen et al., 2003; Taimela et al., 2000). Often, exercise intensity is expressed as a percentage of maximum voluntary contraction with submaximal resistance levels, ranging from 20% to 80% of maximum voluntary contraction (Salo et al., 2012; Jull et al., 2009; Hakkinen et al., 2008; Ylinen, 2007). Endurance training programs are based on the performance of the craniocervical flexion test (Lluch et al., 2013; Jull et al., 2002, 2009; Ylinen, 2007; Falla et al., 2006).

Several authors have attempted to investigate the combined effect of exercise and manual techniques on neck muscle strength and neck muscle endurance in individuals with chronic neck pain, as well as the relationship between exercise adaptation and improvement in pain and disability (Beltran-Alacreu et al., 2015; Bronfort et al., 2001). To date, there is not enough evidence to support the notion that the combination of exercise and spinal manipulation, compared with exercise alone, has any additional positive effect on neck muscle strength in individuals with chronic mechanical neck pain (CMNP) (Bronfort et al., 2001). There is some evidence suggesting that the combination of manual therapy and exercise improves neck muscle fatigue (Beltran-Alacreu et al., 2015). However, this issue remains to be elucidated.

The myofascial trigger point (MTrP) has been defined as a hyperirritable spot within a taut band of skeletal muscle fibers that is painful on compression. Based on the intensity of symptoms, clinicians distinguish MTrP between active and latent (Travell and Simons, 1999). There is a limited number of studies on the effects of exercise and MTrP deactivation techniques, such as ischemic compression, in patients with chronic neck pain (Cagnie et al., 2015).

The integrated neuromuscular inhibition technique (INIT) is an MTrPs deactivation treatment protocol suggested by Chaitow (Chaitow and DeLany, 2008; Chaitow, 2006). It includes the sequence of the ischemic compression technique, the strain-counterstrain technique, and the muscle energy technique, and is aimed at locating and deactivating MTrPs. Initially, the painful spot is located by palpation and ischemic compression is applied to it. Then, retaining the compression at the spot, the muscle in which the MTrP is located is placed in a shortened position so as to reduce the pain caused by the pressure (strain-counterstrain technique). The last part of the protocol includes isometric contraction through the application of the muscle energy technique, aimed at relaxing the entire muscle in which MTrPs were found. The INIT is a technique for deactivating MTrPs that is widely used by physiotherapists in clinical practice. There is some evidence that the combination of the INIT and specific strength exercises is more effective than the application of the INIT alone in reducing pain, decreasing disability, and improving range of motion in individuals with upper trapezius trigger points (Jyothirmai et al., 2015). Nagrale et al. (2010) suggested that the INIT is more effective than the muscle energy technique, while Sibby et al. (2009) stated that the INIT is equally effective to laser application in reducing pain and disability as well as in improving range of motion in individuals with neck pain, due to the MTrPs in the upper trapezius muscle. Nevertheless, there is no evidence on the effect of the INIT in neck muscle strength and endurance in individuals with chronic neck pain and with active or latent MTrPs.

Symptoms in individuals with CMNP are linked to the presence of MTrPs (latent or active) in neck muscles (Cerezo-Tellez et al., 2008; Muñoz-Muñoz et al., 2012). Often, activities that require repetitive use of the same muscle (group) or prolonged poor postures (e.g., office workers) can lead to the development of MTrPs in neck muscles, leading to a situation called *myofascial syndrome*. This phenomenon consists of a regional pain syndrome, characterized by the presence of sensory, motor, and autonomic symptoms caused by MTrPs (Cerezo-Tellez et al., 2008). The existence of MTrPs in chronic pain is related to increased intramuscular electromyographic activity of the agonist (Ge et al., 2014) and antagonist (Ibarra et al., 2011) muscles during synergistic muscle activation as well as to increased muscle fatigue during isometric muscle contraction (Ge et al., 2012). The INIT, like most neuromuscular techniques, is based on the phenomenon of reciprocal inhibition and on post–isometric relaxation in order to combat muscle spasms in a painful area (Chaitow and DeLany, 2008). Thus, the combination of TE and the INIT on neck muscles with active or latent MTrPs could further improve neck muscle strength as well as neck muscle endurance.

Previous studies applied combined protocols of exercise and manipulation (Bronfort et al., 2001) or mobilization (Beltran-Alacreu et al., 2015) for treating chronic neck pain, but interventions combining exercise and a trigger point deactivation technique have not been previously used. The aim of this study was to investigate whether the application of the INIT combined with TE can provide faster and greater improvement in the maximum isometric strength and isometric endurance of neck muscles in patients with CMNP. We hypothesized that the combination of the INIT and exercise would better improve the muscle strength and muscle endurance of patients with chronic neck pain compared with exercise alone. To better monitor treatment effects, several intermediate measurements were performed, the aim of which was to monitor the effect of the intervention at every stage.

2. Methods

2.1. Study population

Forty outpatients diagnosed with CMNP were recruited between June 2016 and March 2017. The participants were men and women between 30 and 60 years of age. Inclusion criteria were symptom duration of at least 3 months, existence of at least one active or latent MTrP in any of the muscles (levator scapulae, upper trapezius, splenius capitis, and sternocleidomastoid), confirmed pathology by radiodiagnostic tests (i.e., X-ray or magnetic resonance imaging), and medical referral for physical therapy with the etiology of neck pain.

Exclusion criteria included the acute stage of symptoms confirmed by visual analog scale (VAS; score >70 mm), participation in any kind of treatment during the past 3 months (e.g., physiotherapy, massage, local injections of anesthetic blocks), participation in an exercise program concerning the neck muscles during the past 6 months, background of neck trauma and/or surgery in the neck region, inflammatory muscle diseases, joint infections, and malignancy.

3. Trial design

This was a single-blind, randomized controlled trial conducted in Thessaloniki, Greece. The two protocols were implemented by two experienced physiotherapists, while measurements were performed by an independent investigator who was blind to the different groups. Neither care providers nor participants could be considered to be blind to the different groups. The participants signed an informed consent form and were randomly divided into two groups. Group allocation was performed by a statistician, who was blinded to the aims of the study, using sealed envelopes. This study was undertaken in conformity with the Code of Ethics of the World Medical Association (Declaration of Helsinki). Ethical approval was granted by the Ethics Committee of the Aristotle University of Thessaloniki (No. 60576/2016).

The general study design is illustrated in a flowchart (Fig. 1). During the first meeting, individuals were asked to rate their general pain intensity on a VAS. In addition, a clinical examination of the neck and shoulder region was performed by an experienced physiotherapist to identify at least one latent or active MTrP.

Following the initial screening, any participant who met the inclusion criteria visited the clinic for a second time, and a history of their lifestyle was recorded. Subjects underwent four treatments per week for 10 weeks. In the 2nd, 4th, 6th, and 10th week, measurements were obtained in a separate (fifth) visit. The participants were not allowed to undergo any other treatment for their neck or shoulder symptoms during the intervention period. All measurements were obtained before the intervention (baseline measurements) and again after the 2nd, 4th, 6th, and the 10th week of the intervention. Furthermore, three follow-up measurements were obtained in the 14th, 22nd, and 32 nd week.

3.1. Outcome measurements

3.1.1. Changes in maximum isometric strength

Changes in the maximum isometric strength of the neck muscles were measured with a Manual Muscle Tester (FPIX 100-kg load cell; Wagner Instruments, Greenwich, CT). The maximum isometric strength of cervical flexion, extension, and side bending to the left and right were assessed with the participant in the supine and prone positions. Measurements from these positions have been characterized as being highly reliable (Shahidi et al., 2012; Dvir and Prushansky, 2008).

Measurement procedure. The measurement procedures were explained in detail to the patients. Prior to testing, patients performed some active, pain-free range of motion movements to prevent pain or injury during their effort. The dynamometer was then placed on the patient's head, and the examiner gradually increased the resistance (at a rate of about 3 kg/s), while the participant tried to keep their head from moving. Whenever the participant's head moved more than 3 or 4°, or when they gave up trying, the measuring process was terminated, and the highest value of the dynamometer was recorded in kilograms. To avoid muscle fatigue or pain, only one measurement was performed in each direction. The measurements were obtained in both the supine and prone positions.

3.1.2. Changes in isometric endurance capacity of sternocleidomastoid and anterior scalene

The isometric endurance capacity of the sternocleidomastoid and anterior scalene was assessed using an isometric test. According to many authors, endurance tests of neck flexors are characterized by medium to high reliability (Childs et al., 2008; Edmondston et al., 2008; Harris et al., 2005).

Measurement procedure. Participants were placed in the supine position with their head supported by the examination table and their neck in a small upper cervical flexion. With the help of a marker, the examiner formed a straight line between the patient's chin and the skin fold produced posterior to the mandible. Then, holding the upper cervical flexion, participants were instructed to lift their head from the table at approximately 20° and to keep this position for as long as possible while the examiner timed the effort with a digital stopwatch hand timer (Amila 44092 Professional Stopwatch). The endurance test was terminated when participants were no longer able to keep their head from touching the table or when the upper cervical flexion could not be maintained any longer. Loss of craniocervical flexion was assessed by observing the line of the marker on the individual skin fold (Fig. 2).

3.1.3. Changes in the deep flexor muscle endurance with the craniocervical flexion test

The craniocervical flexion test is a clinical test of neuromotor control of the deep cervical flexor muscles (longus capitis and longus colli). It includes the performance of five progressive stages of increasing craniocervical flexion range of motion (Fernández-de-las-Peñas et al., 2007; Childs et al., 2008). It is a low-load test performed in the supine position with the patient guided to each stage by feedback from a pressure sensor placed behind the neck (Chattanooga Stabilizer Pressure Biofeedback). Although testing in the clinical setting provides only an indirect measurement of performance, the construct validity of the craniocervical flexion test has been verified in a laboratory setting by the direct measurement of the electromyographic activity of the deep and superficial flexor muscles (Jull et al., 2008).

Measurement procedure. The test procedure was explained in detail to the participants, and they were given time to familiarize themselves with both the stabilizer device and the movement of the upper cervical flexion. The participant was placed in the supine position with their neck supported by the table. To achieve the neutral position, a small roll was placed under the occipital bone. The examiner visually checked the neutral position of the participant's head.

Then, an inflatable air-filled pressure biofeedback sensor was placed between the neck of the participant and the bed and was inflated by the participant up to 20 mm Hg. Each examiner sequentially performed the upper cervical bend movement in the five different positions of the test (22, 24, 26, 28, and 30 mm Hg), holding this pressure for 10 s at each level (Fig. 3). When participants successfully completed the 10-s effort on one level, they had a 30-s break before attempting the next level. The test was completed when the examiner could not keep the 10-s contraction on that level or when the 10-s contraction was completed at 30 mm Hg.

3.2. Testing protocols

3.2.1. Intervention group (TE and INIT)

The first group followed a TE program in combination with the INIT. The exercise program included endurance and resistance training exercises for the neck muscles and had a duration of 45 min. The main parts of the program included muscle retraining of longus colli and endurance training of the deep cervical flexors (10 s of head nodding from different upper cervical flexion angles with a stabilizer through the implementation of the craniocervical flexion test from 20 mmHg to 30 mmHg); resistance exercises for the muscles involved neck flexion, extension, side bending, and rotation of the neck region. Resistance training includes the implementation of isometric (20–70% of maximum voluntary contraction) and isotonic (with resistance to 12–15 repetitions maximum) exercise with resistance bands in all directions up to the pain limits of the participant. Active range of motion exercises for

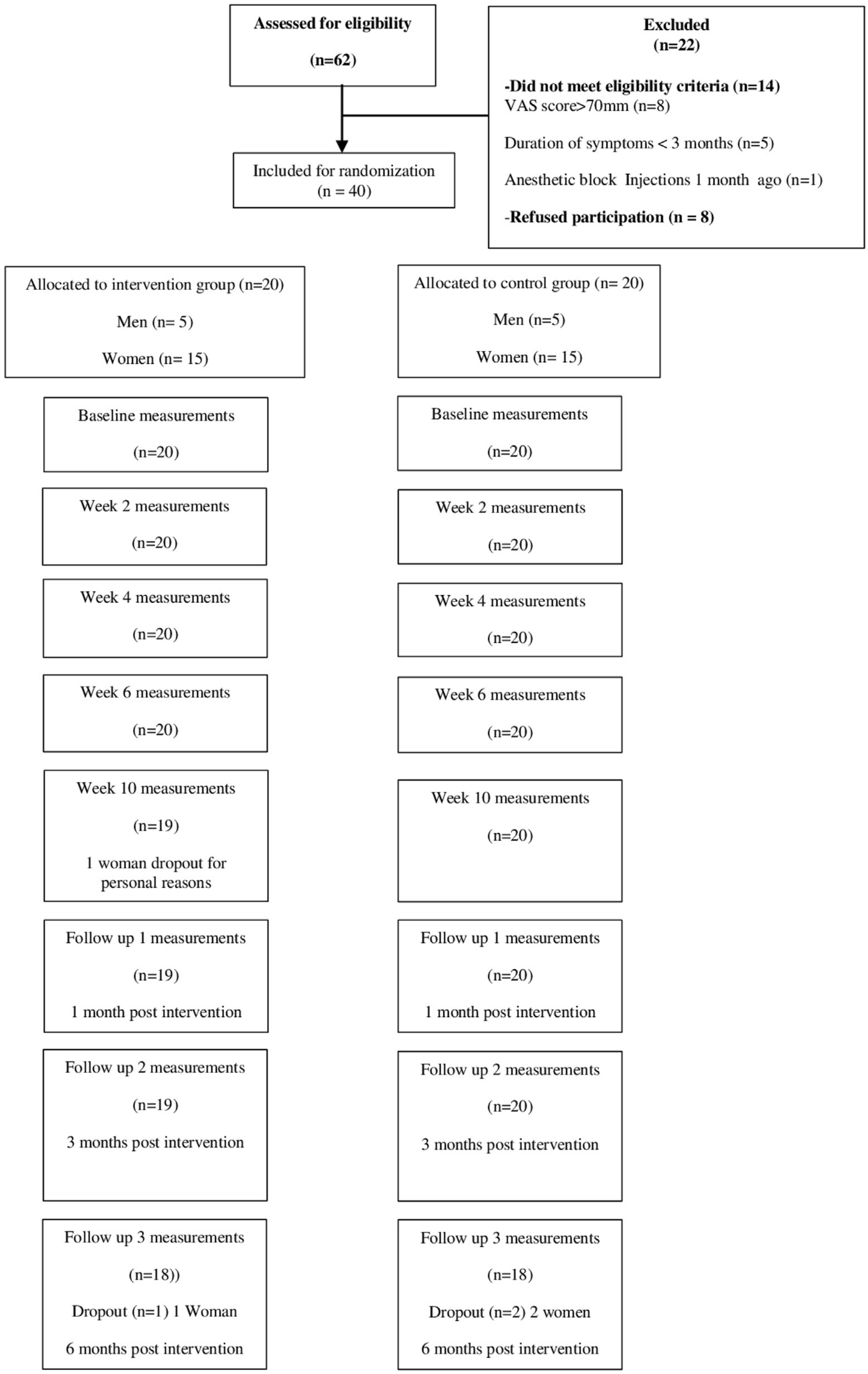

Fig. 1. Flowchart of general study design and number of participants during each phase of the study.

the neck muscles in all directions (cervical flexion, extension, left- and right-side bending and left and right turn), upper limb exercises with resistance bands for the main shoulder and upper limb muscle groups (upper trapezius, rhomboids, coracobrachialis, deltoid, biceps brachii, triceps, wrist and finger flexors); and stretching exercises for the neck (upper trapezius, levator scapulae, sternocleidomastoid) and upper limb muscles (biceps brachii, triceps, wrist and finger flexors).

Fig. 2. Cervical muscle isometric endurance test position.

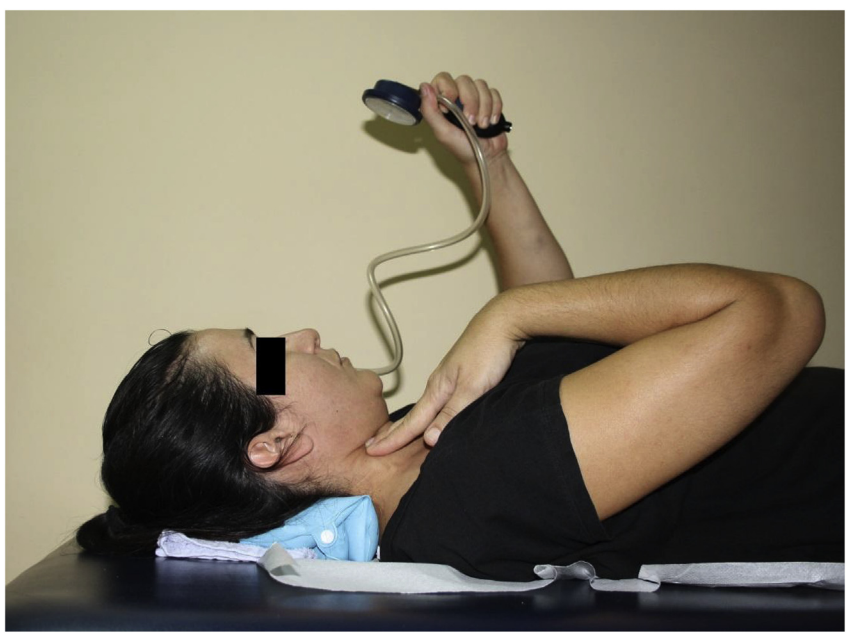

Fig. 3. Application of the craniocervical flexion test.

3.2.2. 15-Min INIT application

The INIT consists of a combined treatment protocol for the deactivation of MTrPs and has been explained by Chaitow (Chaitow and DeLany, 2008; Chaitow, 2006). This protocol includes the following sequence of techniques:

Ischemic compression. Trigger points were identified by the palpation method, and ischemic compression was applied in an intermittent manner for up to 2 min for each trigger point. Pincer grasp (for the trapezius muscle and sternocleidomastoid) or direct digital pressure (for the levator scapulae and splenius capitis muscle) was used with the patients in either the supine position or sitting upright.

Strain-counterstrain positional release technique. When general or local pain began to diminish, the muscle was placed in a position of ease and was held for approximately 20–30 s. Moderate digital pressure was applied to the identified trigger point as participants rated their level of pain on a scale ranging from 1 to 10. Ease was defined as the point at which a reduction in pain of at least 70% was achieved. Once the position of ease was identified, it was held for 20–30 s and repeated three times.

Muscle energy technique. After maintaining the ease position for 20 s, an isometric contraction, focused on the muscle fibers around the trigger point, was initiated. Each isometric contraction was held for 7–10 s and was followed by a soft-tissue stretch. Each stretch was held for 30 s, and it was repeated three times during the treatment session.

The protocol was applied to the three most painful areas of the upper border of the trapezius, sternocleidomastoid, levator scapulae, and splenius capitis muscles. Selection of the muscles took place through a palpating examination before each treatment session.

3.2.3. Control group

The protocol for this group was identical to the previous group, with the sole difference being that the application of the INIT was not included. At the end of the exercise program, a relaxing breathing exercise and gentle stretching were applied for 15 min.

3.3. Statistical analysis

Data were analyzed using SPSS Statistics for Windows, version 23.0 (SPSS Inc., Chicago, IL, USA). For the demographic characteristics of the participants, descriptive and frequencies analysis was applied. Between groups, differences related to the baseline measurements were checked using the independent samples *t*-test. No statistically significant differences in the mean values were found between the two groups in any of the baseline measurements. For each outcome parameter, normal distribution was checked with the Shapiro-Wilk test. An analysis of variance (ANOVA) was applied to each dependent variable testing the factor “Group” at two levels (Intervention Group and Control Group) and the factor “Time of Measurement” at eight time points (1st, 2nd, 4th, 6th, 10th, 14th, 22nd, and 34th week). In the case that the interaction was statistically significant, the simple main effects were reported using the post hoc test Tukey (HSD), in order to explore the effect of the group on each level of time. Only Group-by-Time interaction effects or a main effect for the factor “Time” were further examined.

Intention-to-treat (ITT) analysis methodology was used to manage the study's dropouts. Statistical significance was accepted at a level of 0.05.

A total sample size of at least 32 subjects had to be recruited based on an a priori power analysis (G*Power 3.0.10). This power analysis was performed for the within-between interaction in a repeated-measurements ANOVA with two groups, eight measurements (baseline, measurements after the 2nd, 4th, 6th, 10th, 14th, 22nd, and 34th week), a minimum power of 0.95, an effect size of 0.5, and a significance level of 0.05. At the same time, an additional 10% was added to the calculated sample size for each follow-up measurement; thus, the final sample size was 40 subjects.

Table 1
Demographics of the two groups.

Demographics	Intervention group	Control group
Age (years)	46.8 (8.85)	45.8 (7.73)
Gender (Men/Women)	25% (n = 5) Men	25% (n = 5) Men
	75% (n = 15) Women	75% (n = 15) Women
Duration of symptoms (months)	More than 12 months	
3–6 months	60% (n = 12) 3–6.	35% (n = 7) 3–6.
6–12 months	35% (n = 7) 6-12	35% (n = 7) 6-12
More than 12 months	5% (n = 1) 12+	30% (n = 6) 12+
Employment (yes/no)	65% (n = 13) Yes	65% (n = 13) Yes
	35% (n = 7) No	35% (n = 7) No
Sedentary Job (yes/no)	75% (n = 15) Yes	80% (n = 16) Yes
	25% (n = 5) No	20% (n = 4) No
Working hours/week		
Less than 20	35% (n = 7) <20	30% (n = 6) <20
Between 20 and 40	25% (n = 5) 20-40	30% (n = 6) 20-40
More than 40	40% (n = 8) >40	40% (n = 8) >40
Hours of computer work/week		
0-5 per week	35% (n = 7) 0-5	20% (n = 4) 0-5
5-10 per week	5% (n = 1) 5-10	10% (n = 2) 5-10
10-20 per week	25% (n = 5) 10-20	20% (n = 4) 10-20
More than 20 per week	35% (n = 7) >20	50% (n = 10) >20
Sports (yes/no)	30% (n = 6) Yes	35% (n = 7) Yes
	70% (n = 14) No	65% (n = 13) No
Previous Physiotherapy	95% (n = 19) Yes	85% (n = 17) Yes
	5% (n = 1) No	15% (n = 13) No

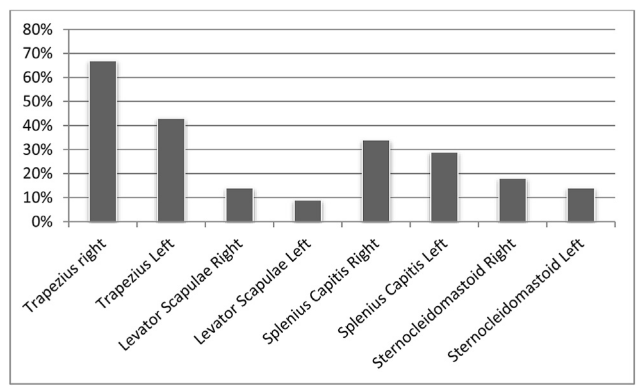

Fig. 4. Incidence of trigger points in the whole sample in the baseline assessment. Trapezius right = 67%; trapezius left = 43%; levator scapulae right = 14%; levator scapulae left = 9%; splenius capitis right = 34%; splenius capitis left = 29%; sternocleidomastoid right = 18%; sternocleidomastoid left = 14%.

4. Results

4.1. Subjects

Demographic features of both treatment groups are summarized in Table 1. Two patients in the IG and two patients in the CG dropped out during the course of the study (Fig. 1). In both groups, most of the participants were women (75%), 65% of each group were employed, and most had an office job. Sixty-five percent of the IG and 70% of the CG performed some exercise. Furthermore, 40% of the participants of each group spent more than 40 h per week in front of a computer. The duration of the participants' symptoms of both groups varied from 3 months to more than 12 months. Almost all participants followed previous physiotherapy treatment on account of neck pain. The majority of MTrPs were found in the trapezius muscle (right = 67%, left = 43%) and the splenius capitis (right = 34%, left = 29%). A smaller number of MTrPs was found in the levator scapulae (right = 14%, left = 9%) and the sternocleidomastoid (right = 18%, left = 14%; Fig. 4).

4.2. Outcome measures

4.2.1. Maximum isometric strength

The two-way ANOVA displayed a significant main interaction effect between the Time and Group factors ($p < .001$) for neck flexion and neck extension maximum isometric strength, whereas a main effect of Time measurements ($p < .05$) was observed on all maximum isometric strength directions (flexion, extension, right- and left-side bending). However, between groups, the differences were observed only in the maximum isometric strength flexion values (Table 2). Tukey's (HSD) post hoc test displayed a significant increase in the maximum isometric strength of neck flexion in the IG from the fourth week ($p = .019$). This difference between groups was maintained in the 10th week ($p = .007$) as well as at the 6-month follow-up ($p = .046$).

4.2.2. Isometric endurance of sternocleidomastoid and anterior scalene

The two-way ANOVA did not demonstrate any significant main interaction effect between the Time and Group factors for the endurance test ($p > .05$), whereas there was a main effect on Time ($p < .001$; Table 3).

Table 2
Flexion, extension, and right- and left-side bending maximum isometric strength (MIS) mean value (*SD*) measurements before the treatment, weekly during the intervention, directly after the treatment period, and at 1-, 3-, and 6-month follow-up in the two patient groups.

	Before treatment	After 2 weeks	After 4 weeks	After 6 weeks	After 10 weeks	1-month follow-up	3-month follow-up	6-month follow-up
Flexion MIS, kg								
IG	5.77 (1.71)	6.147 (1.74)	7.40 (1.66)	8.74 (1.92)	10.93 (1.46)	10.79 (1.79)	9.99 (1.85)	9.66 (1.99)
CG	5.72 (1.44)	5.93 (1.51)	6.18 (1.49)	7.74 (1.77)	9.54 (1.63)	9.20 (1.50)	8.99 (1.37)	8.55 (1.35)
Extension MIS, kg								
IG	12.92 (2.29)	13.47 (2.10)	15.15 (2.19)	16.00 (2.19)	17.14 (2.13)	16.87 (2.03)	16.50 (2.12)	16.19(2.01)
CG	13.14 (1.90)	13.80 (1.60)	14.08 (1.50)	14.92 (1.49)	16.32 (1.58)	15.83 (2.68)	15.75 (1.76)	15.30 (1.84)
Right-side bending MIS, kg								
IG	12.81 (2.06)	13.19 (1.82)	14.22 (2.13)	16.03 (2.44)	18.10 (2.44)	18.33 (2.55)	17.70 (2.15)	17.56 (2.07)
CG	12.77 (1.63)	12.90 (1.66)	13.22 (1.59)	15.13 (2.26)	17.81 (2.61)	17.34 (2.45)	17.08 (2.29)	16.74 (2.31)
Left-side bending MIS, kg								
IG	12.26 (2.02)	12.88 (1.76)	13.37 (1.86)	15.74 (2.33)	17.66 (2.30)	17.84 (2.29)	17.69 (2.26)	17.41 (2.05)
CG	12.44 (1.54)	12.82 (1.50)	13.05 (1.51)	15.30 (2.14)	17.32 (2.28)	17.15 (1.99)	16.97 (2.08)	16.59 (2.00)

4.2.3. Craniocervical flexion test

The two-way ANOVA showed a significant main interaction effect between the Time and Group factors ($p < .001$), as well as a main effect on Time measurements concerning the craniocervical flexion test score on the neck (Table 3). Using Tukey 's (HSD) post hoc test, a difference between groups was observed in the fourth week ($p = .038$).

5. Discussion

In the present study, both groups followed the same exercise protocol, based on the protocol detailed by Jull et al. (2002), tailored to the latest clinical guidelines (Blanpied et al., 2017; Gross et al., 2015, 2016; Bertozzi et al., 2013; Childs et al., 2008). Considering there were no statistically significant differences between the two groups in any baseline measurement nor in participant characteristics, the changes can be attributed to the application of the INIT.

As the results of the current study showed, the maximum isometric strength score increased in both groups after the intervention (Table 2). Even where there was a tendency for further improvement in maximum isometric strength in all directions for the IG, differences between groups were detected only in the maximum isometric strength of the neck flexors. This increase corresponded to 89.4% for IG and 66.8% for CG during the 10 weeks of the intervention and lasted for 6 months after the intervention. It is worth mentioning that the differences between groups began to appear in the fourth week and remained until the end of the intervention period (10 weeks). According to many authors (O'Riordan et al., 2014; Andersen et al., 2011; Chiu et al., 2005; Ylinen et al., 2003), in patients with chronic neck pain, a minimum 6-week period of resistance or endurance training is required for neck and scapular muscle hypertrophy to occur. The fact that the IG displayed differences in the mean flexor maximum isometric strength values beginning in the fourth week can be explained by the impact of combining the INIT and TE. Perhaps such a combination contributed to better management of the IG patients' symptoms during the exercise program, allowing them to avoid any kind of reactions on the part of the neck muscles related to spasms or pain owing to MTrPs. Thus, it is possible that the adaptations to exercise were smoother and faster in the IG.

It is also important to note that the statistically significant difference between the groups remained for 6 months after the intervention (Table 2). According to Miller and colleagues (2010), the effects of combined treatment protocols do not last for long periods after the intervention. It is likely that the therapeutic combination of the INIT and exercise could have better long-term results. However, this issue remains to be determined.

The results of this study are in agreement with the findings of other studies that applied resistance protocols of TE either alone (Chiu et al., 2004; Ylinen et al., 2003) or in combination with manual therapy (Bronfort et al., 2001). Hakkinen et al. (2007). These studies state that manual therapy is effective in reducing pain in individuals with chronic neck pain but that it does not, on its own, constitute an efficient method to increase muscle strength. However, contrary to results by Bronfort et al. (2001), who did not find any further improvement from the combination of TE and manipulation, the INIT application seems to have been responsible for the further increase of maximum isometric strength flexor values in the IG.

The isometric endurance score of the sternocleidomastoid and anterior scalene was improved in both groups after the intervention ($p < .001$), and both groups showed a major improvement during the intervention period (Table 3). The isometric endurance time was improved to 43.6% for the IG and to 35.9% for the CG. This positive impact was maintained for both groups for 6 months. However, there were no differences between the groups, and thus we cannot claim that the combination of the INIT and exercise further increases neck muscle endurance. These results contradict the findings of Beltran-Alacreu et al. (2015), who highlighted the positive effect of multimodal treatment in neck muscle endurance.

The craniocervical flexion test score was increased in both groups after the intervention ($p < .01$). This increase corresponded to 20.3% for the CG and 13.3% for CG. The increased craniocervical flexion test value was maintained in all three follow-up

Table 3
Isometric endurance (IE) and *craniocervical flexion test* (CCFT) score mean value (*SD*) measurements, before the treatment, weekly during the intervention, directly after the treatment period, and at 1-, 3-, and 6-month follow-up in the two patient groups.

	Before treatment	After 2 weeks	After 4 weeks	After 6 weeks	After 10 weeks	1-month follow-up	3-month follow-up	6-month follow-up
IE, seconds								
IG	24.44 (6.91)	26.27 (6.93)	27.91 (6.75)	31.28 (7.07)	35.08 (8.35)	34.32 (8.12)	33.12 (8.25)	32.00 (7.57)
CG	23.88 (4.90)	24.41 (5.41)	26.21 (5.18)	28.48 (6.14)	32.46 (7.48)	31.01 (6.89)	30.58 (6.78)	29.29 (7.07)
CCFT score								
IG	23.60 (1.66)	24.10 (1.51)	26.00 (1.71)	28.45 (2.56)	28.45 (2.56)	26.90 (1.88)	26.90 (2.10)	26.40 (1.78)
CG	24.00 (1.29)	24.30 (1.49)	24.90 (1.51)	27.20 (1.64)	27.20 (1.64)	26.90 (1.99)	26.10 (1.88)	25.70 (1.75)

measurements for both groups (Table 3). Endurance improvement was related to the fact that endurance training was part of the TE protocol (Jull et al., 2008; Hakkinen et al., 2007). However, from Tukey's (HSD) post hoc test, differences between groups were observed only during the fourth week, whereas no differences were found during the 10th week or at the 6-month follow-up measurement. This fact reinforces the conclusion that the adaptation in the IG took place earlier than in the CG. That means that the addition of the INIT to exercise had an additional positive effect on the endurance of the deep flexor muscles compared with exercising alone, contributing to the faster adaptation to exercise. The differences between the IG and CG groups may be explained by the fact that pain related to chronic neck pain and the therapeutic reaction of neck muscles to exercise is connected to the presence of muscular spasm and the existence of trigger points in the neck muscles. Thus, the combination of TE and trigger point deactivation techniques may be more appropriate for these patients. We assume that by helping patients achieve smoother, faster, and more effective benefits of exercise adaptation, the combination of TE and INIT also contributes to long-term adherence to exercise. This treatment can further improve physical therapy management of patients with CMNP in clinical practice.

Some limitations of this study must be taken into account. Neither the patients nor the therapists could be blinded to the study intervention. In addition, the relatively small sample size may have influenced the results. Furthermore, the INIT was applied to only three muscles in each therapy session; thus, it could not completely cover the patients of this group, as some may have had symptoms in more than three muscles on both sides of the body.

6. Conclusion

The therapeutic combination of TE and INIT was found to be more effective than TE alone in increasing neck muscle strength and endurance in individuals with CMNP. There was a significant difference between groups in the maximum isometric strength of neck flexors beginning in the fourth week, which remained for 6 months after the intervention. In addition, the combination of the INIT and TE appears to contribute to the earliest endurance training adaptation in the deep neck flexors. Studies that include TE and trigger point deactivation techniques should be conducted in the future in patients with CMNP.

Declarations

Declaration of interest

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