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EFFECT OF 6-WEEK SHOULDER AND NECK EXERCISES ON IMPROVING NECK DISABILITY OF MIDDLE-AGED AND OLDER ADULTS WITH CHRONIC NECK PAIN

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ABSTRACT

This study explored the effectiveness of 6-week programme involving shoulder and neck exercises on improving the neck disability of middle-aged and older adults with chronic neck pain. Participants in the Intervention Group (IG) were asked to participate in a 6-week training programme of shoulder and neck exercises, thrice a week, in addition to receiving passive modalities. The Control Group (CG) received passive modalities only. A primary outcome measure was change in Neck Disability Index (NDI) and secondary outcome measures involved changes in pain scores on a visual analogue scale and Cervical Range of Motion (CROM). Assessments were conducted at baseline and after 6-week intervention. In total, 72 participants were recruited for randomised controlled study. After the intervention, the pain scores, NDI and CROM of the IG displayed more significant improvement in the post-test than did the CG. The IG achieved significant improvement in NDI (-7.15 scores; $p<0.001$), pain scores (-27.97mm; $p<0.001$) and CROM ($p<0.001$) after the intervention. The intervention can reduce NDI scores, reduce the self-reported perception of pain scores, and improve CROM of middle-aged and older adults with chronic neck pain.

***Keywords*:** Exercise; Neck Disability Index (NDI); Neck pain; Cervical Range of Motion (CROM); Rehabilitation.

INTRODUCTION

Neck pain is a common musculoskeletal disorder. According to a systematic analysis of 195 countries and territories from 1990–2017, the percentage of neck pain experienced ranged from 41.9% to 23.6% in the total population (GBD, 2017) from the Disease and Injury Incidence and Prevalence Collaborators, 2018 project. Data revealed that the prevalence of neck pain in 2017 among middle-aged and older adults was 19.0% to 23.5%, its prevalence in women was higher than in men (Genebra *et al*., 2017). In a 2014-survey of safety and health perceptions in work environments in Taiwan, 88.9% of employees perceived physical ailments in the past year;

among them, 56.9% reported neck pain (Lin & Guo, 2014).

Neck pain influences the work competence, social activities, daily activities, Cervical Range of Motion (CROM) of adults (Chiu & Leun, 2006; Muñoz *et al*., 2016) and attains a moderate correlation with neck disorder (Ris *et al*., 2019) and deep neck muscle strength and endurance (Falla *et al*., 2004; Karimi *et al*., 2016). In clinical practice, patients with neck pain generally receive passive modalities to alleviate discomfort (Kroeling *et al*., 2013; Yang *et al*., 2017), however, passive modalities cannot improve the motor control of neck muscles and cervico-ocular reflex incoordination (Blouin *et al*., 2007; De Vries *et al*., 2016) to enable normal functioning in daily life activities.

Individuals with neck disorders often experience a high activity level of the axioscapular muscles and a low level of the lower trapezius and serratus anterior (Wegner *et al*., 2010; Zakharova-Luneva *et al*., 2012). These changes may lead to scapular dysfunction and neck pain. Conducting a systematic review, Damgaard *et al*. (2013) demonstrated that combined exercise and multimodal physiotherapy programmes can relieve Chronic Neck Pain (CNP). Although intervention exercises for deep neck and axioscapular muscles are important treatments for neck pain (Wegner *et al*., 2010; Zakharova-Luneva *et al*., 2012; Bobos *et al*., 2016), the effectiveness for patients with CNP is not clear. This study hence aims to assess the effectiveness of those physiotherapy intervention programmes for patients with CNP.

The duration of the exercise programmes of previous studies was long and often ranged from 10 to 20 weeks. A long schedule may compromise compliance and effectiveness of the participants (Gallego *et al*., 2016; Lauche *et al*., 2016; Peolsson *et al*., 2016; Saeterbakken *et al*., 2017). Using a portable training tool and short period of intervention, the study designed an easy programme. It was hypothesised that shoulder and neck exercises with passive modalities had better improvement on neck disability than passive modalities among middle-aged and older adults with mild chronic neck pain. Therefore, the present study explored the effectiveness of an intervention programme that combines 6-week shoulder and neck exercises with passive modalities (consisted of hot pack, interferential current therapy and cervical traction) in relieving neck pain.

METHODOLOGY AND DESIGN

Study design

A randomised, controlled, blindly evaluated intervention trial was adopted in this study. Participants were randomly assigned to the Intervention Group (IG) or the Control Group (CG) in a 1:1 allocation ratio. Randomisation was performed by a computer-generated programme and was given to the principal investigator in a series of sealed envelopes. The IG received 35–55 minutes of shoulder and neck exercises combined with passive modalities 3 times per week for 6 consecutive weeks. By contrast, the CG received passive modalities. Participants had to attend 90% of their scheduled intervention visits to be considered compliant with treatment. Those who did not complete treatment were withdrawn from the study.

Participants

After visiting physicians in the rehabilitation department of a medical centre in Taipei, 72 participants experiencing a non-specific neck pain with or without radiculopathy for three months or more were recruited between December 2015 and June 2016. During the screening process, all eligible participants were interviewed and examined personally by a seasoned

clinical physiotherapist with 10 years of experience.

Study protocols, including participants, sample size calculation and ethical consideration, have been previously described (Lin *et al*., 2018). The inclusion criteria were as follows: age 45 years or older, sustained neck pain for over three months and a Visual Analogue Scale (VAS) exceeding 30mm regarding neck pain. The exclusion criteria were as follows: age younger than 45 years, history of spine surgery, major cardiovascular diseases, rheumatoid arthritis, pregnancy, shoulder impingement syndrome, spinal tumour and participated in a neck exercise programme in past 12 months.

(A) CCFE

(B) PEBRE-MBE

(C) PEBRE-MPNFDFE

Figure 1. **SHOULDER AND NECK EXERCISES**

CCFE = Craniocervical Flexion Exercise; PEBRE = Progressive Elastic-Band Resistance Exercises; MBE = Modified Brügger's Exercise MPNFDFE =Modified Proprioceptive Neuromuscular Facilitation Diagonal Flexion Exercise

Interventions

Physiotherapists presented the 6-week passive modalities for the treatment of both IG and CG. Passive modalities were composed of interferential current therapy (Audiotron; EF-150, OG Giken Co., Okayama, Japan) for 15 minutes at a frequency of 2140-2500 Hz, intermittent cervical traction (Orthotrac, OL-2000, OG Giken, Inc., Japan) where the force gradually increases from 14% of bodyweight to a maximum of 25% of bodyweight in a neutral position and 30° flexion for 17 minutes per time and heat pack for 15 minutes, 3 times per week for 6 weeks. The intensity of the passive modalities treatment period does not cause discomfort.

Participants in the IG received 35-55 minutes of progressive shoulder and neck exercises consisting of Craniocervical Flexion Exercise (CCFE) and Progressive Elastic-Band Resistance Exercises (PEBRE) (Figure 1) with one-on-one supervision performed three times per week for 6 consecutive weeks. Based on the muscle training principle of the American College of Sports Medicine, a qualified and experienced physical therapist conducted the exercise programme. The muscle-strengthening activities were repeated 10-15 times (60-70% 1RM) each set. The intensity and number of repetitions of the activities were adjusted every two weeks. Details of the movements involved can be found in Appendix and Figure 1.

According to the CCFE designed by Falla *et al*. (2006), a pressure biofeedback unit (Stabilizer Chattanooga Group, South Pacific) was adopted for the training procedure. This study adopted a PEBRE through the use of Thera-Band (Hygienic Corporation, Akron, OH, USA). Prior to exercise initiation, the most suitable training intensity was established for each participant. To determine the initial training intensity, different levels of elastic-band resistance were employed to measure the 10-Repetition Maximum (RM) using the modified Brügger's exercise (MBE) (Pavlu *et al*., 2007) and the Modified Proprioceptive Neuromuscular Facilitation Diagonal Flexion Exercise (MPNFDFE) (Adler *et al*., 2007). The 10-RM test process was repeated every two weeks and new elastic bands were used to replace the old ones. Prior to the experiment, 30 participants were asked to perform this measurement for test-retest reliability analysis. The correlation coefficients of MBE and MPNFDFE were determined to be 0.75 and 0.77, respectively. No adverse events were found in the database.

Outcome measurements

The primary outcome was assessed through the Neck Disability Index (NDI). The secondary outcomes were assessed through the VAS and CROM. The assessments were conducted on a day that the participants did not receive any therapy. Both pre- and post-intervention measurements were done in the same manner.

The original NDI questionnaire was created by Vernon and Mior (1991) and the translation and validation study of the Chinese NDI versions by Wu *et al*. (2010) has been done. Self-reported neck function was measured using the Chinese version of the NDI. The Chinese questionnaire has high internal consistency (Cronbach's alpha = 0.89) (Gallagher *et al*., 2002) with a one-week test-retest reliability of 0.95. The present study applied the translated questionnaire with the authorisation from Vernon (2008) and Wu *et al*. (2010). The NDI questionnaire comprises 10 items, aiming to evaluate the influence of neck pain on the respondent's daily life.

Each item is rated from 0 (no influence) to 5 points (unable to perform the daily activity described under the influence of severe neck pain) according to different levels of pain description that the respondents select. The full score is 50 points. The higher the score, the more serious the neck pain. For example, a score lower than '4' represents no disability; '5-14'

mild disability; '15-24' moderate disability; '25-34' severe disability; '35' or higher complete disability (Vernon & Mior, 1991). Before the formal experiment, 6 participants who did not participate in the study were asked to complete the NDI for test-retest analysis, with the correlation coefficient determined to be 0.96.

VAS was employed to assess the subjective perceptions of pain scores of the participants. VAS is a 100mm straight line that represents the pain scores, with the left end (0mm) and the right end (100mm) signifying no pain and extreme pain, respectively. Participants mark a short line perpendicular to the scale to indicate their perceived pain scores at rest. The pain scores is then recorded in millimetres. The correlation coefficient of VAS can reach 0.99 (Gallagher *et al*., 2002). Before the formal experiment, 6 participants who did not participate in the study were asked to complete the VAS accordingly for test-retest analysis, attaining a correlation coefficient 0.99.

To measure the CROM of the participants, a CROM instrument (CROM Deluxe, Performance Attainment Associates, Lindstrom, MN) was used. The participants were seated on a chair with back support and were asked to perform the maximum angles of flexion, extension, and side bending and rotation until they felt pain (http://www.spineproducts.com/). In each direction, the mean CROM derived from the three angles was obtained. Audette *et al*. (2010) reported the CROM intraclass correlation coefficient to be 0.89–0.98. Before the formal experiment, 6 participants who did not participate in the study were asked to complete the CROM test accordingly for test-retest analysis, attaining a correlation coefficient from 0.83 to 0.89.

Statistical analysis

IBM SPSS 20.0 for Windows was employed to process and analyse the collected data. All data were normally distributed and the variability of scores for each of the group similar. Descriptive statistics of categorical data, such as gender, educational attainment and administration of oral analgesic were presented in percentage and subjected to the chi-square test. The participants' age, body height, body weight, daily work duration, time since diagnosis, VAS, NDI and CROM were presented as means and standard deviations to conduct an independent t-test to measure the differences between IG and CG before the intervention.

The number and percentage of those participants who used oral analgesics during the study period was presented. A chi-square test was conducted to compare the differences between the IG and CG post-intervention. Inferential statistics were performed using a Generalised Estimating Equation (GEE) to estimate the intervention effectiveness of the 6-week shoulder and neck exercises. Statistical significance was set at $p<0.05$.

Ethical considerations

The Institution Review Board of Taipei Medical University (N201508012) reviewed and approved the research protocol in the spirit of the Helsinki Declaration. All participants gave their written informed consent before data collection commenced. The trial was prospectively registered with the International Standard Registered Clinical Trial Number (ISRCTN51622393).

RESULTS

This study recruited 72 participants from a hospital in Taipei, who met the inclusion criteria

and signed a consent form. Participants were randomly and evenly assigned to either the IG or CG. In the IG, three participants could not continue because of private reasons, whereas in the CG, two could not continue because of private factors and one was on a business trip. Eventually, 33 participants in the IG and 33 participants in the CG completed the pre-test and post-test.

The demographic analysis results revealed that the statistical distributions of the participants in the IG and CG showed no significant difference ($p>0.05$) in any of the aforementioned demographic data, as shown in Table 1.

Table 1. **DEMOGRAPHICS OF PARTICIPANTS'**

Parameter	IG	CG	p-Value
Participants (n)	33	33	
Gender (n), males/females	8/25	13/20	0.19
Age (years), M±SD	57.30±8.74	58.15±8.17	0.69
Body height (cm), M±SD	162.06±7.76	160.70±7.50	0.47
Body weight (kg), M±SD	62.09±10.32	65.55 ±13.67	0.25
Daily work duration (hours) , M±SD	5.24±3.82	6.00±3.50	0.40
Time since diagnosis (months), M±SD	64.39±64.15	42.15±39.77	0.10
Education attainment [n (%)]			
Elementary school	4 (12.1%)	3 (9.1%)	0.41
Junior high school	5 (15.2%)	7 (21.2%)	
Senior high school	5 (15.2%)	10 (30.3%)	
Undergraduate or higher	19 (57.5%)	13 (39.4%)	
Oral analgesic [n (%)]			
Yes	27 (81.8%)	26 (78.8%)	0.76
No	6 (18.2%)	7 (21.2%)	

IG=Intervention Group (neck shoulder exercise + physical modalities)
CG=Control Group (physical modalities) M= Mean SD=Standard Deviation

The use rate in oral analgesics of the IG dropped from 27 (81.8%) to 24 (72.7%) after the intervention, compared with the CG from 26 (78.8%) to 25 (75.8%). The IG had higher use rate change in oral analgesics than the CG, however, the difference was not significant.

Primary outcome: NDI

After the 6-week shoulder and neck exercise intervention, the NDI of the IG dropped from 14.54±3.75 to 5.30±3.04 points, demonstrating a reduction of 9.24 points (−64%) between the pre-test and the post-test ($p<0.001$). The NDI of the CG declined from 13.54±4.78 to 11.45±5.03 points, marking a reduction of 2.09 points (−15%) between the pre-test and the post-test ($p<0.001$) (Table 2). The GEE was used to analyse the interaction between group and time, confirming that the NDI reduction from pre-test to post-test in the IG was 7.15 point ($p<0.001$) greater than that in the CG. The 6-week shoulder and neck exercise intervention significantly reduced NDI (Table 3).

Table 2. **CHANGE IN NDI, PAIN, CROM AFTER INTERVENTION**

OUTCOMES	Intervention Group (*n* = 33)			Control Group (*n* = 33)		
	Pre-test M±SD	**Post-test M±SD**	**△ (%)**	**Pertest M±SD**	**Post-test M±SD**	**△ (%)**
Primary						
NDI (score)	14.54±3.75	5.30±3.04	- 9.24 (64)**	13.54±4.78	11.45±5.03	- 2.09 (15)**
Secondary						
Pain (mm)	51.60±14.62	17.21±16.44	- 34.39 (67)**	47.81±13.88	41.39±18.89	- 6.42 (13)*
CROM (°)						
Flexion	37.09±10.37	44.97±8.76	7.88 (21)**	39.37±8.66	39.78±8.28	0.41 (1)
Extension	52.90±14.02	63.32±13.40	10.42 (20)**	52.45±12.08	49.74±14.21	- 2.71 (5)
Right lat. flex.	27.31±7.12	34.01±8.02	6.70 (25)**	29.51±6.46	28.63±7.21	- 0.88 (3)
Left lat. flex.	29.72±8.02	36.41±8.62	6.69 (23)**	31.12±7.33	29.30±7.75	- 1.82 (6)
Right rotation	56.84±11.72	69.74±10.07	12.90 (22)**	60.74±10.00	58.39±9.28	- 2.35 (4)
Left rotation	57.54±8.96	68.00±10.94	10.46 (18)**	57.88±10.72	56.52±10.22	- 1.36 (2)

IG = Intervention Group (neck shoulder exercise + physical modalities) CG = Control Group (physical modalities) M=Mean
NDI = Neck Disability Index; CROM =Cervical Range of Motion; Lat. flex. = Lateral Flexion SD=Standard Deviation
△ (%)=Post-test–pre-test (△/pre-test)=Change variable values in percentage * $p<0.05$ ** $p<0.001$

Secondary outcomes: PAIN

After the 6-week shoulder and neck exercise intervention, the self-reported perception of pain scores of the IG dropped from 51.60±14.62mm to 17.21±16.44mm, marking a reduction of 34.93mm (−67%) between the pre-test and the post-test ($p<0.001$). The self-reported perception of pain scores of the CG dropped from 47.81±13.88mm to 41.39±18.89mm, attaining a reduction of 6.42mm (−13%) between the pre-test and post-test ($p<0.05$). This indicated that the 6-week physical modalities was also able to reduce the self-reported perception of pain scores of the CG significantly, as shown in Table 2. The GEE was used to analyse the interaction between groups (IG vs. CG) and time (pre-test vs. post-test), revealing that the self-reported perception of pain scores' reduction from pre-test to post-test in the IG was 27.97 mm ($p<0.001$) higher than that in the CG. The training 6-week shoulder and neck exercise intervention significantly reduced the self-reported perception of pain scores (Table 3).

Table 3. **NDI, PAIN, CROM WITH INTERACTIONS OF "GROUP x TIME" USING GEE MODELS**

Parameter	Estimate	SE	95% CI Lower	95% CI Upper	Z	p-Value
NDI (score)						
Group* x time**	-7.15	0.87	-8.85	-5.45	-8.24	<0.001
PAIN (mm)						
Group* x time**	-27.97	3.83	-35.47	-20.47	-7.31	<0.001
CROM[e] (°)						
Flexion						
Group* x time**	7.47	1.60	4.32	10.61	4.66	<0.001
Extension						
Group* x time**	13.13	2.70	7.85	18.42	4.87	<0.001
*Right lateral flex*ion						
Group* x time**	7.58	1.11	5.41	9.75	6.84	<0.001
Left lateral flexion						
Group* x time**	8.51	1.26	6.04	10.99	6.74	<0.001
Right rotation						
Group* x time**	15.25	2.01	11.31	19.18	7.59	<0.001
Left rotation						
Group* x time**	11.82	2.03	7.84	15.81	5.81	<0.001

SE = Standard Error NDI = Neck Disability Index CROM = Cervical Range of Motion
CI=Confidence Interval * Group=Intervention vs. Control Group ** Time=pre-test vs. Post-test

CROM-flexion angle

After the 6-week shoulder and neck exercise intervention, the CROM-flexion angle of the IG increased from 37.09±10.37 to 44.97±8.76 degrees, indicating an increase of 7.88 degrees (21%) between the pre-test and post-test ($p<0.001$). In the CG, the CROM-flexion angle

increased from 39.37±8.66 to 39.78±8.28 degrees, exhibiting an increase of 0.41 degrees (1%; $p>0.05$), as shown in Table 2. The GEE was used to analyse the interaction between group and time, verifying that the increase from pre-test to post-test in the CROM-flexion angle in the IG was 7.47 degrees ($p<0.001$) greater than that in the CG. This indicates that the 6-week shoulder and neck exercise intervention significantly increased the CROM-flexion angle, as shown in Table 3.

CROM-extension angle

After the 6-week shoulder and neck exercise intervention, the CROM-extension angle of the IG increased from 52.90±14.02 to 63.32±13.40 degrees, marking an increase of 10.42 degrees (20%) between the pre-test and post-test ($p<0.001$). In the CG, the CROM-extension angle decreased from 52.45±12.08 to 49.74±14.21 degrees, denoting a decrease of 2.71 degrees (−5%) between the pre-test and post-test ($p>0.05$), as shown in Table 2. The GEE was used to analyse the interaction between group and time, showing that the increase from pre-test to post-test in the CROM-extension angle in the IG was 13.13 degrees ($p<0.001$) greater than that in the CG. This implies that the 6-week shoulder and neck exercise intervention significantly increased the CROM-extension angle (Table 3).

CROM-right lateral flexion angle

After the 6-week shoulder and neck exercise intervention, the CROM-right lateral flexion angle of the IG increased from 27.31±7.12 to 34.01±8.02 degrees, indicating an increase of 6.70 degrees (25%) between the pre-test and post-test ($p<0.001$). In the CG, the CROM-right lateral flexion angle decreased from 29.51±6.46 to 28.63±7.21 degrees, attaining a decrease of 0.88 degrees (−3%) between the pre-test and post-test ($p>0.05$) (Table 2). The GEE was used to analyse the interaction between group and time, revealing that the increase from pre-test to post-test in the CROM-right lateral flexion angle in the IG was 7.58 degrees ($p<0.001$) greater than that in the CG. The 6-week shoulder and neck exercise intervention significantly increased the CROM-right lateral flexion angle (Table 3).

CROM-left lateral flexion angle

After the 6-week shoulder and neck exercise intervention, the CROM-left lateral flexion angle of the intervention group increased from 29.72±8.02 to 36.41±8.62degrees, indicating an increase of 6.69 degrees (23 %) between the pre-test and post-test ($p<0.001$). In the control group, the CROM-left lateral flexion angle decreased from 31.12±7.33 to 29.30±7.75 degrees, demonstrating a decrease of 1.82 degrees (−6%) between the pre-test and post-test ($p>0.05$), as shown in Table 2. The GEE was used to analyse the interaction between group and time, confirming that the increase from pre-test to post-test in the CROM-left lateral flexion angle in the intervention group was 8.51 degrees ($p<0.001$) greater than that in the control group. This implies that the 6-week shoulder and neck exercise intervention significantly increased the CROM-left lateral flexion angle, as shown in Table 3.

CROM-right rotation angle

After the 6-week shoulder and neck exercise intervention, the CROM-right rotation angle of the IG increased from 56.84±11.72 to 69.74±10.07 degrees, marking an increase of 12.90 degrees (22%) between the pre-test and post-test ($p<0.001$). In the CG, the CROM-right rotation angle decreased from 60.74±10.00 to 58.39±9.28 degrees, indicating a decrease of 2.35

degrees (−4%) between the pre-test and post-test ($p>0.05$) (Table 2). The GEE was used to analyse the interaction between group and time, verifying that the increase from pre-test to post-test in the CROM-right rotation angle in the IG was 15.25 degrees ($p<0.001$) greater than that in the CG. This indicates that the 6-week shoulder and neck exercise intervention significantly increased the CROM-right rotation angle (Table 3).

CROM-left rotation angle

After the 6-week shoulder and neck exercise intervention, the CROM-left rotation angle of the IG increased from 57.54±8.96 to 68.00±10.94 degrees, denoting an increase of 10.46 degrees (18%) between the pre-test and post-test ($p<0.001$). In the CG, the CROM-left rotation angle decreased from 57.88±10.72 to 56.52±10.22 degrees, exhibiting a decrease of 1.36 degrees (−2%) between the pre-test and post-test ($p>0.05$) (Table 2). The GEE was used to analyse the interaction between group and time, revealing that the increase from pre-test to post-test in the CROM-left rotation angle in the IG was 11.82 degrees ($p<0.001$) greater than that in the CG. Thus, the 6-week shoulder and neck exercise intervention significantly increased the CROM-left rotation angle (Table 3).

DISCUSSION

The study shows a greater improvement in NDI, self-reported perception of pain and CROM in the intervention group (IG) compared to the control group (CG). The IG received a programme combined with progressive shoulder-neck exercises and passive modalities. The controls received passive modalities alone. Both groups yielded significant within-group improvements in NDI and perception of pain. Previous studies suggested that neck and shoulder girdle muscle training exercises can reduce disability in patients with neck pain (Wegner *et al*., 2010; Bobos *et al*., 2016; Celenay *et al*., 2016). Ylinen *et al.* (2003) reported that programmes with muscle strength and endurance training decrease neck pain and disability compared to aerobic exercise. The present study has similar results.

The NDI scores of participants were 14.54±3.75 points, ranging from mild (5–14) to moderate (15–24) disability. After the intervention, the NDI decreased by 9.24 (64%), achieving more than 5 points in MCID (Vernon, 2008). The NDI score of the CG decreased by only 2.09 (15%), which is consistent with the approximately 2.5-5.4 (16-31%) NDI reduction reported in previous studies that have adopted PEBRE (Ask *et al*., 2009; Ludvigsson *et al*., 2015; Celenay *et al*., 2016). However, this result differs from that of Viljanen *et al*. (2003) who reported 5% NDI reduction. The possible cause of this difference may have been their adoption of low-intensity training (1–3kg dumbbells), whereas the present study adopted a stronger 10RM intensity training. In addition, although the intervention programme proposed by Viljanen *et al*. (2003) involved sessions thrice a week, the low compliance rate of the participants meant that the actual frequency of exercise was once a week. In comparison, the exercise frequency of the present study was maintained at thrice a week under monitoring by the physical therapist. Thus, both the low training intensity and low participant compliance rate of Viljanen *et al*. (2003) might have led to the non-significant results.

The self-reported perception of pain scores of the IG and CG were reduced by 34.39mm (-67%) ($p<0.001$) and 6.42 mm (-13%) ($p<0.05$), respectively. Previous studies have used PEBRE (20–8RM) to reduce participants' pain scores by 5.2-29mm (23-62%). The intervention durations ranged from 10 to 20 weeks of resistance training and 4–6 complex exercises, the

participants were aged 46 years on average and the training equipment were dumbbells and elastic bands (Zebis *et al*., 2011; Andersen *et al*., 2012; Andersen *et al*., 2014; Saeterbakken *et al*., 2017). By contrast, the present study introduced two progressive elastic-band shoulder and neck exercises (10RM) under the most suitable resistance adjusted for individual participants, who were aged 57 years on average and experienced chronic neck pain and neck disability. The results of the present study are consistent with those of previous studies regarding pain score alleviation. With a shorter intervention duration and fewer movements compared with previous studies, the present study attained improvement in the pain scores that reached the Minimal Clinically Important Difference (MCID) of 15–20 mm (Kovacs *et al*., 2008; Michener *et al*., 2011), indicating that an intervention programme that combines 6-week shoulder and neck exercises with physical modalities can effectively reduce the self-reported perception of pain scores.

In the present study, CROM increased significantly after completion of the intervention programme. CROM flexion, extension, right lateral flexion, left lateral flexion, right rotation, and left rotation increased by 7.88° (21%), 10.42° (20%), 6.70° (25%), 6.69° (23%), 12.90 (22%), and 10.46 (18%), respectively. These CROMs achieved the MICD of 6.5 in any direction (Audette *et al*., 2010). The results correspond with that of previous studies, in which CROM flexion, extension, right lateral flexion, left lateral flexion, right rotation, and left rotation have been reported to increase by 4-6° (6–15%), 4-9° (6–16%), 6.1-9° (18–27%), 4.7-9° (11–22%), 3.1-6° (4–12%), and 3.5-9° (4–15%), respectively (Ylinen *et al*., 2003; Karlsson *et al*., 2014 ; Celenay *et al*., 2016). However, the results of the present study do not correspond with those of Taimela *et al.* (2000) in which CROM flexion and extension decreased by approximately 3%, CROM-lateral flexion increased by approximately 1%, and CROM rotation decreased by approximately 2%. This difference may be due to an exercise intervention of restored coordination and posture control of the neck-shoulder muscles rather than strengthening or mobilising them. Therefore, the range of neck motion did not increase significantly in Taimela's study (Taimela *et al.,* 2000).

The intervention programme proposed in the present study accords with the muscle strength training principles, stipulated by the American College of Sports Medicine, which suggest muscle strength of 10RM (75% 1RM) to be tested every two weeks. Consequently, the intervention intensity should be added progressively. In each set, 10–15 repetitions were performed and an additional set is added every two weeks until reaching the maximum of three sets. The results of this study are consistent with those of previous studies regarding the improvement of neck disability of patients. In these studies, the training programme involved high intensity (12–8RM, >70% 1RM) (Vernon, 2008) and progressive resistance (20–8RM) (Ludvigsson *et al*., 2015; Saeterbakken *et al*., 2017) training. In this investigation, the programme combined with 6-week PEBRE and physical modalities significantly improved the self-reported perception of pain, NDI and CROM compared to the programme with physical modalities alone.

LIMITATIONS

A few limitations should be noted. Because the proposed intervention programme combined PEBRE and CCFE, the independent effect of implementing either exercise could not be inferred. With regard to independent therapeutic effects of PERRE and CCFE is a noteworthy limitation of this research. In addition, whether the pain and neck disability of participants

recovered naturally or deteriorated over time, could not be inferred because all participants in the CG received passive modalities. Another limitation is the lack of assessment of long-term follow-up effect of treatment, so it is not known whether the treatment effects last for a considerable period. Additionally, although both groups had similar use rates of oral analgesics, the dosage of oral analgesics was not well controlled in the study.

FUTURE RESEARCH

Future research should explore the effects of shoulder and neck exercises in different diagnosis of neck disorder (myofascial neck pain, whiplash associated disorder, cervical spondylosis, neck disorders with radicular findings). In addition, further investigation should consider increasing the number of intervention groups to determine independent therapeutic effects.

CONCLUSION

The results of this investigation supported the use of PEBRE three times per week for six consecutive weeks on middle-aged and older adults with CNP and can effectively reduce the self- reported perception of pain scores and NDI, as well as increase CROM. Compared to other intervention exercises with a duration of 10 to 20 weeks of resistance training and at least four complex exercises with dumbbells or elastic-band and ball, might deter patients from complying with the intervention programme. Our study provided more convenient and simpler modes to execute due to its portable training equipment and shorter intervention duration. The results can serve as references for determining clinical exercise-based rehabilitation programmes for patients with CNP.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Appendix

NECK AND SHOULDER EXERCISE INTERVENTION PROGRAMME

Exercise	Instructions
Warm up stretches Weeks 1-6	**1. Neck stretching exercises** ***Step 1***: Maintain a sitting position and freely let down the hands at sides of body. ***Step 2***: Slowly tip the head to the right side and hold the position for 10s. Then, slowly tip the head to the left side and hold it for 10s to complete a cycle. Repeat the cycle 5 times. ***Step 3***: Slowly flex head forward and hold position for 10s. Then, slowly extend head backward and hold it for 10s to complete a cycle. Repeat cycle 5 times. **2. Shoulder stretching exercises** ***Step 1***: Maintain a sitting position and freely let down hands at sides of body. ***Step 2:*** Slowly lift the hands and hold them as high as possible, stretch for 10s, and slowly let down hands. Repeat this step five times. ***Step 3:*** Abduct the shoulder joints to 90°, horizontally abduct shoulder joints and make an external rotation; hold the position for 10s before returning to initial movement. Repeat this step five times.
CCFE Weeks 1-6	***Step 1***: Bend knees while lying down with spine and head maintained in median position. ***Step 2***: Fold pressure biofeedback unit into thirds and place it behind upper neck. The participant must place the tongue at mandible with teeth slightly separated to avoid platysma muscle and hyoid muscle compensation. Then, pump air to air bag until it contains 20 mmHg. ***Step 3***: Instruct participant to nod so that pressure biofeedback unit can be increased to 22 mmHg for 10s; then, rest for 3–5s. After 10 repetitions, the next level of training is performed. Five levels (22, 24, 26, 28, and 30mmHg) are involved. Participant rests for 30s before advancing to the next level.
MBE Weeks 1-2 Weeks 3-4 Weeks 5-6	***Step 1***: Maintain a sitting position and hold the shoulder joint in adduction with the elbow flexion at 90°, forearm supination, and the elastic band winding over the palm to avoid slippage. ***Step 2***: Perform scapular retraction and external rotation of shoulder joints, followed by elbow extension and shoulder joint abduction. Then, slowly recover the preparation position. 10RM, 10-15 repetitions, 1 set 10RM, 10-15 repetitions, 2 sets, 1 minute rest between each set 10RM, 10-15 repetitions, 3 sets, 1 minute rest between each set
MPNFDFE Weeks 1-2 Weeks 3-4 Weeks 5-6	***Step 1***: Maintain a sitting position and make a preparation movement by winding the elastic band over right (left) palm to grip and fix an end of elastic band on right (left) thigh. Perform right (left) lateral shoulder joint internal rotation, scapular protraction, forearm pronation and finger flexion. The left (right) hand grip and fix the other end of the elastic band on the left (right) thigh. ***Step 2***: Begin with right (left) forearm supination, followed by scapular retraction and shoulder flexion, abduction, and external rotation. Then, perform trunk rotation. Slowly recover preparation position. 10RM, 10-15 repetitions, 1 set 10RM, 10-15 repetitions, 2 sets, 1minute rest among each set 10RM, 10-15 repetitions, 3 sets, 1minute rest among each set

CCFE = Cranio-Cervical Flexion Exercise MBE = Modified Brügger's Exercise RM = Repetition Maximum
MPNFDFE = Modified Proprioceptive Neuromuscular Facilitation Diagonal Flexion Exercise