MEDICAL SCIENCE MONITOR

CLINICAL RESEARCH

e-ISSN 1643-3750
© Med Sci Monit, 2024; 30: e945349
DOI: 10.12659/MSM.945349

Received: 2024.05.31
Accepted: 2024.07.24
Available online: 2024.07.30
Published: 2024.08.31

Comparison of Outcomes of Physical Therapy Exercises Combined with Either a Video-Based Smartphone Application System or a Written Exercise Program Handout in 34 Patients with Non-Specific Neck Pain

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ABCDF 1 **Won-Deuk Kim**
AEG 2 **DooChul Shin**

1 Department of Physical Therapy, Graduate School of Kyungnam University, Changwon, South Korea
2 Department of Physical Therapy, College of Health and Welfare, Sahmyook University, Seoul, South Korea

Corresponding Author: DooChul Shin, e-mail: icandox@syu.ac.kr
Financial support: This work was supported by a National Research Foundation of Korea (NRF) grant funded by the Korean government (MSIT: Ministry of Science and ICT) (No. NRF-2021R1F1A1060948)
Conflict of interest: None declared

Background: An exercise program was developed using risk factors for non-specific neck pain. This study aimed to compare the effects video-based versus image- and text-based remote home training performed using this exercise program in patients with non-specific neck pain.

Material/Methods: Among the 37 patients with non-specific neck pain recruited, 34 patients who satisfied the inclusion criteria were enrolled in this study. The participants were randomized into the experimental (n=17) and control (n=17) groups. The patients in the experimental group performed exercises using a video-based application system, whereas those in the control group performed exercises using an image- and text-based printout. In-home training was implemented for 6 weeks in both groups. The neck pain intensity, disability index, active range of motion (aROM), forward head posture (FHP), and compensatory neck flexion were measured before and after the intervention. The within-group and between-group differences were analyzed at the end of the interventions.

Results: Improvements in pain intensity, cervical ROM, disability index, FHP, and compensatory neck flexion were observed after in-home training in the experimental group ($P<.05$). An improvement in pain intensity and aROM was observed in the control group ($P<.05$); however, the disability index, FHP, and compensatory neck flexion exhibited no significant differences ($P>.05$). Between-group comparison revealed that the experimental group exhibited greater improvement in pain intensity, cervical ROM, and FHP than the control group ($P<.05$).

Conclusions: The findings of this study suggest that the video-based home exercise program improved pain intensity, aROM, neck disability index, FHP, and compensatory neck flexion in patients with non-specific neck pain.

Keywords: Mobile Applications • Movement • Neck Pain • Range of Motion, Articular • Telerehabilitation

Full-text PDF: https://www.medscimonit.com/abstract/index/idArt/945349

6036 4 3 36

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

Introduction

Non-specific neck pain, defined as discomfort or pain in the neck without any specific underlying cause, is the most common form of neck pain, accounting for 90% of cases of neck pain without neurological symptoms [1]. Non-specific neck pain may occur as a result of a combination of neurological, musculoskeletal, and psychological factors [2].

Changes in the tissues surrounding the cervical spine due to aging, limited mobility, and postural changes (such as rounded shoulder posture and forward head posture [FHP]) have been identified as physical risk factors for non-specific neck pain [3]. Limited cervical range of motion (ROM) can increase the burden on the muscles and ligaments surrounding the cervical spine, resulting in the development of non-specific neck pain. A reduction in the lower cervical ROM has been associated with a higher incidence of neck pain [2]. Rounded shoulder posture and FHP lead to a persistent increase in neck muscle tone. Consequently, a greater amount of energy is required to maintain posture, which increases the risk of non-specific neck pain [3]. Similarly, uneven shoulder height can result in an imbalance in the neck and shoulder muscles and asymmetrical load distribution in the spine, which can lead to non-specific neck pain [4,5]. Compensatory neck flexion decreases deep neck flexor activity and induces hyperactivity of the sternocleidomastoid and scalene muscles. This contributes to the development of FHP and increased muscle tone around the neck and shoulder, which are risk factors for non-specific neck pain [6]. Moreover, it can affect the cervical extension ROM, cervical rotation ROM, upper cervical rotation ROM, rounded shoulders, uneven shoulder height, and compensatory neck flexion.

Several interventions have been proposed for the treatment of non-specific neck pain [1]. Non-specific neck pain with limited joint mobility can increase the muscle tone around the cervical spine and adhesion of the facet joints, resulting in limited ROM. Joint mobilization therapy targeting the neck, back, and chest has been effective in improving pain and function in patients with non-specific neck pain with limited joint mobility [7]. Joint mobilization therapy improves pain and function by improving joint movements in the neck, back, and chest of patients with non-specific neck pain [2]. Previous studies have reported the efficacy of stabilization and coordination-improving exercises in the treatment of non-specific neck pain with impaired motor coordination. Other studies have reported that a comprehensive exercise program that includes exercises for muscle strength, endurance, coordination, and proprioception can improve pain and function in patients with non-specific neck pain [1,8].

An improvement in pain, neck disability index, and job performance has been reported in patients with non-specific neck pain following implementation of neck posture correction, stabilization, and motor coordination-improving exercises [9-11]. However, a multidimensional approach to analyze the physical risk factors must be adopted for the management of non-specific neck pain. Moreover, exercise programs must be developed based on research findings.

Non-specific neck pain has various physical risk factors. Previous studies have developed effective interventions based on risk factors; however, these studies focused primarily on supervised exercise therapy or passive manual therapy performed by a therapist. Active participation of the patient is necessary for effective management of non-specific neck pain. Moreover, various studies have emphasized the essential role of patient education in the management of non-specific neck pain [12-14].

Home exercise programs incorporating postural and motion education performed in conjunction with in-hospital patient education reduce pain, increase ROM, minimize the use of a neck brace, and facilitate faster return to daily activities [15]. Home exercise programs can be implemented via “in-person” and “remote” methods. In-person methods involve learning the exercise program under the guidance of a healthcare professional or physical therapist, whereas remote methods involve the use of texts and images or streaming videos using the internet [16]. Printouts with images and texts are the most commonly used method to implement remote home exercise programs. This method was examined in the present study. Methods incorporating online videos have also been used in recent years [17].

Baeza [18] conducted a study on 40 patients with non-specific neck pain and compared the therapeutic effect observed in the group that received regular care with those observed in the group that performed an internet-based video home exercise program. A significantly greater improvement in neck motor function, pain, and quality of life was observed in the group that received the video program.

Previous studies have reported that the use of video-based exercise programs produced greater improvement in pain and function than text- and image-based printouts in patients with non-specific neck pain. However, these studies directly delivered the video files, and studies that used structured smartphone applications are lacking. The Google Play Store and Apple App Store have registered applications for home-based exercise programs that provide images or videos of stretching exercises for the muscles around the neck, weekly exercise programs, and exercises incorporating yoga or Pilates movements. However, applications based on the physical risk factors for non-specific neck pain that provide videos of exercise programs specifically tailored for such risk factors have not been developed. The efficacy of patient education and implementing

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

effective home exercise programs can be improved by developing smartphone applications according to the multidimensional analysis of physical risk factors. An exercise program based on the physical risk factors for non-specific neck pain and a video-based smartphone application were developed using such a program in this study. This study compared the effects of conventional image- and text-based home exercise programs with those of video-based home exercise programs using a smartphone application on pain intensity, disability index, cervical ROM, FHP, and compensatory neck flexion in patients with non-specific neck pain to determine which method of home exercise program is more effective.

Therefore, this study aimed to compare outcomes from physical therapy exercises combined with either a video-based smartphone application system or a written exercise program handout in 34 patients with non-specific neck pain.

Material and Methods

This study was a pretest-posttest randomized controlled trial (RCT). An exercise program-based smartphone application that can manage the physical risk factors for non-specific neck pain was developed in this study. The smartphone application was based on a home exercise program for patients with non-specific neck pain. The useability and effectiveness of this application were compared with those of conventional image- and text-based home exercise programs.

Participants

The study population comprised patients with neck pain who reported to the Department of Physical Therapy of the J Hospital in Changwon, Gyeongsangnam-do. An announcement was posted on the hospital bulletin board to recruit patients. The inclusion criteria were as follows: 1) patients diagnosed with non-specific neck pain by a physician; 2) patients with a Numeric Pain Rating Scale (NPRS) score of 3-8 points; and 3) patients with neck pain persisting for more than half of the time in the preceding 12 weeks. The exclusion criteria were as follows: 1) history of fracture, spinal surgery, or other orthopedic conditions; 2) presence of any central nervous system disorder, such as brain injury; 3) presence of neurological symptoms, such as numbness or burning sensation in the upper extremities; and 4) presence of a systemic inflammatory disease. A detailed explanation regarding the objective and procedures of the study was provided to all participants, and written informed consent was obtained from all participants. This study was approved by the Institutional Review Board of Kyungnam University (No. 104060-A-2022-034).

Smartphone Application

The Swing2app application development system was used to create a smartphone application, and it was distributed in the form of an apk file that could be installed directly on the subject's smartphone. The application is classified into increasing cervical mobility, correcting posture, and correcting compensatory movements based on physical risk factors. A video is played when each category is touched.

Study Procedures

Exercise methods that were effective in improving pain and function in previous studies on risk factors for non-specific neck pain were selected to develop the exercise program in this study. Articles on interventions for non-specific neck pain were retrieved from the databases of Google Scholar and PubMed. Studies that reported significant improvement in pain and function in patients with non-specific neck pain were selected from the retrieved articles to develop the exercise program. The effect size was calculated based on the selected articles. Studies that reported an effect size of ≥0.5 were selected, and the interventions used in the selected studies were applied to the exercise program in this study. The exercise program was referenced in the videos on exercise methods for each risk factor. The smartphone application was developed based on these videos.

The clinical efficacy of the video-based smartphone application system in the management of patients with non-specific neck pain was compared with that of a conventional image- and text-based printout for a home exercise program. Thirty-four participants were randomly assigned to the experimental (n=17) or control (n=17) groups by drawing lots. The experimental and control groups received 20 min of heat therapy and 15 min of transcutaneous nerve stimulation therapy 3 times a week for 6 weeks. The participants in the experimental group participated in a video-based home exercise program using the smartphone application (3 times a week for 6 weeks), whereas those in the control group participated in a home exercise program using the image and text-based printout (3 times a week for 6 weeks). The participants in both groups performed the same exercises 3 times a week.

The participants completed a questionnaire on pain intensity and disability. In addition, active cervical ROM (comprising flexion, extension, and rotation), FHP, and compensatory neck flexion before and after the intervention were measured in both groups. All measurements were performed 3 times, and the mean value of the 3 repeated measures was used in the analysis (**Figure 1**).

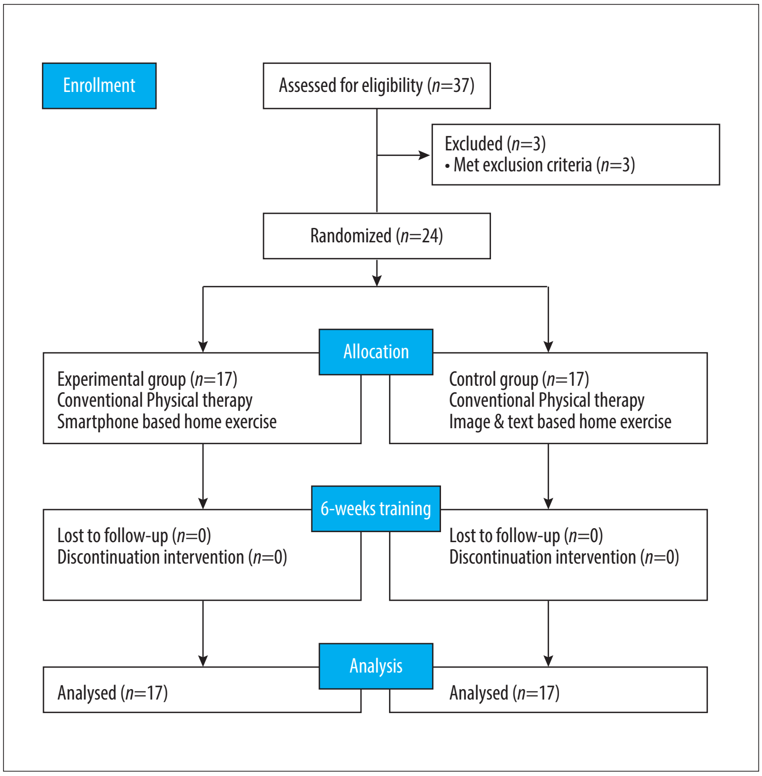

Figure 1. Research procedure (*PowerPoint 365, Microsoft*).

Measures and Data Collection

Pain

Pain reported by the participants on the day of the measurement was recorded using NPRS. The participants were instructed to select a number between 0 (no pain) and 10 (unbearable pain) that corresponds to the level of pain. The test-retest reliability and validity of NPRS were ICC=0.61-0.77 and ICC=0.85, respectively [19].

Neck Disability Index

The neck disability index was measured using the neck disability index questionnaire (NDI). NDI, an assessment tool comprising 2 items related to pain and 8 items related to personal care and daily life, has been widely used to identify the degree of disability in patients with neck pain [20]. Each item on NDI was rated on a scale of 0 to 5 points. The total score was presented as a percentage, with higher scores indicating greater disability. The scores were interpreted as follows: 0-8%=no disability; 10-28%=mild disability; 30-48%=moderate disability; 50-68%=severe disability; and ≥70%=complete disability [21]. The test-retest reliability and validity of NDI were ICC=0.88 and ICC=0.86, respectively [22].

Active Range of Motion

The active cervical ROM was measured using a digital inclinometer. The measurements were performed 3 times, and the mean value of the 3 repeated measures was used in the analysis. The cervical flexion ROM was measured as follows: the participants were instructed to assume a seated position. The first and second inclinometers were placed on the first thoracic vertebra (T1) and the top of the head, respectively. The participants were then instructed to bend their necks, and the angle at the end of the range of cervical flexion was measured.

The cervical extension ROM was measured with participants in a seated position. The first and second inclinometers were placed on T1 and the top of the head, respectively. The participants were instructed to tilt their neck backward subsequently, and the angle at the end of the range of cervical extension was measured.

The cervical rotation ROM was measured as follows: the participants were instructed to assume the supine position and the inclinometer was placed at the center of the forehead. The participants were instructed to rotate their necks and the angle at the end of the range of cervical rotation was measured. The inter-rater reliability and validity of the digital dual inclinometer used to measure the active cervical ROM were ICC=0.98 and r=0.98, respectively [23,24].

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

Forward Head Posture

The craniovertebral angle was measured to determine the FHP [25]. The angle formed between the horizontal line passing through the seventh cervical vertebra (C7) and the line drawn from the tragus to C7 was measured and recorded on photographs of the lateral side of the cervical vertebrae of the participant. Larger craniovertebral angles indicated a greater FHP. The camera was mounted on a tripod such that it was level with the ground and at a height of 1.5 m and 1 m from the ground and participant, respectively. The intra-rater and inter-rater reliability of the craniovertebral angle measurement were ICC=0.86-0.94 and ICC=0.85-0.91, respectively [25].

Compensatory Neck Flexion

The compensatory neck flexion was measured as follows: the participants were instructed to assume the supine position on a table and perform cervical flexion subsequently. Videos from the side were recorded by the investigator while the participants performed cervical flexion. The sagittal head angle at the completion of cervical flexion was measured and recorded. The angle between the line connecting the canthus and tragus and the horizontal line was measured. Larger angles indicated greater compensatory movements [26]. The intra-rater and inter-rater reliability of sagittal head angle measurement were ICC=0.88 and ICC=0.83, respectively [25].

Intervention

Physical Agent Therapy

The participants in both groups received 20 min of hot compress therapy and 15 min of transcutaneous nerve stimulation therapy (Trimix Linus, Nihon Medics, Japan) while lying comfortably in a bed. The hot compress therapy consisted of the application of heat (65°C) to the upper trapezius. Transcutaneous nerve stimulation therapy consisted of the application of high-frequency, low-intensity transcutaneous nerve stimulation with a pulse frequency of 120 pps and pulse duration of 100 µs via electrodes attached to the pain trigger points on the upper trapezius.

Exercise Program

The program included exercises such as self-sustained natural apophyseal glides (self-SNAGs) for improving the active range of motion (aROM) and upper cervical rotation ROM [27]; scapular posterior tilt exercise for the correction of rounded shoulders [28]; wall slide exercise for the correction of uneven shoulder height [29]; and deep neck flexor strengthening exercise for the correction of compensatory neck flexion [30].

Self-Sustained Natural Apophyseal Glides for Cervical Extension

Previous studies have shown that self-SNAGs for cervical extension are more effective than regular physical therapy in reducing pain and increasing ROM in individuals with chronic non-specific neck pain [27]. Thus, self-SNAGs for cervical extension performed using a towel were selected to improve cervical extension ROM in this study. Self-SNAG was performed as follows: The participants were instructed to assume a seated position on a chair and relax. The participants were instructed to place a rolled-up towel on the back of the neck, grab both ends of the towel, and pull it towards the direction of the eyes. The participants were instructed to extend their necks while maintaining the force and direction of pulling the towel. The participants extended the neck to the maximum extent and pulled the towel slightly at the end of the range before returning to the original position. Three sets of 6 repetitions were performed.

Self-Sustained Natural Apophyseal Glides for Cervical Rotation

Self-SNAGs for cervical rotation using a towel were selected to improve the cervical rotation ROM [27].

Improvement of Left Cervical Rotation

The exercise was performed as follows: The participants were instructed to assume a seated position on a chair and relax. The participants were instructed to place a rolled-up towel on the back of the neck and grab the right end of the towel with the left hand and the left end of the towel with the right hand. The left hand was pulled downward in a diagonal direction, and the right hand was pulled towards the eyes. The neck was rotated to the left while maintaining the force and direction of pulling the towel. The neck was rotated to the maximum extent possible, and the towel was pulled slightly at the end of the range of motion before returning to the original position. Three sets of 6 repetitions were performed.

Improvement of Right Cervical Rotation

The exercise was performed as follows: The participants were instructed to assume a seated position on a chair and relax. The participants were instructed to place a rolled-up towel on the back of the neck and grab the right end of the towel with the left hand and the left end of the towel with the right hand. The right hand was pulled downward in a diagonal direction, and the left hand was pulled towards the eyes. The neck was rotated to the right while maintaining the towel-pulling force and direction. The neck was rotated to the maximum extent possible, and the towel was pulled slightly at the end of the

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

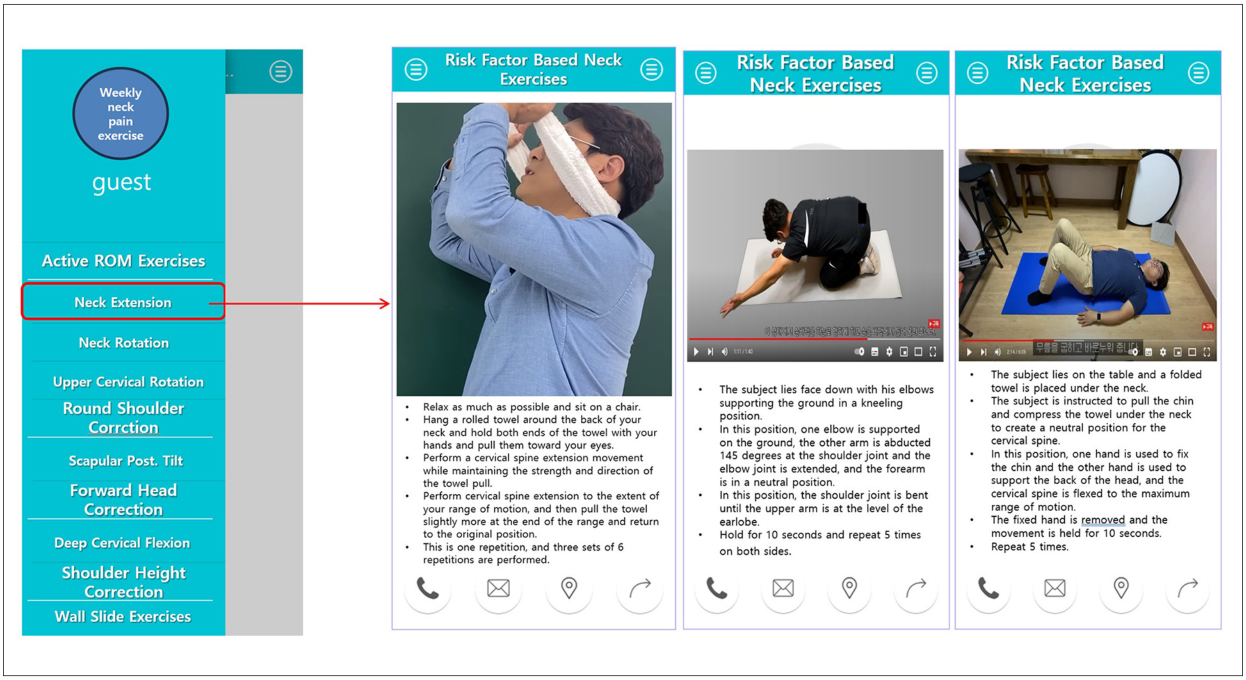

Figure 2. Smartphone application (*PowerPoint 365, Microsoft*).

range of motion before returning to the original position. Three sets of 6 repetitions were performed.

Self-Sustained Natural Apophyseal Glides for Upper Cervical Rotation

Self-SNAGs for upper cervical rotation were selected for improving cervical flex-ion-rotation ROM [27].

Improvement of Left Cervical Flexion-Rotation ROM

The exercise was performed as follows: The participants were instructed to assume a seated position on a chair and relax. The participants were instructed to place a strap on the spinous process of the second cervical vertebra (C2) and grab the left end of the strap with the right hand and the right end of the strap with the left hand. The left hand was pulled downward in a diagonal direction and the right hand was pulled forward parallel to the ground. The neck was rotated to the left while maintaining the force and direction of pulling the strap. The neck was rotated to the maximum extent possible, and the strap was pulled slightly at the end of the range of motion before returning to the original position. Three sets of 6 repetitions were performed.

Improvement of Right Cervical Flexion-Rotation ROM

The exercise was performed as follows: The participants were instructed to assume a seated position on a chair and relax. The participants were instructed to place a strap on the C2 spinous process and grab the left end of the strap with the right hand and the right end of the strap with the left hand. The right hand was pulled downward in a diagonal direction, and the left hand was pulled forward parallel to the ground. The neck was rotated to the maximum extent possible, and the strap was pulled slightly at the end of the range of motion before returning to the original position. Three sets of 6 repetitions were performed.

Scapular Posterior Tilt Exercise

Lee et al [28] compared the corrective effects of scapular posterior tilt exercise, pectoralis minor muscle stretching, and wearing a shoulder brace on the height of rounded shoulders. They revealed that performing the scapular posterior tilt exercise yielded the greatest improvement in the height of rounded shoulders. Thus, the scapular posterior tilt exercise was selected for the correction of the height of rounded shoulders in this study.

The exercise was performed as follows: The participants were instructed to kneel on the ground with their elbows placed on the ground for support. One elbow was placed on the ground for support in this position, and the contralateral arm was abducted from the shoulder by 145°. The elbow was then extended, and the lower arm was kept in a neutral position. The shoulder was flexed in this position until the upper arm reached the earlobe. This position was maintained for 10 s. The exercise was repeated 5 times on each side.

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

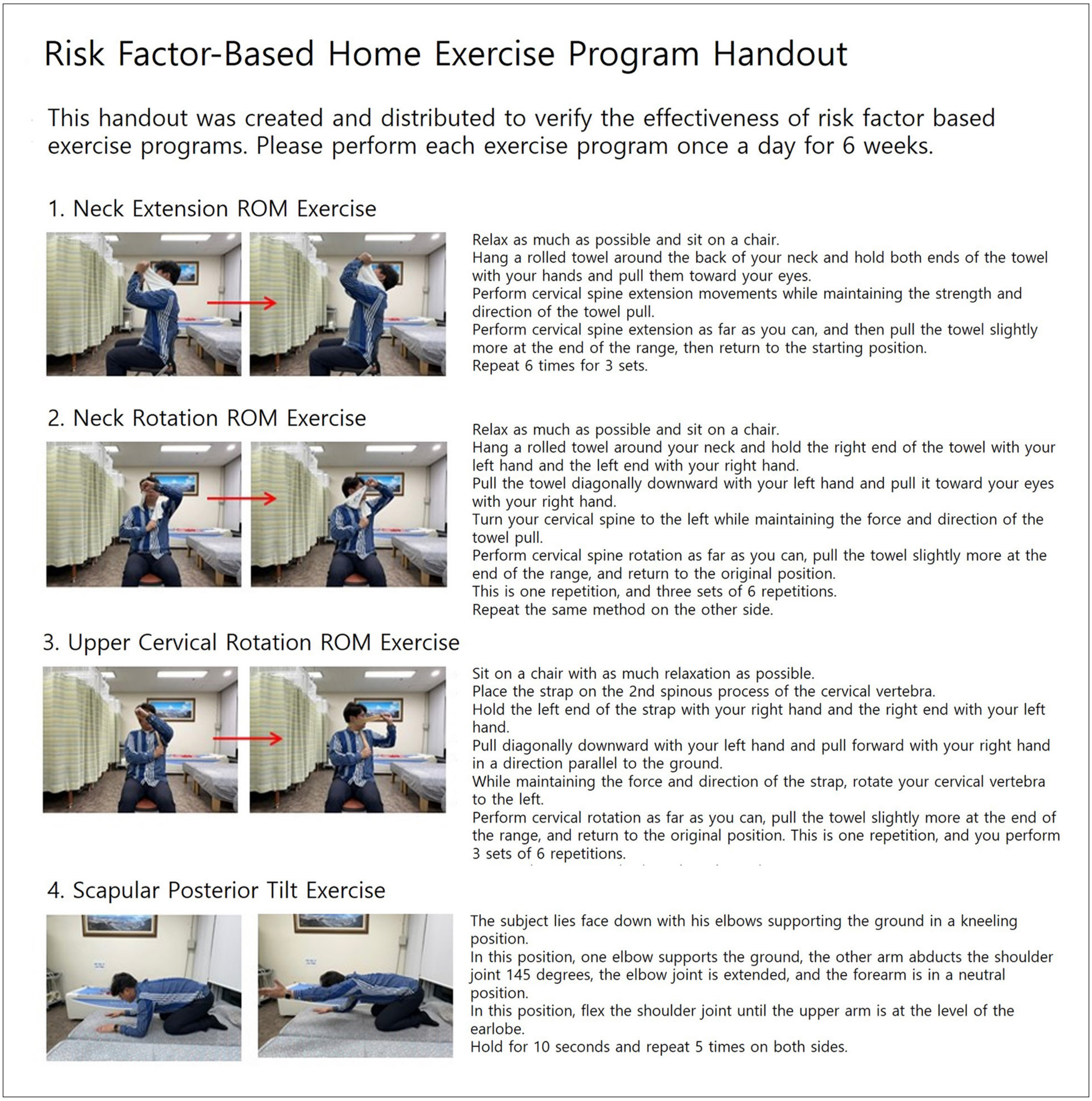

Figure 3. Printout (*PowerPoint 365, Microsoft*).

Wall Slide Exercise

Kim et al [31] reported that the wall slide exercise can effectively correct the position of the scapula and reduce the difference in shoulder height. Thus, the wall slide exercise was selected for the correction of uneven shoulder height in this study.

The exercise was performed as follows: The participants were instructed to assume a seated position on a chair with the back against the wall. The backside, from the back of the head to the tailbone, was pressed firmly against the wall, and the chin was pulled slightly inward. The shoulders were then abducted by 90° and the elbows were flexed by 90°. The shoulders were rotated outward such that the back of the hand could touch the wall. The arms were raised as if drawing an arc from this position. The participants were instructed to ensure that the elbow and back of the hand were in contact with the wall and that the shoulders did not rise.

Deep Neck Flexor Strengthening Exercise

Blomgren et al [30] analyzed 12 RCTs to determine the effects of the deep neck flexor strengthening exercise in patients with non-specific neck pain and reported that performing the deep

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

Table 1. General characteristics of participants.

Variable		Experimental group (n=17)	Control group (n=17)	p
		Mean±SD	Mean±SD	
Sex	Male	12	11	
	Female	5	6	
Age		41.53±12.67	37.15±10.92	0.267
Height		168.59±7.78	172.25±8.40	0.181
Weight		66.94±13.51	71.65±43.57	0.299
Weekly computer use (hours)		20.12±17.34	16.95±14.13	0.544
Weekly smartphone use (hours)		17.29±9.07	21.75±7.65	0.114
Pain intensity (points)		4.29±1.49	5.5±1.27	0.112
Neck disability index (%)		24.12±9.81	29.3±11.56	0.154

SD – standard deviation.

neck flexor strengthening exercise resulted in a reduction in pain and an increase in muscle strength and endurance. Thus, the deep neck flexor strengthening exercise was selected for the correction of compensatory neck flexion in this study. The exercise was performed as follows: The participants were instructed to lie down on a table and place a folded towel under the back of the neck for support. The towel was pressed under the neck while pulling the chin inward to bring the cervical spine into a neutral position. The neck was flexed to the maximum extent in this position. One hand was used to fix the chin, and the other hand was used to support the back of the head. The hand used to fix the chin was then removed, and this position was maintained for 10 s. The exercise was repeated 5 times.

Smartphone Application

A video-based smartphone application was developed and distributed to the experimental group to provide instructions pertaining to the home exercise program that had been developed (**Figure 2**).

Printout

A printout containing images and text was distributed to the control group to provide instructions pertaining to the home exercise program that had been developed (**Figure 3**).

Statistical Analysis

All statistical analyses were performed using SPSS 21.0. The Kolmogorov-Smirnov test was used to assess the normality of the data. Descriptive statistics were used to analyze the general characteristics of the participants. A paired-sample *t* test was used to evaluate the pre-post within-group differences, whereas an independent-sample *t* test was used to evaluate the pre-post between-group differences. The significance level (α) was set at ≤.05.

Results

General Characteristics

The experimental group comprised 12 men and 5 women, whereas the control group comprised 11 men and 6 women. The mean age of the participants in the experimental and control groups was 41.53 years and 37.15 years, respectively. The mean height in the experimental and control groups was 168.95 cm and 172.25 cm, respectively. The mean weight in the experimental and control groups was 66.94 kg and 71.65 kg, respectively. The mean weekly computer use in the experimental and control groups was 20.12 h and 16.95 h, respectively. The mean weekly smartphone use in the experimental and control groups was 19.7 h and 21.75 h, respectively. The mean pain intensity score in the experimental and control groups was 4.29 points and 5.5 points, respectively. The mean disability index in the experimental and control groups was 24.12% and 29.30%, respectively (**Table 1**).

Comparison of the Effectiveness of Remote Home Training

The mean within-group change in the NPRS scores in the experimental and control groups was 2.23 points and 1.65 points, respectively, with significant differences being observed before and after the implementation of the home exercise program (P<.05). However, the between-group comparison revealed no significant differences (P>.05).

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

Table 2. Comparison of pain and disability index.

Variable		Experimental group (n=17) Mean±SD	Control group (n=17) Mean±SD	*t*	*p*
Pain intensity (points)	Pre	4.29±1.49	5.5±1.27		
	Post	2.05±0.82	3.85±0.81		
	Pre-post	2.23±1.85	1.65±1.26	1.134	0.264
	t	4.968	5.819		
	p	.000	.000		
Neck disability index (%)	Pre	24.12±9.81	29.3±11.55		
	Post	12.52±3.71	25.9±6.61		
	Pre-post	11.58±1.97	3.4±15.32	-.045	.964
	t	4.627	.992		
	p	.001	.334		

SD – standard deviation.

Table 3. Changes in cervical active range of motion.

Variable		Experimental group (n=17) Mean±SD	Control group (n=17) Mean±SD	*t*	*p*
Cervical flexion ROM (°)	Pre	38.76±8.37	39.70±4.61		
	Post	44.18±9.18	40.15±4.81		
	Pre-post	5.41±3.26	.450±.686	6.159	.000
	t	6.843	2.932		
	p	.000	.091		
Cervical extension ROM (°)	Pre	61.41±13.61	64.1±4.78		
	Post	67.41±11.71	65.15±5.48		
	Pre-post	6±3.51	1.05±1.19	6.159	.000
	t	7.032	3.943		
	p	.000	.001		
Cervical rotation ROM (°)	Pre	141.12±30.77	137.15±15.2		
	Post	147.18±29.15	138.85±15.38		
	Pre-post	6.05±3.09	1.7±2.1	5.055	.000
	t	8.08	3.943		
	p	.000	.001		

ROM – range of motion; SD – standard deviation.

Within-group comparison of the difference in disability index revealed a significant difference of 11.58% after the implementation of the home exercise program in the experimental group ($P<.05$). However, no significant difference was observed in the control group ($P<0.5$). Between-group comparison revealed no significant differences ($P>0.5$; **Table 2**).

Within-group comparison of the changes in the cervical flexion aROM revealed a significant change of 5.41° ($P<.05$) in the experimental group. However, no significant difference was observed in the control group ($P>.05$). Between-group comparison revealed a significant increase in the cervical flexion aROM in the experimental group compared with that in the control group ($P<.05$).

Within-group comparison of the change in the cervical extension aROM revealed significant differences of 6° and 1.05° in the experimental and control groups, respectively ($P<.05$).

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

Table 4. Changes in forward head posture and compensatory neck flexion.

Variable		Experimental group (n=17)	Control group (n=17)	*t*	*p*
		Mean±SD	Mean±SD		
Forward head posture (°)	Pre	129.24±4.48	126.55±6.98		
	Post	113.88±2.66	122.95±4.89		
	Pre-post	15.35±4.89	3.6±8.14	3.119	.004
	t	12.923	1.976		
	p	.000	.063		
Compensatory neck flexion (°)	Pre	65.53±8.65	66.55±11.82		
	Post	51.18±4.36	59.7±11.42		
	Pre-post	14.85±8.44	6.85±19.04	.674	.505
	t	7.005	1.069		
	p	.000	.124		

SD – standard deviation.

Between-group comparison revealed a significant increase in the cervical extension aROM in the experimental group compared with that in the control group (*P*<.05).

Within-group comparison of the change in the cervical rotation aROM revealed significant differences of 6.05° and 1.7° in the experimental and control groups, respectively (*P*<.05). Between-group comparison revealed a significant increase in the cervical rotation aROM in the experimental group compared with that in the control group (*P*<.05; **Table 3**).

Within-group comparison of the change in FHP revealed a significant difference of 15.35° in the experimental group (*P*<.05). However, no significant difference was observed in the control group. Between-group comparison revealed a significant decrease in FHP in the experimental group compared with that in the control group (**Table 4**).

A significant decrease in compensatory neck flexion of 14.85° (*P*<.05) was observed in the experimental group. However, no significant difference was observed in the control group. Between-group comparison revealed no significant difference between the 2 groups (*P*>.05; **Table 4**).

The effect size was calculated using Cohen's d formula to identify the clinical efficacy according to the type of home exercise program [32]. Large effect sizes of 1.89 and 1.69 were observed in the experimental and control groups, respectively, for pain intensity. Moderate effect sizes of 0.59, 0.51, and 0.52 were observed for flexion, extension, and rotation, respectively, in the experimental group for aROM. In contrast, small effect sizes of 0.09, 0.19, and 0.11 were observed for flexion, extension, and rotation, respectively, in the control group. An extremely large effect size of 5.77 was observed in the experimental group for FHP; a large effect size of 0.73 was observed in the control group.

Discussion

This study aimed to investigate the effects of an exercise program that was developed via a multidimensional physical approach and a smartphone application developed based on this exercise program. The factors associated with pain and disability in patients with non-specific neck pain were screened in this study to develop an exercise program, which was used to develop a smartphone application. The study compared the effects achieved via performing a home exercise program using image and text-based printouts with those achieved via performing a home exercise program using a video-based smartphone application. The effects on pain, cervical ROM, FHP, and compensatory neck flexion in patients with non-specific neck pain were analyzed for this purpose. The changes in the outcomes after implementing the 6-week home exercise program were analyzed.

Analysis of the outcomes before and after the implementation of the 6-week home exercise program revealed improvement in pain, cervical ROM, disability index, FHP, and compensatory neck flexion in the experimental group. In addition, an improvement was also observed in pain intensity and cervical ROM in the control group; however, no significant differences in disability index, FHP, and compensatory neck flexion were observed. These findings indicate that the physical risk factor-based home exercise program had a positive effect on improving pain and function in patients with non-specific neck pain.

Significant improvement in pain and aROM was observed after the implementation of the home exercise program in the

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

experimental and control groups. Previous studies have reported that patient education programs, in conjunction with regular physical therapy, were effective in improving non-specific neck pain and that educating patients regarding posture and movement can lead to a reduction in pain, increase in ROM, and a reduction in the use of a neck brace, thereby facilitating a faster return to daily life [12,13,32]. A recent RCTs reported that an 8-week home exercise program that incorporated stretching, endurance strengthening, stabilization, and coordination strengthening exercises yielded a significant improvement in pain and ROM in patients with non-specific neck pain. This is consistent with the findings of the present study [33]. These findings suggest that the home exercise program implemented in this study can effectively improve pain and aROM in patients with non-specific neck pain as it was developed based on an analysis of the physical risk factors for non-specific neck pain. Moreover, it is a complex exercise program that incorporates cervical flexibility exercise, neck and shoulder posture correction, and deep cervical flexor strengthening exercise.

The present study revealed a significant improvement in FHP in the experimental group after the implementation of the home exercise program; however, no significant improvement was observed in the control group. Zronek et al [15] reported an improvement in neck and back mobility and FHP in patients with non-specific neck pain who performed home exercise programs, which was consistent with the findings of the present study. This finding indicates that neck and shoulder posture correction exercise programs can effectively improve mobility and FHP in patients with non-specific neck pain. The exercise program implemented in the present study was able to effectively improve FHP as it included wall slide and scapular posterior tilt exercises for neck and shoulder posture correction.

The present study also revealed a significant improvement in compensatory neck flexion in the experimental group only after the implementation of the home exercise program. Chua et al [34] reported an increase in neck muscle activity and improvement in compensatory neck flexion in the group performing a home exercise program. This program combined cervical stabilization exercises that included deep neck flexor strengthening and joint proprioception improvement exercises. This finding is consistent with the findings of the present study. Thus, cervical stabilization exercise can be an effective intervention for improving compensatory neck flexion in patients with non-specific neck pain. Moreover, the deep neck flexor strengthening exercise included in the exercise program implemented in the present study effectively contributed to the improvement of compensatory neck flexion.

The home exercise program implemented in the present study resulted in an improvement in pain, disability index, aROM, FHP, and compensatory neck flexion as it was developed based on the correlation analysis of physical risk factors for non-specific neck pain.

Between-group comparisons revealed a greater improvement in pain, active cervical ROM, and FHP in the experimental group compared with that in the control group. This finding indicates that the degree of improvement in pain and function may differ depending on the type of home exercise program implemented, which is consistent with the findings of previous studies [16]. Yang et al [35] implemented a 12-week home exercise program using images printed on paper and videos. A greater amount of exercise and higher levels of knowledge and awareness regarding physical activity promotion were observed in the group that received the video-based program compared with that in the group that received the image-based program. Chhabra et al [36] implemented an 8-week exercise program in a group performing a home exercise program using a smartphone application and a group performing a conventional exercise program. They reported that the group using the smartphone application showed greater improvement in pain and function than the other 2 groups. The control group, which received a paper printout comprising images and text showed no significant differences in disability index, FHP, and compensatory neck flexion in the present study. Moreover, the between-group comparison revealed a greater improvement in pain, cervical ROM, and FHP in the experimental group that used the video-based smartphone application than in the control group. These results could be attributed to the fact that the video-based smartphone application can convey how movements should be performed more effectively than images and text printed on paper. Moreover, it facilitates easier understanding, while also enabling visual feedback using exercise motions and time codes in the video and auditory feedback through verbal instructions. Furthermore, differences in knowledge of performance were observed among the participants depending on the type of home exercise program, with video feedback producing higher knowledge of performance than image feedback and higher knowledge of performance. This resulted in higher learning achievement and greater exercise performance time [35].

Large effect sizes of 1.89 and 1.69 were observed in the experimental and control groups, respectively, for pain intensity when effect sizes were calculated using Cohen's d formula to investigate the clinical efficacy according to the type of home exercise program [32]. Moderate effect sizes of 0.59, 0.51, and 0.52 were observed for flexion, extension, and rotation, respectively, in the experimental group for aROM. In contrast, small effect sizes of 0.09, 0.19, and 0.11 were observed for flexion, extension, and rotation, respectively, in the control group. A very large effect size of 5.77 was observed in the experimental group for FHP. In contrast, a large effect size of 0.73 was observed in the control group. These findings confirmed that

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

the video-based application was more effective in improving aROM and FHP than the image- and text-based printout.

Contrary to the hypothesis of this study, the findings revealed no significant differences between the experimental and control groups in terms of uneven shoulder height, rounded shoulder height, and compensatory neck flexion. Posture correction and movement pattern improvement exercises are often performed under the guidance of a therapist, which enables detailed exercise guidance and support of fixed points for accurate movement. However, as this study compared and analyzed within-group and between-group differences according to the type of home exercise program, the scope for a therapist to intervene was limited in both groups. Consequently, the differences in postural problems, such as uneven shoulder height and rounded shoulder height, and movement pattern-related problems, such as compensatory neck flexion, may not have been observed between the 2 groups owing to these reasons.

This study had some limitations. First, occupational characteristics, such as those of office workers, field workers, and homemakers, were not considered in the present study; consequently, there is a lack of evidence regarding the effect of the implementation of the home exercise program among particular occupational groups. Second, differences according to the biological sex characteristics could not be discussed as the differences between the sexes were not analyzed in the present study. Third, it is difficult to determine whether consistent exercise therapy in a hospital setting is more effective than consistent participation in a home exercise program as the effects of the home exercise program were compared in an environment with no therapist intervention.

Thus, future studies must aim to overcome these limitations by investigating the effects on particular occupational groups and differences between the sexes. In addition, the effectiveness of exercise therapy performed in a hospital setting must be compared with that of a home exercise program.

The findings of the present study emphasize the importance of home exercise programs in educating patients regarding improving pain and function in patients with non-specific neck pain. Various forms of in-person and remote delivery methods are being used for more effective delivery of home exercise programs. The findings of the present study demonstrated that delivery via video-based smartphone application was effective in improving pain, disability, and function in patients with non-specific neck pain among the various delivery methods for home exercise programs. Thus, providing video-based home exercise programs in clinical practice may facilitate more effective management of pain and function.

Conclusions

This study aimed to investigate the effects of home exercise programs performed using image- and text-based printouts and a video-based smartphone application on pain, cervical ROM, neck and shoulder posture, and compensatory neck flexion in patients with non-specific neck pain. The study compared and analyzed the differences in the outcomes after the implementation of the 6-week home exercise program.

Improvements in pain, cervical ROM, disability index, FHP, rounded shoulder height, and compensatory neck flexion were observed after implementation of the home exercise program. Improvements in pain intensity, aROM, and rounded shoulder height were observed in the control group; however, no significant differences were observed in the disability index, FHP, and compensatory neck flexion. Between-group comparisons performed according to the type of home exercise method revealed greater improvement in pain, cervical ROM, and FHP in the experimental group than in the control group. The findings of the present study suggest that a video-based home exercise program would have a positive effect on improving pain and function in patients with non-specific neck pain.

Declaration of Figures' Authenticity

All figures submitted have been created by the authors, who confirm that the images are original with no duplication and have not been previously published in whole or in part.

References:

1. Blanpied PR, Gross AR, Elliott JM, et al. Neck pain: Revision 2017: Clinical practice guidelines linked to the international classification of functioning, disability and health from the orthopaedic section of the American Physical Therapy Association. J Orthop Sports Phys Ther. 2017;47(7):A1-A83
2. Popescu A, Lee H. Neck pain and lower back pain. Med Clin North Am. 2020;104(2):279-92
3. Mahmoud NF, Hassan KA, Abdelmajeed SF, et al. The relationship between forward head posture and neck pain: A systematic review and meta-analysis. Curr Rev Musculoskel Med. 2019;12(4):562-77
4. McLean SM, May S, Klaber-Moffett J, et al. Risk factors for the onset of non-specific neck pain: a systematic review. J Epidemiol Community Health. 2010;64(7):565-72
5. Jun D, Zoe M, Johnston V, O'Leary S. Physical risk factors for developing non-specific neck pain in office workers: A systematic review and meta-analysis. Int Arch Occup Environ Health. 2017;90:373-410
6. Jull G, Falla D. Does increased superficial neck flexor activity in the craniocervical flexion test reflect reduced deep flexor activity in people with neck pain? Man Ther. 2016;25:43-47
7. Clar C, Tsertsvadze A, Hundt GL, Clarke A, Sutcliffe P. Clinical effectiveness of manual therapy for the management of musculoskeletal and non-musculoskeletal conditions: Systematic review and update of UK evidence report. Chiropr Man Therap. 2014;22(1):12

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

8. Damgaard P, Bartels EM, Ris I, et al. Evidence of physiotherapy interventions for patients with chronic neck pain: A systematic review of randomised controlled trials. ISRN Pain. 2013;2013:567175
9. Conlin A, Teasell R, Bhogal S, Sequeira K. Treatment of whiplash-associated disorders-part I: Non-invasive interventions. Pain Res Manag. 2005;10(1):21-32
10. Drescher K, Hardy S, Maclean J, et al. Efficacy of postural and neck-stabilization exercises for persons with acute whiplash-associated disorders: A systematic review. Physiother Can. 2008;60(3):215-23
11. Teasell RW, McClure JA, Walton D, et al. A research synthesis of therapeutic interventions for whiplash-associated disorder (WAD): Part 2 – interventions for acute WAD. Pain Res Manag. 2010;15(5):295-304
12. Gross A, Forget M, St George K, et al. Patient education for neck pain. Cochrane Database Syst Rev. 2012;(3):CD005106
13. Meeus M, Nijs J, Hamers V, et al. The efficacy of patient education in whiplash associated disorders: A systematic review. Pain Physician. 2012;15(5):351-61
14. Monticone M, Ambrosini E, Cedraschi C, et al. Cognitive-behavioral treatment for subacute and chronic neck pain. Spine (Phila Pa 1976). 2015;40(19):1495-504
15. Zronek M, Sanker H, Newcomb J, Donaldson M. The influence of home exercise programs for patients with non-specific or specific neck pain: A systematic review of the literature. J Man Manip Ther. 2016;24(2):62-73
16. Anwer S, Alghadir A, Brismée J-M. Effect of home exercise program in patients with knee osteoarthritis: A systematic review and meta-analysis. J Geriatr Phys Ther. 2016;39(1):38-48
17. Hirohama K, Tamura H, Hamada K, et al. Effects of non-face-to-face and noncontact interventions on knee pain and physical activity in older adults with knee osteoarthritis: A systematic review and meta-analysis. J Aging Phys Act. 2022;31(2):319-29
18. Baeza J. The effectiveness of a home exercise program in improving pain, mobility, and quality of life in patients with neck pain: A randomized controlled study. Clinical Rehabilitation. 2018;32(1):62-70
19. Chiarotto A, Maxwell LJ, Ostelo RW, et al. Measurement properties of visual analogue scale, numeric rating scale, and pain severity subscale of the brief pain inventory in patients with low back pain: A systematic review. J Pain. 2019;20(3):245-63
20. Lim HHR, Tang ZY, Hashim M, et al. Cross-cultural adaptation, reliability, validity, and responsiveness of the Simplified-Chinese Version of Neck Disability Index. Spine (Phila Pa 1976). 2020;45(8):541-48
21. Vernon H. The Neck Disability Index: State-of-the-art, 1991-2008. J Manipulative Physiol Ther. 2008;31(7):491-502
22. Young IA, Dunning J, Butts R, et al. Reliability, construct validity, and responsiveness of the neck disability index and numeric pain rating scale in patients with mechanical neck pain without upper extremity symptoms. Physiother Theory Pract. 2019;35(12):1328-35
23. Bucke J, Spencer S, Fawcett L, et al. Validity of the digital inclinometer and iPhone when measuring thoracic spine rotation. J Athl Train. 2017;52(9):820-25
24. Cánovas-Ambit G, García-Vidal JA, Martín-San Agustín R, et al. Validity and reliability of Veloflex to measure active cervical range of motion in asymptomatic and symptomatic subjects. Peer J. 2021;9:e11228
25. Lau H, Chiu T, Lam T-H. Measurement of craniovertebral angle with electronic head posture instrument: criterion validity. J Rehabil Res Dev. 2010;47(9):911-18
26. Mani S, Sharma S, Kaur D. Web plot digitizer software: can it be used to measure neck posture in clinical practice. Asian Journal of Pharmaceutical and Clinical Research. 2018;11(Special2):86-87
27. Reid SA, Callister R, Katekar MG, Rivett DA. Effects of cervical spine manual therapy on range of motion, head repositioning, and balance in participants with cervicogenic dizziness: A randomized controlled trial. Arch Phys Med Rehabil. 2014;95(9):1603-12
28. Lee J-h, Cynn H-s, Yoon T-l, et al. The effect of scapular posterior tilt exercise, pectoralis minor stretching, and shoulder brace on scapular alignment and muscles activity in subjects with round-shoulder posture. J Electromyogr Kinesiol. 2015;25(1):107-14
29. Kim T-H, Lim J-Y. The effects of wall slide and sling slide exercises on scapular alignment and pain in subjects with scapular downward rotation. J Phys Ther Sci. 2016;28(9):2666-69
30. Blomgren J, Strandell E, Jull G, et al. Effects of deep cervical flexor training on impaired physiological functions associated with chronic neck pain: A systematic review. BMC Musculoskel Disord. 2018;19(1):415
31. Kim E-K, Kim JS. Correlation between rounded shoulder posture, neck disability indices, and degree of forward head posture. J Phys Ther Sci. 2016;28(10):2929-32
32. Monticone M, Cedraschi C, Ambrosini E, et al. Cognitive-behavioural treatment for subacute and chronic neck pain. Cochrane Database Syst Rev. 2015;2015(5):CD010664
33. Freimann T, Merisalu E, Pääsuke M. Effects of a home-exercise therapy programme on cervical and lumbar range of motion among nurses with neck and lower back pain: A quasi-experimental study. BMC Sports Sci Med Rehabil. 2015;7:31
34. Chua SK, Muthalib NFA, Shukri M, et al. Effects of home exercise program on pain and neck functions in individuals with non-specific neck pain. Malaysian Journal of Medicine & Health Sciences. 2021;17(Suppl. 3):60-67
35. Yang C-L, Chen J-L, Tsay S-L, Hsiao C-Y. The effectiveness of printed and video materials for promoting physical activity in sedentary older adults: A randomized controlled trial. International Journal of Nursing Studies. 2012
36. Chhabra H, Sharma S, Verma S. Smartphone app in self-management of chronic low back pain: A randomized controlled trial. Eur Spine J. 2018;27:2862-74