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RESEARCH ARTICLE

Effects of The Postural Based Telerehabilitation on Pain, Posture, Enegry Consumption and Performance in Mechanic Neck Pain: A Crossectional Study-12-Week Trial

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Abstract
Telerehabilitation can be proposed to individuals with mechanic neck pain to improve functional abilities and limit the risk of early degeneration of the musculoskeletal system due to postural problems. This study was conducted to investigate the effect of 12-week telerehabilitation on pain, posture, performance, and energy consumption in individuals with mechanical neck pain.A telerehabilitation program was applied to 78(23.79 ± 8.95)individuals with mechanic neck pain. A synchronized posture-based exercise program was performed 3 times a week for 12 weeks. Pain, postural measurements, performance, and energy consumption levels were determined for each participant before and after telerehabilitation program. Craniovertebral, shoulder, and eye angle were measured with a smartphone application. Clinical tests were used to measure muscle shortness. Performance measurement was evaluated with the 6-minute walk test. The Physiological Cost Index was used for energy consumption assessment.Craniovertebral angle were increased (p=0.001),eye angles were improved after 12-week telerehabilitation (p=0.002). Shortenedpostural muscles were assessed as in normal length after telerehabilitation (p<0.001). There was a significant increase in performance after telerehabilitation (p=0.001). No significant changes in energy consumption of individuals were found after telerehabilitation (p=0.384).This study showed positive effects of telerehabilitation in individuals with mechanic neck pain on pain, posture, and performance. Telerehabilitation can be suggested as an effective modality to decrease pain, improve posture, and performance in individuals with mechanic neck pain.

Keywords
Neck Pain; Posture; Performance; Telerehabilitation; Energy Consumption; Exercise

INTRODUCTION

Staying in the same posture for a long time causes musculoskeletal system problems. Especially in the internet age, excessive usage of mobile phones and other electronics leads postural problems in many people (Arshadi et al. 2019). Among these postural problems, the common ones are decreased cervical lordosis, increased thoracic kyphosis, shortened pectoral muscles, rounded shoulders, and mechanical neck pain. The most common of these problems is the mechanic neck pain. Mechanical neck pain is defined as the pain that occurs in the cervical, occipital, or posterior scapular region without any specific pathology such as a neurological problem, tumor or

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inflammation. It is stated that most of the mechanical acute neck pain attacks in adults are resolved with or without treatment, however approximately 50% of the patients report that the pain is recurrent and chronic (Joshi et al. 2019). It also causes economic burden, loss of labour (Hogg-Johnson et al. 2009).

Applications such as strengthening, stretching, yoga, pain-oriented approach and behavioural treatments are performed for an ideal posture to correct postural problems (Harman et al. 2005). It was proved that these exercise applications improve muscle size, increase muscle strength, and help to gain awareness of postural smoothness during the activities of daily living. There are studies in which short and long-term exercise programs were applied to improve chronic neck pain and postural disorders, however studies about mechanical peck pain are limited (Harman et al. 2005; Joshi et al. 2019; Masaracchio et al. 2018). Cazotti et al (2018) stated that Pilates exercises improve quality of life and are used as an analgesic in mechanical neck pain. Arshadi et al. (2019) showed that corrective exercises improve upper quadrant musculoskeletal disorders in people with upper crossed syndrome. Besides, Jaroenrungsup et al. (2021) demonstrated that self-posture corrective exercises improve neck muscle strength, muscle length, and endurance in individuals with head-forward syndrome.

The trapezius, pectoralis major- minor, and latissimus dorsi are the key muscles in individuals with mechanical neck pain and postural problems (Cleland et al. 2006). Dysfunction of these muscles is seen in individuals whose joint mechanics are affected in the cervical region. Decrease in cervical lordosis, increase in thoracic kyphosis, shortening of pectoral muscles and rounding of shoulders cause increased loads on posterior neck muscles (Singla et al. 2017). These increased loads cause pain, tension, discomfort and musculoskeletal disorders in the neck and thoracic region (Kocur et al. 2019). For this reason, muscle strengthening and stretching exercises that can modify these postural loads, are included as recommended exercises (Park et al.2021). Strengthening the deep flexor muscles and shoulder retractor muscles, stretching the cervical extensor and pectoral muscles are among the recommended exercises (Arshadi et al. 2019). Jaroenrungsup et al. (2021) applied Chintack, neck isometric exercises, scapulothoracic muscle strengthening exercises and stretching exercises for trapezius muscles for 6 weeks in individuals with head-forward syndrome and showed that neck muscle strength and muscle length improved, and neck muscle endurance increased. Cazotti et al (2018) applied pilates exercises for 12 weeks and achieved improvements in individuals with mechanical neck pain. When the literature is examined, it has been seen that the studies have developed especially in the direction of telerehabilitation, but there is a need for studies showing the effect of tele-exercise applications developed for individuals with mechanical neck pain (Cazotti et al. 2018; Jaroenrungsup et al 2021).

Telerehabilitation was seen as an alternative method rather than a mandatory part for the health system. The concept of telerehabilitation is suggested as a form of rehabilitation services, but the COVID-19 pandemic has accelerated the telerehabilitation trend for continuity of rehabilitation services (Fiani et al. 2020). Telerehabilitation can reduce the cost of providing services for patients as well as healthcare systems. Easy patient access, individuality, and self-efficacy lead to reduced hospitalizations, increased health literacy and health-related quality of life (Bowman et al. 2022). Telerehabilitation applications can be carried out on different populations for different purposes such as tele-assessment, tele-education, and tele-rehabilitation (Fatoye et al. 2020; Hernando-Garijoet al. 2021). In the meantime, telerehabilitation continue to grow and studies found that telerehabilitation interventions were effective on pain and posture. However, limited number of studies investigated telerehabilitation applications on mechanical neck pain (Alsobayelet al. 2021; Kosterink et al. 2010; Özer et al. 2021).

Telerehabilitation has only recently been applied to individuals with mechanical neck pain, and a very few studies are available. As Özer et al. (2021) compared synchronous and asynchronous exercise programs in chronic neck pain and, there is only one study was found in mechanical neck pain by using telerehabilitation (Alsobayelet al. 2021). Therefore, this study aimed to assess the effect of the synchronized tele-exercise protocol, which is generally applied in clinical setting, on posture, energy consumption and performance in individuals with mechanical neck pain.

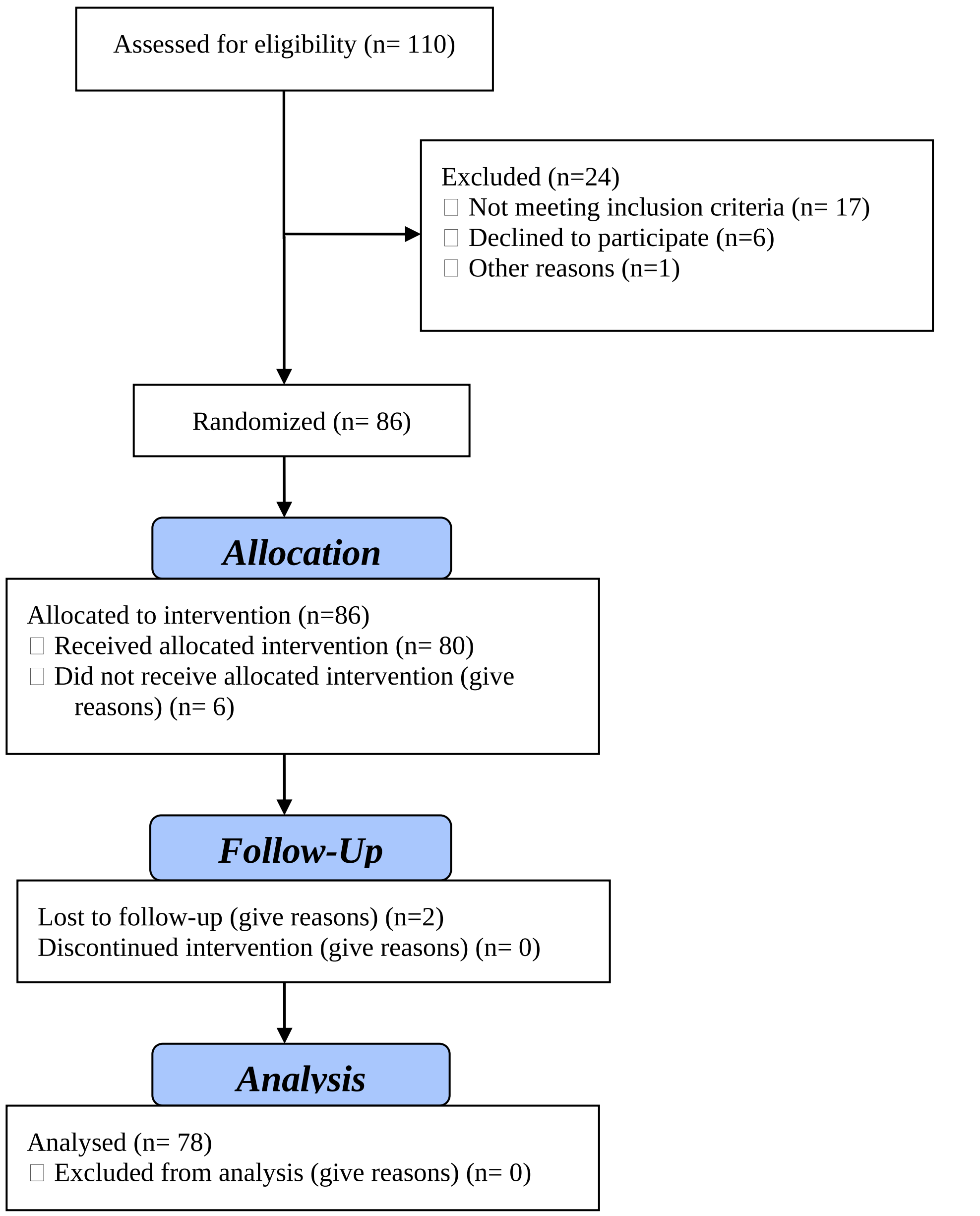
MATERIALS AND METHODS

This cross-sectional study was conducted at the Faculty of Physiotherapy and Rehabilitation, University of Health Science Turkey. Evaluations were performed in the university physiotherapy laboratories. Participants were informed about the study and provided written informed consent.

Participants

Individuals diagnosed with mechanical neck pain who applied to the university's excellence center between September 2021 and December 2021 were screened. A cross-sectional selection of 110 individuals met the inclusion criteria. All participants signed a written, informed consent form.This study was performed in accordance with the 1964 Helsinki declaration and its later amendments. University of Health Science Turkey, Gulhane Scientific Research Institutional Review Board approved this study (protocol number: 2022-80).Assessments were made before and after posture-based telerehabilitation.The exercise program was applied online, and the evaluations were applied face to face. G * power 3.1.9.4 program was used to calculate sample size, with 5% type 1 error, 10% type 2 error and 90% power. The sample size was calculated as 68 based on our pilot study by applying six-minute walk test. However, 80 participants were included in case of dropouts (Figure 1).

Figure1. CONSORT 2010 flow diagram



The inclusion criteria were: i) age between 18-45, ii) volunteer to participate iii) having neck pain for at least 3 months, iv) mechanical neck pain diagnose obtained by an orthopaedist or a neurologist. The exclusion criteria were i) having inflammatory rheumatological diseases, or structural deformity ii) having previous surgery related to the cervical spine, iii) having traumatic neck pain, iv) having inflammatory or malignant disease, v) congenital malformation of the spine, vi) having radical symptoms such as paresis, tingling or numbness, vii) receiving corticosteroid or opioid treatment over the past year.

Demographic variables were recorded. Visual analog scale (VAS) was used to measure mechanical neck pain level (Begum et al. 2019). Neck muscles shortness was evaluated with clinical test(OtmanS. 2014). Shoulder, eye and craniovertebral angle measurement was performed with Kinovea(Puigi Divi et al. 2017). The Six Minute Walk test was used for performance assessment (Enright P.L. 2003). Functional Cost Index was used for energy consumption calculations(Graham et al. 2005).

Visual analogue scale

Patients were asked to mark their pain level on a horizontal visual analogue scale consists of a 10-cm line. The ends were defined as extreme limits of pain, oriented from left (no pain) to the right (extreme pain). Cut-offs for classifying pain intensity on the 10 cm line were; less than 3 cm mild pain, between 3 and 6 cm moderate pain, bigger than 6cm severe pain (Begum et al. 2019).

Craniovertebral, Shoulder, and Eye Angles

The assessments of craniovertebral angle, shoulder angle and eye angle were measured by using lateral-photography via Kinovea program (Elwardany et al. 2015). In standing lateral posture, spinous process of C7, the canthus of eye, and the tragus of ear were marked (Fig. 3)(Ruivo et al. 2015) . Craniovertebral angle was determined by two reference points: one line that runs from the swallow of the ear to seventh cervical vertebra (C7) and other horizontal line parallel to the ground that passes only through the spinous apophysis of C7. Measured angle less than 50°–53° indicates forward head posture(Gallego-Izquierdo et al. 2020). The eye angle, the angle formed at the intersection of horizontal line through the tragus of ear and external canthus of the eye, was measured. Shoulder angle, the angle formed at the intersection of horizontal line through C7 spinous process and the midpoint of greater tuberosity of humerus and posterior aspect of acromion, was measured (Contractor et al. 2020).

Figure 2. Craniovertebral (a), eye (b) and shoulder (c) angle measurement

6-minute walk test (6MWT)

The 6-minute walking test (6MWT) was used to determine performance of participants. The outcome of the test is the distance covered over a time 6 minutes. Participants were asked to walk as far as possible for 6 minutes. Participants walked back and forth in 10 m long section of hallway. The test track was marked at 1-meter intervals in order to calculate the distance covered at the end of the test (Enright P.L. 2003).

Physiologic cost index (PCI)

The purpose of PCI is to measure energy index of gait in different populations. Physiological consumption index was calculated with [(hearth rate after walking)- (resting hearth rate)) / (walking velocity)] equation (Graham et al. 2005). Hearth rate was measured before and after test with Polar watch (Polar S725X, Polar Electro, Finland) (Hill et al. 2020).

Assessment of muscles shortness pectoralis major (clavicular and sternal part)

While testing pectoralis major muscle's clavicular part, patient was asked to be in supine position with the knees bent, elbows were placed in the extension and the shoulder in external rotation with 90-degree abduction position. If the arm drops and stays flat on the table without trunk rotation, it was accepted as normal length. If the arm didn't drop on the table, it was accepted as shortness. Sternal part of the M. Pectoralis Majors' shortness test was measured in the same supine position while shoulder in external rotation, 135 degrees of abduction, and the elbow was extended. If the arm didn't drop on the table, shortness was recorded as positive (Otman S. 2014). The shortness tests were done face to face.

Pectoralis minor

M. Pectoralis minor shortness test was applied on a hard bed, with the patient's knees flexed, the lumbar region straight, palms facing down, and supine on the side of the trunk. The physiotherapist, who applied it for shortness, stood by the patient's bedside and observed the shoulder girdle and applied pressure down the shoulders to make sure there was no shortness (Otman S. 2014).

Latissimus dorsi

M. Latissimus dorsi shortness test; While the patient was lying on his back with his knees flexed and palms facing down, the physiotherapist who performed the test was asked to raise the patient's arms above his head by flexing them with the elbow extended. Thearms should be flexed by keeping the head by theside, but thearms should touch the bed without disturbing thes mooth ness of the lumbar region. If these muscles are short, they will not contact. To determine the short ness, the angle between the humerus and the bed is measured or the distance between the lateral epicondyle of the humerus and the bed is measured (Otman S. 2014).

Intervention

The training program included following exercises: bilateral pectoral stretching, chin tack, cervical isotonic exercises, stretching of the upper trapezius and longus colli, scapular region strengthening exercises, shoulder capsular stretching, Wand exercises, and stabilization exercises. The training program applied 3 times a week, 50 minutes each time, for 12 weeks. (Figure 3). Participants performed the synchronous tele-exercises via Microsoft Teams program. A physiotherapist who is specialised in corrective exercises, run the telerehabilitation sessions. To ensure that participants exercise sufficiently, exercise variation was set according to the ACSM recommendations (AmericanCollege of Sports Medicine, 2019).

Data analysis

The SPSS 21 package program (IBM Corp., Armonk, NY, USA) was used for statistical analyzes. Central tendency and distribution measures and descriptive statistical data were obtained for all variables in the study. Then, Kolmogorov-Smirnov test and other normality tests were used to evaluate whether the variables showed normal distribution. Descriptive characteristics of individuals were given as mean, standard deviation, and frequency. Statistical significance level was accepted as $p < 0.05$. Wilcoxon paired sample tests were used to compare the values before and after telerehabilitation. Cohen's d calculation between group difference measures was used to determine effect sizes. Cohen explained that a small effect has an effect size of 0.2, a moderate effect of 0.5, and a large effect size of 0.8. The values were evaluated at the significance level $p<0.05$ (Larner A.J. 2014).

RESULTS

The demographic details of the participants; age, height, weight, and BMI are presented in Table 1. A significant difference was observed before and after telerehabilitation on the CVA ($p=0.001$) and eye angle ($p=0.002$) with an average improvement in the angles +3 degrees. The performance on the 6MWT was significantly improved ($p < 0.001$) with an average increase in the distance of 6.24 m before and after rehabilitation. No significant change was found between before and after telerehabilitation for the energy consumption of individuals ($p=0.384$) but there is a decrease in heart rate /velocity about 0.8 (Table 2). There was a significant difference in muscle shortness between before and after telerehabilitation (Table 3).

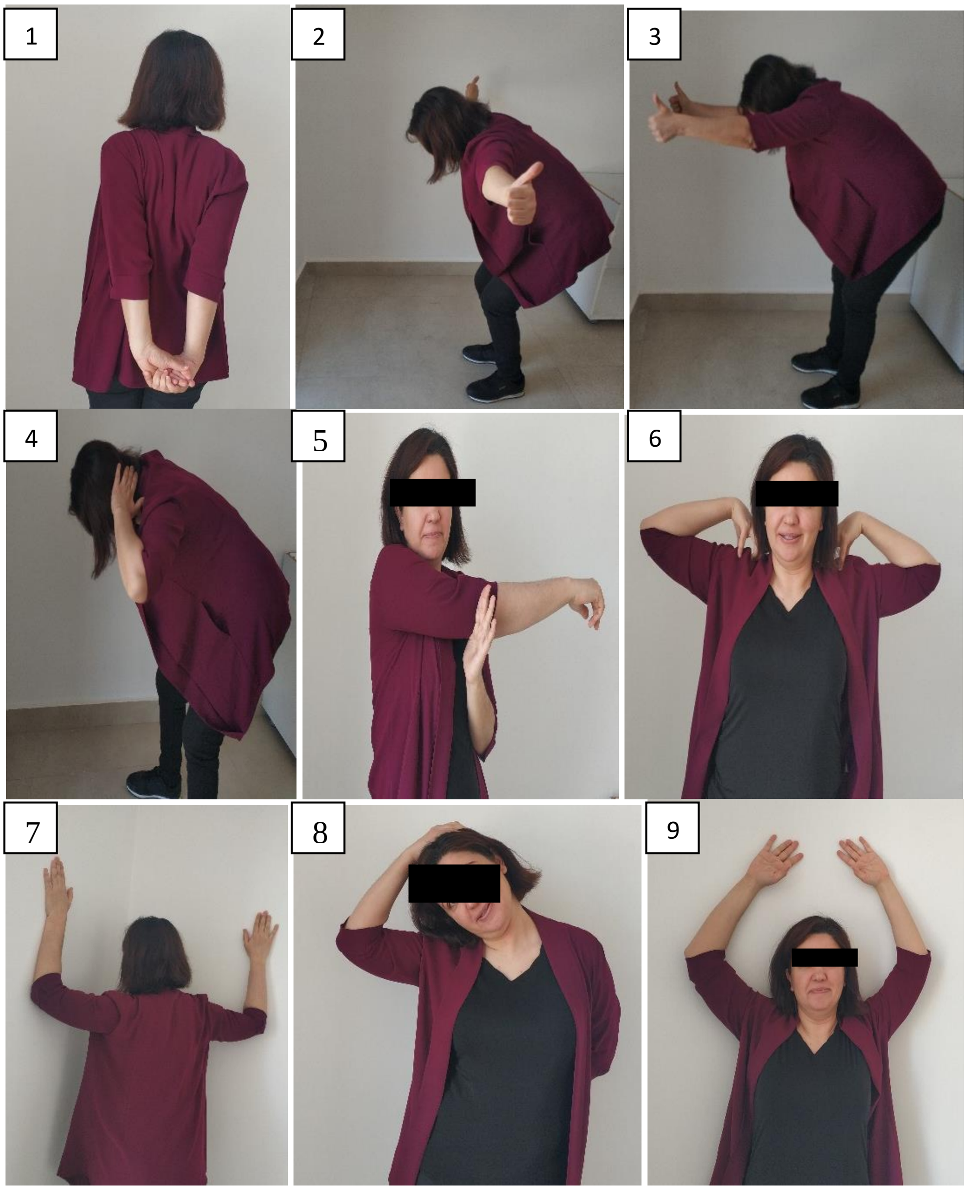


Figure 3. Telerehabilitation exercise program 1- Pectoral streching,2- Rhomboid strenghening, 3- Deltoid, trapezius strenghening, 4- Toracal and Lumbal extansor strenghening,5- Shoulder capsule streching bilateral, 6- Circling back with arms, 7- Streching bilateral pectoral muscles, 8- cervical muscle strecthing, 9- angel drawing on the wall

Table 1. Demographic characteristics of the participants

	M±SD
Age (years)	*23.79* ± *8.95*
Height (cm)	168.65 ± 8.40
Weight (kg)	66.20 ± 14.09
BMI (kg/m^2)	23.21 ± 4.14
Gender (%)	
Female	49(62,8)
Male	29(37,2)

M: Mean, SD: Standard Deviation, BMI: Body Mass Index

Table 2. Comparison of ThePain, Posture, Performance and Energy Consumption Before and After Telerehabilitation

	Before Telerehabilitation Median (Min-Max)	After Telerehabilitation Median (Min-Max)	*Z*	*p*
Pain (Cm)	5(3-6)	2(0-4)	-6.854	<0.001*
Craniovertebral Angle (Degree)	50(12.6-48)	54,50(28-49)	3.208	0.001*
Eye Angle (Degree)	18,10(4-45)	21(1-40)	3.084	0.002*
Shoulder Angle (Degree)	53(2-89)	54(10-97)	1.076	0.282
Performance (meter)	550(193-798)	600(200-890)	6.245	<0.001*
Energy Consumption (Pulse. sn /m)	3.26(2.08-4.93)	2.32(1.08-3.95)	-0.870	0.384

Wilcoxon test, *p<0.05; Min: Minimum, Max: maximum,cm: centimeter,sn: second,m : meter

Table 3. Comparison of the Percent age difference of the Muscle Shortness between Before and AfterTelerehabilitation

MuscleShortness (%)	**Pre-Telerehabilitation**	**Post-Telerehabilitation**	**p**
Latissimus Dorsi			
Yes	36 (46.2)	46 (41)	**<0.001***
No	42 (53.8)	32 (59)	
Pectoralis Major Clavicular Part			
Yes	39(50)	44 (56.4)	**<0.001***
No	39(50)	34 (43.5)	
Pectoralis Major Sternal Part			
Yes	32(41)	28 (35.9)	
No	46(59)	50 (64.1)	**<0.001***
Pectoralis Minor			
Yes	65(83.3)	60 (76.9)	**<0.001***
No	13(16.7)	18(23.1)	

McNemar Test, *p<0.001

DISCUSSION

This study examined the effects of 12-week postural-based telerehabilitation on pain, posture, performance, and energy consumption of individuals with mechanic neck pain. As a result of this study, increases were detected in craniovertebral, shoulder and eye angles in the neck region and improvements in muscle shortness and performances in individuals with mechanic neck pain. No differences were detected in shoulder angles and energy consumption in mechanic neck pain between before and after telerehabilitation. To our knowledge, this study is one of the studies that study in the literature examining the effects of 12 weeks of postural-based telerehabilitation on pain, posture, performance, and energy consumption on mechanic neck pain.

Posture exercises, stretching and strengthening of neck muscles have positive effects on pain and disability in the treatment of the cervical region. Chen et al. (2016) demonstrated that telerehabilitation was useful in chronic neck pain promoting the desired outcome of increased range of motion in neck rehabilitation exercises by altering visual feedback. Özer et al (2021) showed that telerehabilitation provided positive gains on pain intensity, muscle endurance, postural alignment and disability levels. Similarly, this study results in the mean pain intensity that were statistically significant for before and after telerehabilitation. The authors think that postural improvements aftertel rehabilitation reduce the stress on the joints in the neck, resulting in a reduction in pain (Katz and Tenforde. 2020). Problem specific exercise programs improve muscle length, muscle flexibility (ROM), CVA., muscle strength, and reduce pain related symptoms (Yoo, 2013). Park et al.(2014) reported a positive effect on CVA and rounded shoulder posture when stretching and elastic bands were applied in addition to neck and chest muscle strengthening exercises. Also, another study showed that 16-weeks resistance and stretching training program improved forward head and protracted shoulder postures in adolescents (Ruivo et al. 2017). Lynch et al (2010) studied the effects of an 8-week tele-exercise training program on the shoulder angle among 28 professional swimmers between 17-23 ages. Lynch et al (2010) applied an exercise program that was a combination of stretching and strengthening exercises that was performed 3 times a week. It was indicated that performing this training program had a positive effect on reducing the amount of forwarding head and shoulder angle. In this study, increase in CVA and eye angle was also found. However, there was no significant increase in SHA.

In the literature on mechanic neck pain studies, no consensus has yet been reached on the effect of mechanic neck pain on performance. Saeterbakken et al. (2017) showed that specific strength training for neck and shoulder pain in office workers reduced pain, but there was no change in 6-minute walk test. A few more studies demonstrated that on patients with nonspecific low pain using the Numeric Pain Rating Scale, Roland Morris Disability Questionnaire, and performance tests and found a moderate association between self-reported disability and performance-based assessment of functional disability (Nguyen and Randolf, 2017). Asiri et al (2021) proved a negative correlation with pain and functionalperformance. Duray et al (2018) showed that proprioceptive training is effective on motor performance in individuals with chronic neck pain. However, to the best of the researchers' knowledge, so far, it has not been reported any research on performance measurement in individuals with mechanic neck pain. This study results indicated that 6-minute walk test scores were improved significantly after telerehabilitation in individuals with mechanic neck pain.

When the mobility of the trunk is compatible with the movements of the cervical, thoracic and lumbar regions, coordinated movement occurs smoothly. The slightest problem in the cervical region has a negative effect on trunk mobility, and a coordinated, smooth trunk causes more muscle activation during movement. It has been reported that energy consumption is higher (about 40%) in individuals with disabilities and muscular problems, which cause worsened walking economy (Kamp et al. 2014). Kamp et al. (2014) showed that energy consumption increased as the functional status of disabled individuals deteriorated. Henchoz et al. (2015) determined that patients with low back pain adapt their motor control as a protective strategy against pain and increase energy consumption by increasing muscle activation in the lumbal region during walking. However, in this study there is no significant difference before and after telerehabilitation. Since there are no studies evaluating energy consumption related to neck pain in the literature, it is thought that this study will shed light on future studies. In addition, we believe that this is due to the fact that energy consumption is a difficult subject to investigate and interpret because it is affected by many factors.

It is known that the shortness of the muscles around the neck should be evaluated in cervical region pain (Durmuş B. 2014). As a result of the evaluations, it is aimed to correct the muscle imbalance by using strengthening exercises for the elongated muscles and stretching exercises for the shortened muscles. Stretching exercises provide elongation in the elastic component of the musculotendinous unit, thus it plays an active role in reducing muscle stiffness and pain (Cobanoglu et al. 2021). Price et al. (2020) showed the positive effect of stretching exercises on pain. Like previous literature, the results of this study showed that 12-week telerehabilitation improved muscle shortness significantly.

This study limits the generalizability of our results since only patients with moderate neck pain and disability were included. The authors believe that results of this study will shed light on future studies by increasing awareness about mechanic neck pain management. The authors anticipate the need for studies investigating the effectiveness of telerehabilitation programs in different sample groups.

In conclusion, this study proves that 12-week telerehabilitation program improves pain, posture, and performance in individuals with mechanic neck pain. Telerehabilitation can be suggested as an effective modality to decrease pain, improve posture and performance in individuals with mechanic neck pain.

Conflict of interest

The authors declare no conflict of interest. No financial support was received.

Ethics Statement

The approval of the Ethics Committee of Gülhane scientific research was obtained for the study (2022/03 ; 2022-80-17.02-2022).

Author Contributions

Study Design, TYŞ and DT; Data Collection, BNA; Statistical Analysis, BNA, MÖ; Data Interpretation, EY and TYŞ; Manuscript Preparation, SİU and DT; Literature Search, TYA, BNA, MÖ and SİU. All authors have read and agreed to the published version of the manuscript.

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