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Article

Telerehabilitation with Web-Based Exercises for Individuals with Postural Problems: Digital Touch to Posture Disorders—A Randomized Controlled Study

Running Title: Telerehabilitation on Postural Problems

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Abstract

Background: Postural problems such as head forward posture, thoracic hyperkyphosis and lumbal hyperlordosis, when seen together, further complicate postural control, increasing the importance of comprehensive approaches in treatment. This study aims to examine the effect of 6 weeks telerehabilitation with web-based exercises and compare the home based exercises in individuals with postural problems. **Trial Design:** A Randomized Controlled Study. **Methods:** 34 volunteers with postural deformity among young adults were randomly divided into telerehabilitation (n=17) and control (n=1) groups. Craniovertebral, thoracic kyphosis, and lumbal lordosis angles of all individuals were evaluated with a smartphone application (Clinometer+ Bubble), hamstring, and pectoral muscle shortness with a goniometer, and trunk muscle endurance with endurance tests created by McGill and Sorenson. Whilst the tele-rehabilitation group was provided with a video-based exercise programme, the control group was advised to follow the same exercise programme at home. Exercises were performed 3 days a week for 6 weeks, 1 hour session. Participants in the telerehabilitation group were followed up with synconised video conference. **Results:** A significant difference was observed in the telerehabilitation group in muscle shortness and the endurance tests ($p<0.05$). Only a significant difference in left ($p=0.03$) and right ($p=0.04$) muscle shortness was observed in the home exercise group. Significant differences were observed in Craniovertebral and lumbal lordosis angles between groups ($p<0.05$), with the telerehabilitation group showing better outcomes. When examined kyphosis angle, muscle shortness, and endurance tests between groups were found to be similar ($p>0.05$). **Conclusions:** Six weeks of telerehabilitation can improve muscle shortness and trunk endurance in young adults with postural deformities. Both the exercise program using telerehabilitation and the home exercise program were beneficial for individuals with postural problems, with more favorable effects observed in the telerehabilitation group.

Keywords: exercise; kyphosis; lordosis; posture; telerehabilitation

1. Introduction

Telerehabilitation is a type of rehabilitation in which information and communication technology allows for the remote provision of physical rehabilitation services, including assessment, monitoring, intervention, supervision, training, counseling, etc. [1]. Offers an innovative approach using various communication technologies such as telephony, videoconferencing, computer software and mobile applications [2]. Recent studies have shown that the use of telerehabilitation can result in significant clinical gains [1,2]. Suner et al. showed that an online exercise program significantly improved trunk proprioception and muscular endurance in their study [3].

The convex curvature of the thoracic spine, or kyphosis, is regarded as “normal” when it is between 20 and 40° [4]. Increased thoracic kyphosis can significantly alter the position of the scapula and tends to increase scapular protraction and anterior tilt, decreasing range of motion and function of the shoulder [4,5]. Lumbar lordosis refers to the inward (ventral) curvature of the lumbar spine [6]. One of the most crucial components of the spine is lumbar lordosis. Because of its unusual location and direct contact with the pelvis, it is very significant. Strength against the compressive forces of gravity is provided by lumbar lordosis [7]. It has been suggested that postural pain, radiculopathy, and facet pain are mostly caused by increased lordosis [8]. Pacheco et al. discovered that among college students, 97% had pelvic asymmetry, 85.7% had cervical hyperlordosis, 74.2% had thoracic kyphosis, and 65.7% had lumbar hyperlordosis [9]. Ardakani et al. reported that the female to male ratio of thoracic hyperkyphosis was 2:1 and that this anomaly was seen in 38% of individuals aged 20-50 years and 35% of individuals aged 20-64 years [10].

With the benefit of offering rehabilitation from any location, telerehabilitation appears to be a useful treatment option for musculoskeletal problems [11]. According to Khruakhorn et al., telerehabilitation with simultaneous message feedback and visual demonstration enhanced kyphosis angle, physical function, and quality of life [12]. Huang et al. [13] in their meta-analysis, Huang et al. examined the benefits and effectiveness of telerehabilitation, especially in scapular and shoulder disorders, and showed that it was more effective than home exercise in improving range of motion, functional outcomes and quality of life. Mbada et al. showed in their study that telerehabilitation had positive effects on general health status and quality of life in individuals with low back pain [14].

Although the effect of telerehabilitation on postural problems in different parts of the spine is known in the literature [13,15], there is no holistic study evaluating head forward posture, thoracic hyperkyphosis and lumbar hyperlordosis together. It has been challenging to draw precise findings that apply to people with postural issues due to the variability of the included research in terms of study design, patient groups, outcome measurements, and educational delivery methods. The studies emphasized the necessity of randomized trials [13,15]. Increased accessibility to rehabilitation services, less time spent traveling and feeling exhausted, and more scheduling flexibility are just a few advantages of telerehabilitation. However, more study is essential to assess its efficacy and results [16]. Thus, the purpose of this study is to compare the results of home-based exercises and telerehabilitation with web-based workouts for six weeks in people with postural issues.

2. Materials and Method

2.1. Participants

This randomized study included 34 individuals aged between 18-45 years. Participants were allocated to the intervention or control group in a 1:1 ratio using a computer-generated simple randomisation sequence (Random.org). An independent researcher generated and concealed the allocation sequence using sequentially numbered, opaque, sealed envelopes. Participants will be recruited voluntarily and a consent form was signed. Helsinki principles was followed and ethical approval obtained from University of Health Sciences, Non-Interventional Clinical Research Ethics Committee with the decision number 2025–228. The clinical trial number for the study was obtained on 25 May 2025. The clinical trial number is NCT06964750. This study was conducted between June and October 2025 on young adults with spinal pain who applied to the Spinal Health Unit of Gülhane Physical Therapy Faculty. After postural evaluation of the youngsters, those with postural deformities were randomly divided into groups. Participants group were divided into two groups as telerehabilitation 17 people and home-based group as 17 (Figure 1).

CONSORT 2010 Flow Diagram

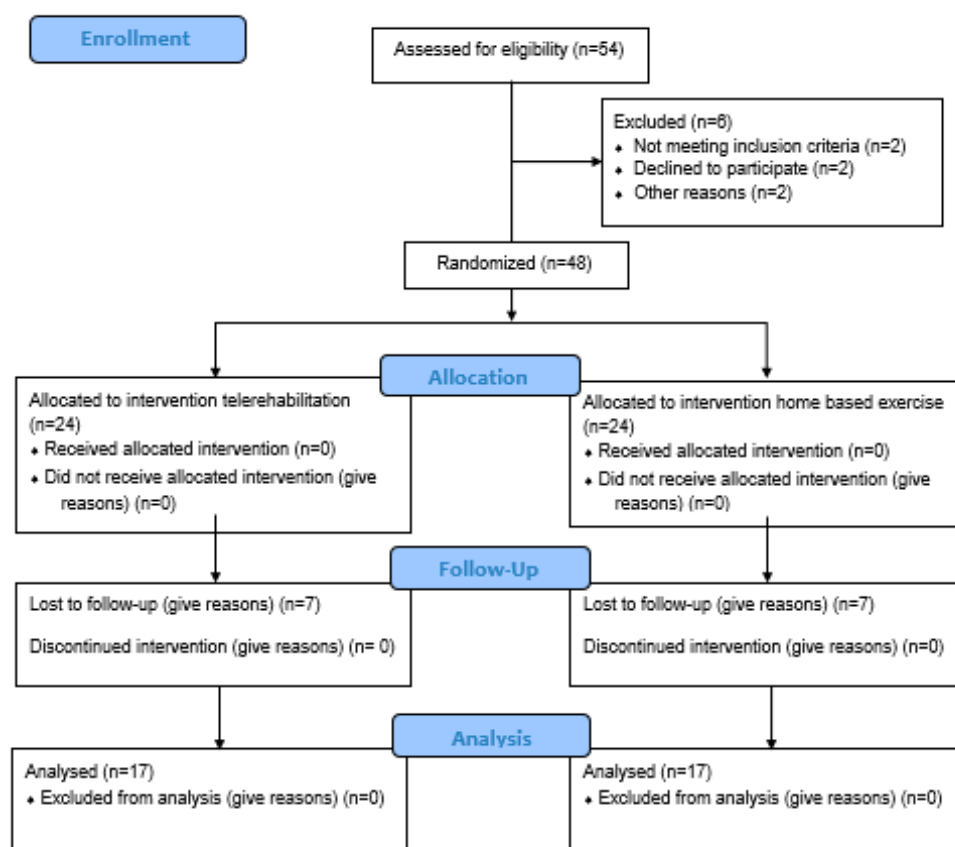


Figure 1. Flow Diagram.

In determining the sample size, based on the study by Rahmani et al. [17], when the primary outcome measure was taken as lumbal lordosis, it was deemed appropriate to have 20 participants in each group based on a 90% power. However, considering the possibility of participants dropping out during the study, it was deemed appropriate to recruit 50 participants, which is 25% more than the initial sample size.

Participants were eligible for inclusion if they voluntarily agreed to participate in the study, and had a body mass index (BMI) below 30 kg/m². Additional inclusion criteria required the presence of cervical, thoracic, or lumbal pain greater than 3 on the Visual Analog Scale (VAS) and a craniovertebral angle measured as less than 52 degrees, indicating forward head posture. Individuals were excluded if they presented with acute or chronic neck, back, or low back pain of a severity that would interfere with testing procedures, or if they were regular exercisers or amateur/professional athletes, as habitual training could confound postural and endurance outcomes. Participants were also excluded if they had a known spinal deformity such as scoliosis; a history of spinal surgery; or any neurological, orthopedic, or congenital disorder affecting the spine. Additional exclusion criteria included visual or hearing impairments that could limit the ability to follow instructions or perform assessments, as well as having received physiotherapy treatment within the previous six months.

2.2. Assessment Parameters

2.2.1. Spine Angles

Individuals with postural issues will have their craniovertebral, thoracic kyphosis and lumbar lordosis angles, hamstring and pectoral muscle shortening, and trunk endurance assessed. Two reference points were used to determine the craniovertebral angle: a line that runs from the ear's tip to the seventh cervical vertebra (C7) and another horizontal line parallel to the ground that only goes through the spinous apophysis of C7 [18–20]. Craniovertebral, thoracic kyphosis and lumbar lordosis angles: The “Clinometer + bubble level” application, which is a smartphone application, available on the Google Play Store and validated by Elpeze et al. will be used [18–20].

2.2.2. Shortness Tests

Hamstring Muscle Shortness Test: The individual will be asked to perform active knee extension while positioned supine with the hip joint in 90 degrees of flexion. The lower back and non-measured knee will be fixed on the bed. The individual will be asked to slowly extend the hip and knee. When there is no knee tremor, the value measured with the goniometer will be recorded in degrees. Hamstring muscle shortness will be determined as individuals with active knee extension less than 70 degrees [21].

Pectoral Muscle Shortness Test: The individual will be supine with knees slightly flexed. In this position, the patient will be allowed to contact the bed freely with their hands behind their back, maintaining the smoothness of the lumbar vertebrae and without forcing the elbows. If the elbows are not in contact with the bed, the distance between the lateral epicondyle of the humerus and the bed will be measured with a tape measure [22].

2.2.3. Trunk Endurance Tests

Lateral bridge test, Sorensen test and trunk flexors endurance test will be evaluated. Measurements will be recorded in seconds using a chronometer. The tests were planned to be terminated when the test position was disturbed. Each measurement will be performed 2 times and the best measurement will be used for statistical analysis.

Lateral Bridge Test: The lateral trunk muscles' static endurance was assessed using the lateral bridge test. The test required the individuals to elevate their bodies on their forearms and toes, turn sideways to their right, and stay in this position. On the opposite side, it was repeated [23].

Sorensen Test: This test was used to assess the static endurance of the trunk extensors. The subjects were positioned face down, with their pelvis, hips, and knees resting on the bed. They were instructed to extend their upper bodies straight forward over the edge of the table [24].

Mc-Gill Endurance Test: Subjects will be asked to assume a supine position with knees bent at 90°. They will then be asked to raise their head and shoulders until the lower angles of the scapula cross the table. The person will be allowed to correct this position once. The number of seconds this position is maintained will be measured by the observer using a hand-held stopwatch [25].

2.2.4. Telerehabilitation Exercise Programme

A predetermined exercise program selected by connecting to the telerehabilitation group from Muscle Wiki, a web-based exercise site, will be transmitted to the individuals. These exercises will be done 3 days a week for 6 weeks and will be followed synchronously with a group call via Whatsapp Application. In addition, the exercises initially lasted approximately 45 minutes, with 2 sets of 10 repetitions. From the third week onwards, the programme progressed to 3 sets of 15 repetitions, with exercise progression determined and adjusted according to each participant's individual progress [26].

2.2.5. Home Based Exercises

In the home based exercise group, the same exercises will be given to individuals using a written and visual exercise form (Figure 2). Individuals will be asked to mark whether they have performed the exercises using an online Excel platform for verification purposes. Additionally, the exercises, which included 2 sets of 10 repetitions, initially took about 45 minutes. The program advanced to 3 sets of 15 repetitions starting in the third week [13,27,28].

EXERCISE BROCHURE


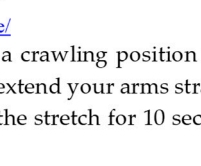
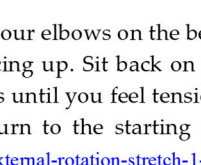
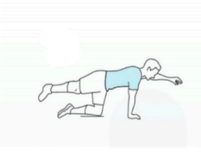
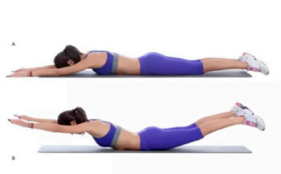


1. **Latissimus dorsi stretching:** The person is asked to place both hands flat against the wall in front of them. They are then asked to slowly lower their body until they feel tension. After stretching for 10 seconds at the lowest point, they are asked to return to the starting position.  6
<https://musclewiki.com/tr-tr/stretch/male/lats/lats-stretch-variation-one/>
2. **Stretching the arms over the head on both sides:** Start in a crawling position with your hands and knees on a mat. Sit back on your heels and extend your arms straight out in front of you. Rest your forehead on the floor. Hold the stretch for 10 seconds at the lowest point, then return to the starting position. 
<https://musclewiki.com/tr-tr/yoga/male/lats/child-pose-arms-extended/>
3. **Stretching on the bench:** Kneel in front of the bench with your elbows on the bench. Then hold the bar at shoulder width with your palms facing up. Sit back on your heels and press your head down between your arms. Press until you feel tension in your back and shoulders, hold for 10 seconds, then return to the starting position. 
<https://musclewiki.com/tr-tr/recovery/male/lats/lat-and-shoulder-external-rotation-stretch-1-kneeling-dowel/>
4. **Crossed Arm and Leg Extension While Crawling:** Get into a crawling position. Lift your hips and shoulders upward until they are at a 90-degree angle. Extend one leg and the opposite arm straight forward. Hold the stretch for 10 seconds, then return to the starting position. Repeat on the other side. 
<https://musclewiki.com/tr-tr/recovery/male/abdominals/core-stability-1-crosslateral-limb-raise-4pt-position>
5. **Strengthening the core muscles in the prone position:** Get into a prone position. Keep your arms above your head and lift your chest and arms off the floor while squeezing your glutes. Then bring your arms back down to your sides, drawing a circle in the air.  31
<https://musclewiki.com/tr-tr/recovery/male/lowerback/swipe-around-prone/>
6. **Neck muscle stretching:** Stand upright with your feet shoulder-width apart. Place one hand on your head and the other near your ear. Gently pull your head toward the same shoulder. After stretching for 10 seconds, return to the starting position. Repeat on the other side.  36
<https://musclewiki.com/tr-tr/stretch/male/traps/traps-stretch-variation-one/> [15]
7. **Plank:** Place your forearms on the floor with your elbows bent at 90 degrees and aligned under your shoulders. Your arms should be shoulder-width apart and parallel to the floor. Your feet should be together, and only your toes should touch the floor. Lift your abdominal area so it does not touch the floor, and form a straight line from your heels to the top of your head. Hold this position for as long as you can.  42
<https://musclewiki.com/tr-tr/workouts/beginner-bodyweight-workout> [25]
8. **Hamstring stretch:** Lie down on the floor with your legs extended toward the wall. Bend one leg at the knee and rest it against the wall. Extend the other leg straight up toward the wall and rest it against the wall. At this stage, push your thigh toward the wall. After stretching for 10 seconds, return to the starting position. Repeat on the other side.

Figure 2. Exercise Brochure.

2.3. Statistical Analysis

The IBM SPSS Statistics package, version 23.0 (SPSS Inc., Chicago, IL), was used for data management and analysis. For quantitative data, the mean and standard deviation (SD) presented. For qualitative variables, percentages (%) displayed. $p < 0.05$ was the threshold for statistical significance. Using the “One-sample Kolmogorov-Smirnov test” and creating a “Histogram” in the statistical analysis test choice, the suitability of all the data for a normal distribution assessed. Within-group differences compared using non-parametric testing using the “Mann-Whitney U test.” To demonstrate group differences, the “Wilcoxon signed-rank test” employed. Additionally, “Pearson’s chi-square” analysis used to look at variations between categorical variables. $p < 0.05$ was chosen as the threshold for statistical significance.

3. Results

When the telerehabilitation and home-based exercise groups were compared before the exercises, there was no difference between the two groups in terms of demographic characteristics ($p > 0.05$) (Table 1). Among the demographic characteristics, only age was found to be different ($p = 0.016$).

Table 1. Comparison of demographic feature between groups.

Variables	Telerehabilitation Group (n=17) (Mean±SD)	Home-Based Exercise Group (n=17) (Mean±SD)	P
Age(year)	22.17±1.28	23.94±2.04	0.016 ^a
Height (cm)	167.11±8.95	169.23±8.67	0.413 ^a
Weight (kg)	62.23±8.85	68.00±12.85	0.170 ^a
BMI (kg/m ²)	22.26±2.57	23.74±4.32	0.357 ^a
Gender n (%)			0.654 ^b
Man	3 (17.6)	5 (29.4)	
Woman	14 (82.4)	12 (70.6)	
Pain n (%)			0.098 ^b
None	1 (5.9)	7 (41.2)	
Low back	12 (70.6)	8 (47.1)	
Neck	3 (17.6)	1 (5.9)	
Upper back	1 (5.9)	1 (5.9)	
Physical Activity n (%)			0.300 ^b
Yes	6 (35.3)	9 (52.9)	
No	11 (64.7)	8 (47.1)	

BMI: Body Mass Index; a: Mann-Whitney U Test; b: Chi-Square Test; n=participants; % percentage.

In terms of craniovertebral, thoracic kyphosis, lumbal lordosis angles, muscle shortness, and endurance tests for pre-interventions, there was no difference between the telerehabilitation and home-based exercise groups prior to the exercises ($p > 0.05$). There was a difference only in the measurement of right pectoral muscle shortness ($p = 0.03$) (Table 2).

Table 2. Comparison of craniovertebral angle, kyphosis angle, lordosis angle, muscle shortness, endurance tests for pre-interventions between groups.

Variables	Telerehabilitation Group (n=17) (Mean±SD)	Home-Based Exercise Group (n=17) (Mean±SD)	Z	P
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Angles (Degree)				
CVA	29.47±9.12	34.58±7.65	-1.51	0.120
KA	19.29±4.39	21.68±6.07	-1.36	0.170
LA	22.52±5.94	17.76±8.27	-1.74	0.080
Shortness (centimeter)				
Hamstring(L)	29.58±10.08	30.76±15.29	-0.34	0.720
Hamstring (R)	30.41±11.74	34.17±15.73	-0.57	0.560
Pectoral (L)	2.11±1.40	0.79±1.33	-2.61	0.090
Pectoral (R)	2.17±1.38	0.76±1.48	-2.99	0.030*
Endurance (second)				
Lateral Bridge (L)	26.73±14.90	36.65±23.74	-1.01	0.310
Lateral Bridge (R)	36.40±21.04	34.41±24.19	-0.49	0.610
Sorensen	27.22±14.47	42.74±29.84	-1.87	0.060
Mc-Gill	42.13±24.28	51.08±26.06	-0.98	0.320

CVA: Craniovertebral Angle; KA: Kyphosis Angle; LA: Lordosis Angle; SD: Standart Deviation; Z: inter-group comparison; P: Mann-Whitney U Test; p*<0.05.

When comparing within groups, a significant difference was observed in the telerehabilitation group in terms of muscle shortening and in the lateral bridge left side test of the endurance tests after exercises (p<0.05). Only a significant difference in left (p=0.03) and right (p=0.04) hamstring muscle shortening was observed after 6 weeks in the home exercise group (Table 3). When comparing the results of the 6-week exercise programs between the telerehabilitation and home exercise groups, significant differences were observed in CVA and LA angles (p<0.05), with the telerehabilitation group showing better outcomes. When examined in terms of KA, muscle shortness, and endurance tests results, the test results between the groups were found to be similar (p>0.05) (Table 4).

Table 3. Comparison of craniovertebral angle, kyphosis angle, lordosis angle, muscle shortness, endurance tests for intragroups.

Variables	Telerehabilitation Group (n=17) (Mean±SD)		Z	p	Home-Based Exercise Group (n=17) (Mean±SD)		Z	P
	Pre-test	Post-test			Pre-test	Post-test		
Angles (Degree)								
CVA	29.47±9.12	28.44±7.22	-.220	0.82	34.58±7.65	34.35±4.87	-.826	0.40
KA	19.29±4.39	17.94±4.09	-1.038	0.29	21.68±6.07	21.14±6.49	-.802	0.42
LA	22.52±5.94	21.41± 5.46	-.483	0.62	17.76±8.27	15.94±6.87	-1.204	0.22
Muscle Shortness								
Hamstring (L) degree	29.58±10.08	19.11±10.49	-3.198	<0.001*	30.76±15.29	23.35±12.36	-2.094	0.03*
Hamstring (R) degree	30.41±11.74	21.88± 13.16	-2.212	0.020*	34.17±15.73	26.88±12.35	-2.046	0.04*
Pectoral (L) centimeter	2.11±1.40	0.79± 0.91	-3.133	0.002*	0.79±1.33	0.70±1.12	-.756	0.45
Pectoral (R) centimeter	2.17±1.38	0.82±10.02	-3.074	0.002*	0.76±1.48	0.52±0.94	-1.134	0.25
Endurance (second)								
Lateral Bridge (L)	26.73±14.90	35.54±19.0	-2.783	0.005*	36.65±23.74	38.02±23.096	-.664	0.50

Lateral Bridge (R)	36.40±21.04	36.47±20.3-2	0.733	34.41±24.19	31.08±13.06	-0.317	0.75
Sorensen	27.22±14.47	38.46±21.6-8	0.053*	42.74±29.84	41.25±27.43	-0.035	0.97
Mc-Gill	42.13±24.28	45.21±29.5-4	0.776	51.08±26.06	49.99±6.93	-0.105	0.91

CVA: Craniovertebral Angle; KA: Kyphosis Angle; LA: Lordosis Angle; SD: Standart Deviation; Z: intra-group comparison; P: Wilcoxon Test; p* $<$ 0.05.

Table 4. Comparison of craniovertebral angle, kyphosis angle, lordosis angle, muscle shortness, endurance tests post intervention between groups.

Variables	Telerehabilitation Group (n=17) (Mean±SD)	Home-Based Exercise Group (n=17) (Mean±SD)	Z	P
	Post-test	Post-test		
Angles (Degree)				
CVA	28.44±7.22	34.35±4.87	-2.041	0.041*
KA	17.94±4.09	21.14±6.49	-1.525	0.131
LA	21.41± 5.46	15.94±6.87	-2.226	0.026*
Shortness () Degree				
Hamstring(L)	19.11±10.49	23.35±12.36	-1.149	0.259
Hamstring (R)	21.88± 13.16	26.88±12.35	-1.593	0.111
Endurance (second)				
Pectoral (L)	0.79± 0.91	0.70±1.12	-0.872	0.383
Pectoral (R)	0.82±10.02	0.52±0.94	-1.143	0.253
Lateral Bridge (L)	35.54±19.05	38.02±23.096	-1.103	0.918
Lateral Bridge (R)	36.47±20.32	31.08±13.06	-0.396	0.692
Sorensen	38.46±21.68	41.25±27.43	-0.499	0.617
Mc-Gill	45.21±29.54	49.99±6.93	-0.465	0.642

CVA: Craniovertebral Angle; KA: Kyphosis Angle; LA: Lordosis Angle; SD: Standart Deviation; Z: between-group comparison; P*: Mann-Whitney U Test; p* $<$ 0.05.

4. Discussion

The purpose of this study was to compare the effects of home-based workouts on postural deformities in people with posture issues and to investigate the 6-week impact of telerehabilitation with web-based activities. The results showed positive developments in trunk endurance tests and muscle shortening in the telerehabilitation group after 6 weeks. After 6 weeks, positive developments in hamstring muscle shortening were observed in the home exercise group. When the telerehabilitation and home exercise groups were compared after treatment, telerehabilitation was found to be more effective on spinal angles.

4.1. Angles

Clinical guidelines suggested that multidisciplinary non-surgical management for most musculoskeletal spinal conditions [29]. Telerehabilitation-based exercise approaches are valid and reliable tools among non-surgical methods used in adults with spinal pain [30,31]. Özel et al.

demonstrated in their studies that structured exercise therapy, when applied with or without supervision in rehabilitation, can improve outcomes for chronic nonspecific neck pain [31]. Khruakhorn et al showed that an 8-week telerehabilitation program was effective and efficient in improving thoracic kyphosis and craniovertebral angle in elderly individuals with a thoracic kyphosis angle greater than 45 degrees and forward head posture, showing no difference in effectiveness and efficiency compared to in-person treatment at the clinic [12]. This study showed that there were slight improvements in spinal angles in the groups before and after the 6-week exercise program, and the results were similar between the groups. Although the results of the study are similar to those in the literature, considering that the individuals included in the study did not have conditions such as hyperlordosis or kyphosis, these results are considered to be a positive development. Furthermore, this study is one of the few studies that examines all spinal angles together with 6 weeks of telerehabilitation-based exercises, and it is thought that it will guide future studies in this direction.

4.2. Hamstring Muscle Shortness

The improvements in muscle shortening observed in this study are consistent with existing evidence showing that hamstrings and pectoral muscles respond differently to telerehabilitation and home exercise program approaches [2,15]. Lower-limb flexibility is known to respond favorably even to uncomplicated and low-cost stretching routines when performed consistently and with sufficient volume [32,33]. Birkaç randomize çalışma, günlük veya neredeyse günlük hamstring germe egzersizlerinin genç yetişkinlerde esnekliği önemli ölçüde artırdığını ve lumbopelvik biyomekaniği iyileştirdiğini bildirmektedir. Bu da, katılımcıların yeterli başlangıç eğitimi aldıkları takdirde sagittal düzlem esnekliğinin daha az denetim gerektirebileceği fikrini desteklemektedir [32,34].

Short hamstrings have been linked to altered pelvic tilt, increased lumbar spine loading, and impaired lumbopelvic rhythm—factors associated with low back pain and reduced functional performance [34,35]. Importantly, interventions improving hamstring extensibility have been shown to beneficially influence sagittal spine alignment and reduce mechanical stress on the lumbar region [35]. Hamstring stretching appears to be sufficiently robust to benefit from well-instructed home programs even in the absence of continuous supervision.

4.3. Pectoral Muscle Shortness

In contrast, changes in pectoral muscle shortness demonstrated a different pattern, occurring only in the telerehabilitation group. This divergence aligns with upper-quarter evidence highlighting that anterior shoulder soft-tissue structures—such as the pectoralis major and minor—require greater technical precision during stretching to avoid compensatory thoracic extension or scapular anterior tilting [36,37]. Indeed, a 7-week pectoralis major and minor stretching has been shown to reduce forward shoulder posture and enhance scapular mechanics, but only when properly supervised and monitored for compensatory movements [37]. These findings suggest that telerehabilitation confers a distinct advantage for technique-dependent upper-quarter flexibility training, where real-time cueing, correction of compensation, and dosage monitoring are essential for effective tissue loading.

4.4. Trunk Endurance Tests

The literature indicates that meaningful improvements in trunk endurance occur when exercise programs last longer than six weeks and include structured, progressive loading [38–40]. Hoppes et al. demonstrated that a core stabilization program significantly improved trunk extensor and flexor endurance in adults with low back pain [38]. Geçit et al. similarly emphasized that an eight-week progressive core intervention resulted in significant improvements in trunk flexor and lateral endurance [40]. A 2024 randomized trial evaluating the effects of structured core training showed significant improvements across Sorensen, lateral bridge, and trunk flexor endurance tests after a nine-week protocol, underscoring that endurance gains are strongly time- and dose-dependent [41].

The selective improvement in lateral trunk endurance observed in the present study carries meaningful implications. Advances in lateral stabilizers are thought to stem from improvements in motor unit firing rather than structural changes. It is thought that 6-week telerehabilitation or home exercise programs may promote neuromuscular adaptations in individuals with lower trunk endurance. In future studies, extending the training period or incorporating a more rigorous progression plan could reasonably enhance these initial gains and lead to more comprehensive improvements in body performance.

4.5. Telerehabilitation- Home Based Exercises

The advantages observed in the telerehabilitation group appear consistent with emerging evidence suggesting that remotely supervised exercise programs may enhance movement quality, exercise fidelity, and postural control more effectively than unsupervised home routines [42,43]. Recent studies in individuals with postural neck pain and forward head posture have similarly demonstrated that telerehabilitation produces superior gains in craniovertebral angle and deep cervical flexor function compared with unsupervised or conventional programs, underscoring the importance of guided motor-learning strategies for postural correction [2,31,44].

However, parameters such as thoracic kyphosis, overall body strength, and overall muscle shortening generally respond more slowly. Therefore, the absence of differences between groups in terms of kyphosis angle and overall strength after 6 weeks of telerehabilitation and home exercise programs indicates that longer-term application is necessary. Importantly, the improvement in craniovertebral and lumbal lordosis angles is consistent with numerous studies showing that postural exercises are effective over a 6-week period [2,12,44].

Furthermore, this study is one of the few studies that examines all spinal angles together with 6 weeks of telerehabilitation-based exercises, and it is thought that it will guide future studies in this direction. This study has several limitations that should be considered when interpreting the findings. First, the intervention duration was limited to six weeks, which may be insufficient to elicit substantial changes in global trunk endurance or spinal alignment parameters that typically respond over longer timeframes. Second, the sample consisted of patients from a single center, which may limit the generalizability of the results to broader populations with different physical activity levels, occupational demands, or postural habits. Third, adherence to the home-based exercise program was monitored through self-report, which is subject to reporting bias. Finally, as this trial focused on short-term outcomes, the long-term sustainability of postural improvements remains unknown. Future research should incorporate follow-up assessments to evaluate retention, relapse, or further adaptation over time.

5. Conclusion

This randomized controlled trial demonstrated that a six-week telerehabilitation program delivered through web-based exercises produced clinically meaningful improvements in craniovertebral and lumbal lordosis angles, pectoral muscle flexibility, and lateral trunk endurance in young adults with postural deviations. While both telerehabilitation and home-based exercise programs were effective in improving hamstring flexibility, only the telerehabilitation group showed improvements in pectoral muscle shortness. Although trunk endurance and kyphosis angle did not differ significantly between groups, the selective gains observed in the telerehabilitation group highlight the potential of digitally supervised exercise to facilitate early neuromuscular adaptations and enhance postural learning. These outcomes support the growing body of evidence indicating that telerehabilitation is a viable—and for some postural parameters, superior—alternative to unsupervised protocols in the management of posture-related musculoskeletal impairments.

In future studies, extending the intervention period, incorporating gradual loading and objective compliance monitoring could further enhance the benefits observed in this study and contribute to more comprehensive postural and neuromuscular improvements.

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