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RESEARCH ARTICLE

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Long-term impact of self-mobilization via telerehabilitation vs. manual therapy and home exercise on pain and function in cervical degenerative disease

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ABSTRACT

Purpose: Cervical Degenerative Disease (CDD) commonly leads to neck pain, functional impairment, and reduced quality of life. This study aimed to compare the long-term effects of home exercise, manual therapy, and telerehabilitation-assisted treatment on pain, functionality, and patient satisfaction in individuals with CDD.

Patients and methods: Sixty-six patients diagnosed with CDD were randomly assigned to three groups: home exercise ($n=23$), manual therapy ($n=22$), and telerehabilitation ($n=21$). All groups participated in an 8-week exercise program, with the manual therapy and telerehabilitation groups receiving additional sessions twice a week. Pain was measured using the Visual Analogue Scale (VAS), pain threshold with an algometer, neck function with the Neck Disability Index and range of motion (ROM), and patient satisfaction with the Patient Satisfaction Questionnaire-18.

Results: All groups significantly improved pain, function, and ROM over time ($p<0.05$). But there were no significant differences between groups at the 6-month follow-up. Manual therapy and telerehabilitation significantly enhanced patient satisfaction, particularly in communication and technical quality ($p<0.05$).

Conclusion: Home exercise, manual therapy, and telerehabilitation improve long-term outcomes in CDD. Manual therapy and telerehabilitation provide greater patient satisfaction, making them viable options for long-term management. Telerehabilitation can be used as an alternative when necessary.

IMPLICATION FOR REHABILITATION

- Home exercises, manual therapy, and telerehabilitation in cervical degenerative disease have shown positive long-term effects on pain, neck functions and patient satisfaction.
- Telerehabilitation offers an alternative treatment option, as it is both accessible and applicable over the long term.
- Manual therapy and telerehabilitation enhance patient satisfaction while preserving the value of in-person therapies for personalized care.
- The combined use of manual therapy, telerehabilitation, and home exercises may provide more effective and sustained results.

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Neck pain; manual therapy; self-mobilization; telerehabilitation; exercise

Introduction

Cervical degenerative disease (CDD) is caused by the degeneration of cervical vertebrae due to physiological and biomechanical factors [1]. The degeneration process occurs in multiple stages, including dysfunction, instability, and stabilization. Pain associated with CDD affects the brachial, shoulder, and neck regions [2]. Common symptoms include neck stiffness, headaches, unilateral or bilateral shoulder pain, non-radicular upper arm pain, eye and vestibular dysfunction, and anterior chest wall pain [3]. Treatment for CDD typically involves joint and soft tissue mobilizations, spinal manipulations, injections, and patient education, and preventive methods, though these approaches have a low evidence supporting their efficacy [4]. Exercise therapy has been reported to reduce pain and improve function in individuals with CDD [5].

Although exercise programs are effective in the treatment of CDD, no standardized algorithm exists for specific pathologies [6]. Additionally, challenges such as patient compliance, travel requirements, work obligations, and insurance limitations have been identified as barriers to face-to-face exercise therapy [7].

A systematic review and meta-analysis evaluating the effects of exercise on cervical radiculopathy (CR) found that exercise,

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whether applied alone or in combination with other treatments, reduces pain and improves functional status. However, no standardized exercise protocol has been established for CR patients [8].

Manual therapy is commonly used to treat CDD and its associated mechanical, neurological, and vascular sequelae, while also restoring segmental mobility [9]. The combination of manual therapy and exercise has been shown to effectively reduce neck pain and improve function. However, a standardized manual therapy protocol has not been established, and it is recommended to be used in conjunction with exercise rather than as a standalone treatment [10,11].

Telerehabilitation, which utilizes electronic communication channels to provide healthcare services, aims to eliminate the barriers associated with face-to-face treatment and offer patients longer-term solutions. Recent studies have shown promising telerehabilitation, which increasing interest in its applications [12]. However, there is a lack of studies specifically examining its effectiveness in individuals with CDD.

Given this information, there is a clear need for interventions that individuals with CDD can perform independently and that provide long-term benefits. This study hypothesizes that differences will be observed in pain, neck function, and patient satisfaction among the home exercise, manual therapy, and telerehabilitation groups. Therefore, the purpose of this study is to compare the long-term effects of home exercise, manual therapy, and telerehabilitation on pain, functionality, and patient satisfaction in individuals with CDD.

Materials and methods

Before starting the study, the necessary permission and approval were obtained from the ethics committee for noninvasive research (approval no: 2021/080). The study was conducted between October 2021 and June 2022 at the Physical Therapy and Rehabilitation Unit of Malatya Education and Research Hospital.

The study included individuals who were diagnosed with CDD by a specialist physician and referred to physiotherapy and rehabilitation. Eligible participants had experienced neck pain lasting longer than three months, had a neck pain score of at least 4 according to the Visual Analog Scale (VAS), and were able to adapt to the study protocol. Patients with surgical indications, those receiving treatment at another institution, those with severe neurological loss, metastatic malignancy, a history of trauma, or any orthopedic, neurological, or metabolic problems other than CDD were excluded from the study.

Prior to the study, a power analysis was conducted to determine the required sample size, which indicated that at least 21 subjects should be included in each group. The sample estimation was performed using publicly available statistical software, OpenEpi, version 3 (http://www.openepi.com). A total of 66 patients were included in the study. The participants were randomly assigned to three groups using the closed-envelope method: the first group was the home exercise group (EG), the second group was the manual therapy group (MT), and the third group was the telerehabilitation group (TR). All exercise interventions were performed over an eight-week period, five days per week, with an average duration of 60 min per session.

Measurements

Demographic information, including age, height, weight, gender, and body mass index (BMI) (kg/m^2) was recorded for all three groups. Assessments were conducted at four time points: before treatment, at the end of treatment (8th week), at the 1st follow-up (3rd month), and at the 2nd follow-up (6th month). Patient satisfaction was evaluated at the 8th week after treatment. All measurements were performed by a physiotherapist who was not involved in the treatment process.

Pain assessment

Pain levels were assessed using the Visual Analog Scale (VAS). Patients marked their pain level on a 10 cm line, with the starting point labeled as "I have no pain" and the endpoint labeled as "I have maximum pain." The marked point was then measured using a ruler. The VAS is a reliable single-item scale that supports other assessment methods [13]. Pain threshold was measured in the suboccipital region using a pressure algometer with a 1 cm^2 rubber tip, which measuring up to 10 kg in kg/cm^2 [14]. Patients with chronic pain have been shown to have significantly lower pain thresholds compared to healthy controls [15].

Functional level

Neck function was evaluated using the Neck Disability Index (NDI), which includes 10 sections: pain intensity, personal care, lifting, reading, headache, concentration, work, driving, sleeping, and recreation. A score of 0 represents the best possible function, while 50 represents the worst [16]. The NDI is a reliable tool for distinguishing between individuals who improved and those who did not [17].

Range of motion

Cervical Range of Motion (ROM) was assessed using a universal goniometer to measure cervical flexion and extension. The Kendall-McCreary criteria were applied during measurements, which were performed three times, with the average values were recorded [16].

Patient satisfaction

Patient satisfaction was assessed using the Patient Satisfaction Questionnaire-18 (PSQ-18). The questionnaire evaluates the quality of health services received at the end of treatment and consists of seven subcategories: general satisfaction, technical quality, interpersonal attitude, communication, financial factors, time spent with healthcare providers, and accessibility/convenience. Responses are scored on a 5-point Likert scale [18].

The first group, **the Home Exercise Group**, was instructed to perform exercise programs lasting 45–60 min, five days a week.

Home Exercise Program	
Postural Exercises Patients initially receive comprehensive posture training, where they learn to maintain correct posture during daily activities and exercise routines. (Hold each pose for 20 s, repeat 10 times)	1. **Hands Clasped Behind Head:** The patient sits or stands, clasps their hands behind their head, and pushes their elbows backward while bringing them toward one another. 2. **Hands on Waist:** The patient stands or sits and places their hands on the sides of their waist. They then pull their elbows back, pinching the scapulae together. The torso should remain still, with movement generated solely from the shoulders. 3. **Hands Clasped Behind Back:** The patient stands or sits, places their hands behind their lower back with straight arms, and lifts them as high as possible. The shoulders are pulled back, bringing the shoulder blades together.
Isometric Exercises with a Towel (3 sets of 10 repetitions in each direction, with 30 s of rest between sets)	1. **Forward Resistance:** The patient holds both ends of the towel and places it against their forehead, pushing their head forward while pulling the towel in the opposite direction to create resistance. 2. **Backward Resistance:** The patient places the towel at the back of their head, and leans backward, pressing against the towel while pulling it forward to generate resistance. 3. **Lateral Resistance:** The towel is placed on one side of the head. The patient pushes their head sideways while pulling the towel in the opposite direction to create resistance. This exercise should be performed separately for both sides.
Cervical Stabilization Exercises (3 sets of 10 repetitions, with 30 s rest between sets)	1. **Supine Position Chin Tuck:** The patient lies on their back, lifts their head slightly, and tucks their chin toward their chest. 2. **Face-Up Trunk Flexion:** The patient lies on their back and slightly lifts their upper body while keeping the neck straight. The lower back remains on the ground. 3. **Forearms on the Ground Trunk Extension:** The patient lies face down, places their forearms on the ground, and keeps their upper body slightly elevated. 4. **Quadruped Position:** The patient assumes a hands-and- knees position, maintaining a straight spine to engage the deep muscles of the neck. 5. **Bilateral Extremity Movements:** While in the crawling position, the patient lifts one arm or leg at a time, maintaining balance and stability.
Stretching Exercises (Hold each stretch for 5 s, perform 3 sets of 10 repetitions, with 30 s of rest between sets)	1. **Neck and Head Forward Flexion:** While sitting or standing, the patient gently bends their head forward, using both hands for support. 2. **Head Extension:** While sitting or standing, the patient carefully tilts their head backward. 3. **Head Rotation:** While sitting or standing, the patient turns their head to one side and uses the opposite hand for support. One hand is placed on the chin while the other applies slight pressure on the elbow.

The second group, the Manual Therapy Group, was asked to perform the same 45- to 60-min home exercise program five days a week. In addition to the exercises, a physiotherapist administered manual therapy to the participants twice a week. The physiotherapists applied non-thrust manipulation techniques, including anteroposterior shifting, lateral shifting, rotation with traction, and both general and segmental cervical traction. These methods aim to support functional recovery and alleviate neck pain [19]. The effectiveness of different manual therapy techniques is believed to be similar [20].

Cervical General and Segmental Traction: In this technique, the participant is positioned supine with their head on the bed. The physiotherapist stands at the head of the bed, placing one hand under the participant's chin and the other under their head to grasp the occiput. The physiotherapist then gently pulls on the head, applying traction to the cervical spine. The traction is maintained for 8 to 10 s before slowly returning to the starting position.

Segmental Anterior-Posterior Shifts: In this technique, the participant is supine. The physiotherapist performs anterior-posterior shifts along the cervical vertebrae while maintaining cervical traction, supporting the occiput with one hand and the underside of the chin with the other. The therapist progresses systematically from the upper cervical segments to the lower segments.

Segmental Lateral Shifts: In this technique, the participant is supine. The therapist places their thumbs near the participant's ears while using the other fingers support the occiput. Starting with the upper spinal segments, the physiotherapist slowly shifts laterally, progressing toward the lower segments.

The third group, the Telerehabilitation Group, was asked to participate in the same 45–60 min home exercise program five days a week. In addition to performing their exercises, they also engaged in self-mobilization with synchronous telerehabilitation sessions guided by a physiotherapist twice weekly.

Active Cervical Rotation: Participants wrapped a towel behind their necks and held both ends. While rotating their necks, they applied light pressure with the towel to guide the movement. The left hand supported rotation to the right, while the right hand supported rotation to the left.

Active Cervical Extension: Participants placed the towel behind their necks, extended their necks backward, and pulled both ends of the towel forward [21].

Statistical analysis

Continuous variables were presented as mean ± standard deviation, and categorical variables as frequency and percentage values. The Shapiro-Wilk test was used to assess normality. Based on the normality test result, when the assumption of normality was met, an independent samples t-test was used for two independent groups, and a paired sample t-test was used for two dependent groups. For comparisons involving more than two independent groups, a One-Way Analysis of Variance (ANOVA) was applied when the normality assumption was met, while for dependent groups, a Repeated Measures ANOVA was used. When the normality assumption was not met, the Kruskal-Wallis H test was employed for comparisons between more than two independent groups, and the Friedman test was used for comparisons between more than two dependent groups. The Pearson Chi-square and Fisher-Freeman-Halton tests were applied for comparisons of categorical variables. For pairwise comparisons where significant differences were found in groups with more than two variables, the Bonferroni correction was applied. IBM SPSS Statistics 25.0 (SPSS Inc, Chicago, USA) was used for statistical analysis, and statistical significance was set at $p < 0.05$.

Results

There were no significant differences between the groups regarding the demographic characteristics of the individuals ($p > 0.05$) (Table 1).

Table 1. Demographic characteristics of the patients.

	HEG ($n=23$) X ± SD	MTG ($n=22$) X ± SD	TRG ($n=21$) X ± SD	F/χ^2	p*
Age (year)	50.39 ± 6.19	47.05 ± 7.51	46.00 ± 4.76	2.979	0.058[a]
Weight (kg)	71.48 ± 9.69	75.55 ± 14.77	69.24 ± 10.79	1.550	0.220[a]
Height (cm)	161.52 ± 7.22	165.73 ± 8.06	160.19 ± 7.74	3.087	0.053[a]
BMI	27.39 ± 3.19	27.50 ± 5.17	26.99 ± 3.97	0.090	0.914[a]
Gender n(%)					
Female	19 (82.6)	14 (63.6)	18 (85.7)	3.554	0.169[b]
Male	4 (17.4)	8 (36.4)	3 (14.3)		

HEG: Home Exercise Group; MTG: Manual Therapy Group; TRG: Telerehabilitation Group; BMI: Body Mass Index; X: mean; SD: Standard Deviation; a: One-way ANOVA; b: Chi square test, *$p<0.05$.

The time-dependent changes in VAS, NDI, ROM-CF and ROM-CE values among individuals in the HE, MT, and TR groups differed significantly ($p<0.05$). While no significant time-dependent changes in TWM were observed within the HE and MT groups ($p>0.05$), a significant difference was found in the TR group ($p<0.05$). A significant difference was also observed between the groups in ROM-CF measurements after treatment (8 weeks) and in ROM-CE measurements at the 3-month follow-up. Furthermore, a significant difference was found between the groups in patient satisfaction measurements, particularly in general satisfaction, technical quality, and communication (Table 2).

Table 2. Intra-group and inter-group comparisons of clinical measurements at different evaluation time points.

		HEG	MTG	TRG	X ^{2}/F	p*
VAS	T0	6.91 ± 1.70	7.41 ± 1.44	7.38 ± 1.74	1.981	0.371[b]
	T1	4.87 ± 1.87	4.50 ± 1.18	5.33 ± 1.93	2.255	0.324[b]
	T2	4.74 ± 1.71	5.18 ± 2.24	4.76 ± 2.16	0.393	0.822[b]
	T3	4.33 ± 2.43	4.39 ± 1.85	4.24 ± 2.66	0.324	0.851[b]
F/χ^2		22.875	28.959	24.524		
p*		**<0.001**[a]	**<0.001**[a]	**<0.001**[a]		
Algometer (suboccipital)	T0	5.89 ± 2.55	6.38 ± 3.00	5.26 ± 1.95	1.664	0.435[b]
	T1	8.29 ± 3.19	8.82 ± 3.68	6.58 ± 3.09	6.844	0.033[b]
	T2	8.03 ± 3.21	8.04 ± 4.09	7.29 ± 2.93	0.404	0.817[b]
	T3	8.49 ± 2.97	8.73 ± 3.94	7.66 ± 3.70	1.777	0.411[b]
		26.214	25.264	25.851		
		<0.001[d]	**<0.001**[d]	**<0.001**[d]		
Neck Disability Index	T0	18.17 ± 7.66	17.77 ± 8.09	18.67 ± 7.91	0.069 F	0.933[c]
	T1	13.69 ± 6.18	11.27 ± 5.28	13.86 ± 7.49	1.135 F	0.328[c]
	T2	12.17 ± 6.40	11.95 ± 6.89	11.71 ± 6.95	0.102 F	0.975[c]
	T3	14.08 ± 7.88	11.50 ± 6.21	11.71 ± 8.77	0.786 F	0.460[c]
F/χ^2		8.237	10.112	7.411		
p*		**0.001**[a]	**<0.001**[a]	**<0.002**[a]		
ROM-CF	T0	43.69 ± 8.68	44.77 ± 8.08	44.05 ± 8.75	0.234	0.890[b]
	T1	50 ± 9.04	57.5 ± 8.69	51.67 ± 7.64	8.140	**0.017**[b]
	T2	53.69 ± 9.32	58.64 ± 9.15	56.43 ± 10.26	3.558	0.169 [b]
	T3	56.3 ± 10.68	57.05 ± 9.72	56.9 ± 10.43	0.138	0.933 [b]
F/χ^2		12.297	19.221	12.172		
p*		**<0.001**[a]	**<0.001**[a]	**<0.002**[a]		
ROM-CE	T0	36.96 ± 11.84	38.86 ± 10.57	40.48 ± 8.93	2.608	0.271[b]
	T1	41.09 ± 11.37	42.73 ± 12.6	47.14 ± 8.59	4.436	0.109[b]
	T2	41.74 ± 8.61	45.23 ± 10.63	51.43 ± 8.96	9.653	**0.008**[b]
	T3	45.22 ± 7.9	45.23 ± 11.79	50.95 ± 10.08	4.375	0.112[b]
F/χ^2		4.176	6.677	9.520		
p*		**0.009**[a]	**0.001**[a]	**<0.001**[a]		
Patient Satisfaction	General Satisfaction	4.24 ± 0.42	4.84 ± 0.24	4.83 ± 0.24	29.90	**<0.001**[b]
	Technical Quality	4.67 ± 0.31	4.93 ± 0.14	4.95 ± 0.10	15.34	**<0.001**[b]
	Interpersonal Manner	4.76 ± 0.26	4.88 ± 0.21	4.90 ± 0.20	5.12	0.077[b]
	Communication	4.59 ± 0.44	4.91 ± 0.25	4.90 ± 0.26	11.63	**0.003**[b]
	Financial Aspects	5 ± 0	5 ± 0	4.98 ± 0.11	2.14	0.343[b]
	Time Spent with Doctor	4.93 ± 0.17	4.93 ± 0.18	4.95 ± 0.15	0.19	0.907[b]
	Accessibility and Convenience	4.89 ± 0.18	4.96 ± 0.09	4.96 ± 0.09	3.10	0.212[b]

HEG: Exercise Group; MTG: Manual Therapy Group; TRG: Telerehabilitation Group; VAS: Visual Analog Scale, ROM-CF: Range of Motion Cervical Flexion; ROM-CE: Range of Motion Cervical Extension. $p<0.05$; a: repeated measures analysis of variance (F); b Kruskal Wallis H test (X2); c: One-way ANOVA (F); d: Friedman test (X2); T0: first measurement, T1: 8th week measurement; T2: 3rd month measurement; T3: 6th month measurement.

Table 3. Intra-group comparison of clinical measurements of patients at different evaluation time points compared to before treatment.

		HEG		MTG		TRG	
		t	p	t	p	t	p
VAS	T0-T1	4.017	**0.001**[a]	10.752	**<0.001**[a]	4.607	**<0.001**[a]
	T0-T2	4.721	**<0.001**[a]	4.410	**<0.001**[a]	6.200	**<0.001**[a]
	T0-T3	5.078	**<0.001**[a]	6.000	**<0.001**[a]	4.961	**<0.001**[a]
NDI	T0-T1	3.719	**<0.001**[a]	5.551	**<0.001**[a]	3.343	**0.003**[a]
	T0-T2	4.742	**<0.001**[a]	3.524	**0.002**[a]	4.540	**<0.001**[a]
	T0-T3	2.156	**0.042**[a]	4.000	**<0.001**[a]	2.834	**0.010**[a]
ROM-CF	T0-T1	−3.844	**<0.001**[a]	−6.062	**<0.001**[a]	−3.269	**<0.001**[a]
	T0-T2	−4.592	**<0.001**[a]	−6.508	**<0.001**[a]	−4.647	**<0.001**[a]
	T0-T3	−4.869	**<0.001**[a]	−5.187	**<0.001**[a]	−4.258	**<0.001**[a]
ROM-CE	T0-T1	−1.571	0.130[a]	−3.196	**0.004**[a]	−2.573	**0.018**[a]
	T0-T2	−1.901	**0.070**[a]	3.216	**0.004**[a]	−4.552	**<0.001**[a]
	T0-T3	−3.321	**0.003**[a]	−3.261	**0.004**[a]	−4.481	**<0.001**[a]

HEG: Home Exercise Group; MTG: Manual Therapy Group; TRG: Telerehabilitation Group; VAS: Visual Analog Scale, ROM-CF: Range of Motion Cervical Flexion; ROM-CE: Range of Motion Cervical Extension. a: dependent sample t test (t); T0: first measurement, T1: 8th week measurement; T2: 3rd month measurement; T3: 6th month measurement.

Table 4. Pairwise comparisons of groups and corresponding effect sizes.

	HEG-MTG			HEG-TRG			MTG-TRG		
	Cohen d	z	p[a]	Cohen d	z	p[a]	Cohen d	z	p[a]
ROM-CF	0.845	−2.838	**0.008**	0.199	−0.665	0.509	0.711	2.339	0.028
ROM-CE	0.362	−1.207	0.344	1.104	−3.65	**0.002**	0.629	−2.071	0.032
General Satisfaction	1.744	−5.915	**0.001**	1.704	−5.782	**0.001**	0.042	0.137	0.917
Technical Quality	1.073	−3.652	**0.002**	1.193	−4.104	**0.001**	0.164	−0.541	0.718
Communication	0.889	−3.016	**0.005**	0.848	−2.874	**0.007**	0.039	0.128	0.952

HEG: Home Exercise Group; MTG: Manual Therapy Group; TRG: Telerehabilitation Group; ROM-CF: Range of Motion Cervical Flexion; ROM-CE: Range of Motion Cervical Extension. $p < 0.017$ (Bonferroni correction); a: Mann-Whitney U test.

Additionally, significant differences were observed in the pre-and post-treatment results of the HE and MT groups in VAS, NDI and ROM measurements. The TR group showed significant differences in all pre- and post-treatment results (Table 3).

Pairwise comparisons between groups are presented in Table 4. A significant difference was observed between HEG-TRG in ROM-CE and HEG-MTG in ROM-CF. Additionally, significant differences were found in general satisfaction, technical quality and communication parameters in pairwise comparisons of HEG-MTG and HEG-TRG.

Discussion

Cervical spine degeneration is often referred to as cervical degenerative spondylosis, cervical degenerative disease, cervical spondylosis, cervical osteoarthritis, and cervical arthritis. Research indicates that approximately two-thirds of the population will experience cervical degenerative disorders at some point in their lives [22]. Pain is a significant symptom associated with cervical degenerative conditions and is the primary reason patients seek treatment [23]. This study compares the short- and long-term effects of exercise, manual therapy, and telerehabilitation-supported self-mobilization techniques on pain levels, cervical function, and patient satisfaction in individuals diagnosed with degenerative diseases of the cervical spine. The effectiveness of these treatment approaches was assessed through control measurements conducted at four time points: before treatment, at the end of the eighth-week, at the three-month follow-up, and the six-month follow-up.

Strength, endurance, stretching, and stabilization exercises are commonly used to treat neck pain, and these methods have been reported to be particularly effective for chronic neck pain [24]. A multimodal approach is recommended, as combined therapies, including education, neuromuscular exercises, proprioceptive training, manual therapy, and posture training have been shown to be more effective, according to the literature [25].

Comprehensive reviews and meta-analyses demonstrate that the combined use of manual therapy and exercise is more effective than either modality alone [26]. In patients with chronic neck pain, it has been shown that the combination of manual therapy with exercise improves neck function, pain severity, and cervical range of motion more effectively than exercise alone. Additionally, these improvements have been reported to persist during a 6-months [27]. Another study reported a faster reduction in pain sensation in the group that received a combination of manual therapy and exercise [28]. Similarly, Akguller et al. found that patients who received both manual therapy and exercise had superior pain score outcomes compared to those who underwent either treatment alone [29]. In our study, exercise programs were applied to all groups. While no significant difference were observed in long-term pain and functionality levels, patient satisfaction and certain functional measurements showed better results in the groups that received manual therapy and telerehabilitation compared to home exercise alone.

The meta-analysis by Reyhana and Wahyuni (2024) revealed that while manual therapy has little effect on functional improvement, it produces positive outcomes in increasing joint range of motion. However, the impact on functional enhancement was not statistically significant [30]. In our study, neck functionality and cervical ROM improved in both the short- and long-term across all groups. While no significant differences were observed in neck function between the groups, differences in cervical ROM improvements appeared after treatment. The manual therapy and telerehabilitation groups demonstrated a larger effect magnitude compared to the home exercise group.

Telerehabilitation provides remote rehabilitation services through real-time videoconferencing, recorded videos, telephone conversations, or virtual reality. While asynchronous telerehabilitation involves the subsequent analysis of digital images, synchronous telerehabilitation delivers immediate feedback and instruction, facilitating real-time engagement [31]. Research has shown that asynchronous telerehabilitation is more effective than standard home exercise brochures [32]. However, no significant difference has been reported between synchronous and asynchronous telerehabilitation applications [33]. In our study, we used synchronous telerehabilitation to provide the participants with real-time, interactive rehabilitation services.

Telerehabilitation has been shown to provide comparable benefits in pain relief and function improvement when compared to traditional physiotherapy [34–36]. However, more research is required to evaluate the long-term effects of manual treatment and telerehabilitation on individuals with cervical conditions [37]. To date, no study has specifically examined the long-term effects of telerehabilitation-assisted self-mobilizations in individuals with neck disorders. This study indicates that telerehabilitation leads to long-term improvements in pain relief, neck function, and joint mobility.

Researchers have found that self-mobilization techniques, when combined with exercise, can help improve the range of motion for cervical lateral flexion and rotation while also reducing the risk of declining neck function [38]. Self-mobilization techniques are also incorporated into home exercise programs for manual therapy groups as part of face-to-face rehabilitation programs [39]. In our study, we observed functional improvements in neck function across all three groups over time.

Although telerehabilitation gained popularity during the COVID-19 pandemic, both patients and practitioners believe it can remain a valuable component of the treatment process even in the post-pandemic era [40]. It is recommended that telerehabilitation be incorporated as a clinical practice tool in cases where physiotherapists who apply manual therapy deem it appropriate and beneficial [41]. In our study, we observed high levels of patients satisfaction when evaluating the participants' satisfaction with their treatment after the intervention.

A systematic review by Amin et al. (2021) revealed that individuals with musculoskeletal disorders were highly interested in telerehabilitation and considered it an effective treatment alternative [42]. During the pandemic, the uninterrupted access to care provided by telerehabilitation made it an important treatment option. Research has indicated that patients were as satisfied with therapy delivered *via* telehealth as with face-to-face treatment. However, some studies reported lower satisfaction ratings related technological issues and appointment booking systems in telerehabilitation groups [43]. We did not encounter such issues in our study.

Given the convenience, flexibility, and positive outcomes associated with telerehabilitation, healthcare professionals may consider it either as a standalone option or as part of a hybrid care model [44]. It is recommended that clinicians confidently integrate telerehabilitation as an intervention tool for patients who prefer this method or for those without access to face-to-face treatment [45].

Conclusions

This study compared the long-term effects of home exercises, manual therapy, and telerehabilitation-assisted treatment methods in individuals with CDD. The findings revealed that all three methods had positive long-term effects on pain, neck functions, and patient satisfaction. Patients in the telerehabilitation group, exhibited high levels of satisfaction, suggesting that telerehabilitation could serve as an effective alternative, especially for long-term management. Both manual therapy and telerehabilitation stood out in terms of patient satisfaction, providing patient-centered, long-term solutions.

In conclusion, manual therapy, telerehabilitation, and home exercises were all effective and applicable treatment methods for CDD patients. Telerehabilitation shows promise for future treatment strategies, particularly due to its independent, home-based applications and its efficacy in long-term management. We recommend telerehabilitation as a safe and viable option for patients who lack access to face-to-face treatment.

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