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Research Article

The Effect of Telehealth-Based Rehabilitation on Patient Reported Outcomes and Objective Clinical Measurements in Patients With Degenerative Meniscal Tear

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Abstract

Aim: The study aimed to compare the effectiveness of telehealth-based home exercises and conventionally prescribed home exercises in patients with degenerative meniscal tears.
Material and Method: A two-armed, randomized controlled study was conducted with 49 participants with degenerative meniscal disease. Patients were randomized into Telerehabilitation (TR=25) and Conventional Home Exercise Rehabilitation (CR=24) groups. The TR group provided video exercises and self-management education via an online platform. The same protocol was given to the CR group in the clinical setting. Pain with Visual Analog Scale, muscle strength with Hand-Held Dynamometer, proprioception with Baseline bubble inclinometer, functional status with Western Ontario and McMaster Universities Osteoarthritis Index, exercise adherence with Exercise Adherence Rating Scale, quality of life with Short Form-12 were evaluated at baseline and after eight weeks of intervention. In addition, satisfaction and usability were assessed with the Telemedicine Satisfaction and Usefulness Questionnaire at week 8.
Results: The TR group improved activity pain, proprioception, some parameters of the muscle strength outcomes, and exercise adherence scores ($p<0.05$). The TR group was not superior to the CR group regarding pain at rest, quality of life and functional status ($p>0.05$). In addition, 52 percent of the TR group reported high levels of satisfaction and usability.
Conclusion: Despite increased participation and satisfaction, the telerehabilitation group noticed improvements in clinician-based measures (proprioception, strength) but not in rest pain, function, and quality of life. As a result, telerehabilitation-based home exercises prescribed to these patient groups are more effective.

Keywords: Menisci, mobile health, self-care, video exercise

INTRODUCTION

Degenerative meniscal lesions are a widespread disease burden, particularly in middle-aged and older individuals (1). Although this type of lesion is mainly seen in the posterior horn of the medial meniscus, additionally overloading the joint, malalignment, and excessive body weight accelerate degenerative meniscus formation (2). The literature provides updated approaches (exercise, surgery) and discusses how appropriate treatment should be in degenerative meniscal lesions (3). Conservative and surgical treatment components are recommended in the treatment of degenerative meniscal lesions. Especially in the last decade, conservative approaches have replaced arthroscopic surgical approaches in treating degenerative meniscal lesions (4). Hence, a conservative treatment component, including evidence-based physiotherapy, is frequently administered in degenerative meniscal tears (if there is no sign of locking or entanglement) (5). Effective approaches that constitute the most essential part of evidence-based physiotherapy and play a key role in individuals with this disease burden are exercise programs that increase muscle strength and function (6). Different studies have emphasized the positive effects of exercises on pain, muscle strength, and quality of life in individuals with degenerative meniscal tears (7,8).

CITATION
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In recent years, health services have been prescribed to individuals through telecommunication technologies and access to health centers. Via remote telerehabilitation, physiotherapy applications are increasingly prescribed for individuals with musculoskeletal problems. With telerehabilitation, it is possible to meet with patients remotely, and evaluation, consultation, physiotherapy, and follow-up are alternative and low-cost methods (9,10). Physiotherapists can use different communication techniques and sound evidence-based strategies such as video exercises, video conferencing, self-management principles, e-mail, telephone, and messages (11). Telerehabilitation has been reported to positively affect pain and function when given simultaneously (real-time) with videoconferencing in individuals with musculoskeletal problems (12). Moreover, it has been reported that the evaluation of musculoskeletal disorders involving the knee through telerehabilitation is feasible and has good inter or intra-rater reliability (13).

Telerehabilitation services are gradually developing with the spread of telemedicine applications in musculoskeletal disorders (9). In another experiment, two methods (videoconference, telemedicine follow-up, and office-based follow-up) were compared in the postoperative follow-up of individuals who had arthroscopic meniscectomy and repair. In conclusion, it has been emphasized that telemedicine and traditional office-based follow-up are equivalent to each other in the postoperative follow-up of individuals who have undergone arthroscopic meniscectomy and repair, and the importance of telemedicine follow-up as an alternative method (14). As yet, there is no study evaluating the effects of telerehabilitation on clinical status, patient satisfaction, and quality of life using subjective and objective measurements in individuals with degenerative meniscal lesions followed by conservative treatment. In addition, degenerative meniscal injury usually involves middle-aged individuals, and middle-aged individuals may adapt more easily to tele-rehabilitation methods. Therefore, we aimed to conduct the present study in this population. The study aimed to compare the effectiveness of telehealth-based and conventional paper-based home exercises on patient-reported outcomes and objective clinical measures in patients with degenerative meniscal tears. We hypothesized that telerehabilitation-based home exercises would be more effective than traditional paper-based home exercises in patients with degenerative meniscus.

MATERIAL AND METHOD

Study Design and Participants

A randomized controlled trial was conducted in Muğla Sıtkı Koçman University, Department of Orthopedics and Traumatology. Forty-nine participants diagnosed with degenerative meniscus injury by an orthopedic specialist were included in the study. The trial is reported according to the "CONsolidated Standards of Reporting Trials (CONSORT) stages and taken into account the recommendations of Standard Protocol Items: SPIRIT (Statement of Recommendations for Interventional Trials)" (15).

Inclusion criteria were; (1) individuals aged between 18 and 65, (2) individuals diagnosed with degenerative meniscus injury after clinical and radiological evaluations by an orthopedic specialist and decided to follow up with conservative treatment. Exclusion criteria from the study: (1) people with a history of surgery due to degenerative meniscus injury, 2) orthopedic and neurological conditions that could prevent evaluation and/or treatment, (3) conditions that may prevent communication in the evaluation and follow-up of individuals.

At the baseline, 85 individuals were recruited. However, 25 were excluded as they did not meet the inclusion criteria. A total of 60 patients were randomly allocated to the groups. Eleven individuals were excluded from the study for different reasons. As a result, 49 patients, including 24 conventional home exercise rehabilitation (CR) and 25 telerehabilitation (TR), were analyzed (Figure 1).

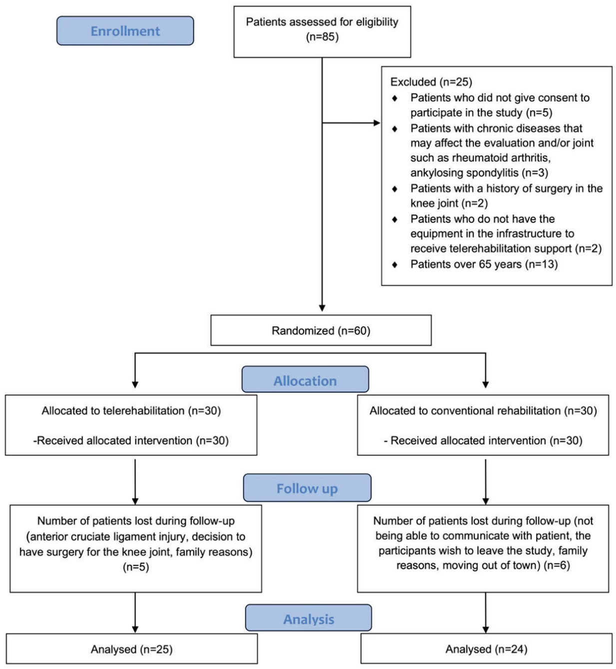

Figure 1. CONSORT flow chart of the study

Recruitment

Participants who met all criteria were informed about the study. The purpose, method, and possible risks of the study were explained to the individuals diagnosed with degenerative meniscal injury within the scope of the information. Written informed consent was obtained from individuals who agreed to participate in the study.

Sample Size

According to a power analysis that was calculated with G-Power 3 (16), regarding the reference values of the study with identical methodology (17), the effect size was calculated as 1.00. At least 23 individuals were calculated to be required for each group, with a power of 0.95 and a confidence interval of 0.05.

Ethical Consideration

The study protocol was approved by the ethics committee of Muğla Sıtkı Koçman University (Decision dated 05/01/2022 and numbered 1/IV). The study protocol was registered (ClinicalTrials.gov Identifier: NCT05233839).

Randomization

The study's allocation method was determined by the order of patients' arrival using the random assignment table generated by the "National Institutes of Health National Cancer Institute Clinical Trial Randomization Tool."

Interventions

The TR group received video-based exercise and self-management education. The CR group received the identical paper-based exercise and education protocol. The exercise program included stretching and strengthening exercises for lower extremity muscles given to individuals diagnosed with degenerative meniscus injury as part of conservative treatment (Additional File 1) (Figure 2). All individuals were asked to do the exercises for eight weeks (10 repetitions once a day). In addition, the exercises were tailored to the individual's needs. Self-management criteria include educational information such as joint protection techniques and methods of coping with pain (Additional File 2). The individuals in the TR group were shown home exercises and self-management criteria in the clinic on the first day, and they were asked to do it correctly. Relevant documents were sent to individuals' mobile phones via the online platform. Similarly, the individuals in the CR group were shown the exercises and self-management criteria in the clinic on the first day. However, an exercise brochure with pictures and explanations was given instead of a video.

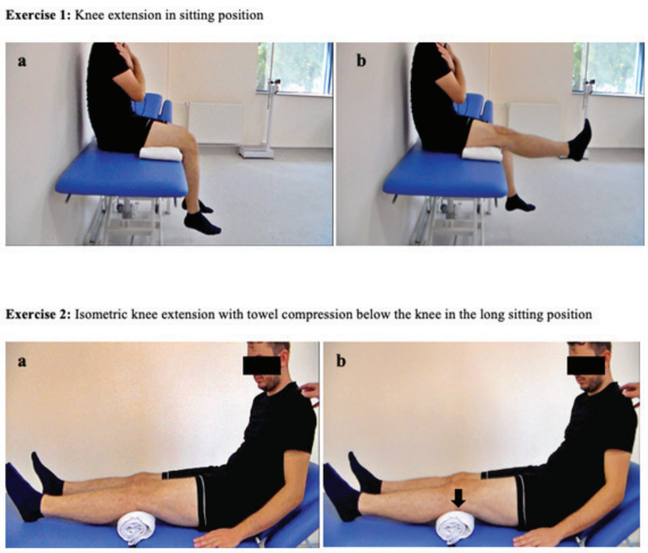

Figure 2. Exercise sample from the rehabilitation protocol

Pain intensity of individuals in both groups "Visual Analog Scale (VAS), functionality Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), proprioception Baseline bubble inclinometer, muscle strength Lafayette hand-held dynamometer, exercise compliance Exercise Adherence Rating Scale (EARS), quality of life Short Form-12 (SF-12) measured at the baseline and 8th week. At the end of the study, patient satisfaction was evaluated with the Telemedicine Satisfaction and Usefulness Questionnaire (TSUQ)".

Visual Analog Scale

The study evaluated pain severity with the VAS. Individuals participating in the study were asked to mark the severity of pain (0: no pain, 10: maximum pain) on a 10 cm straight line. Pain severity was evaluated for both rest and activity status (18).

Western Ontario and McMaster Universities Osteoarthritis Index

Individuals' level of functionality was assessed with the WOMAC. WOMAC is a patient reporting scale comprising 24 questions with three sub-dimensions: pain, stiffness, and physical function. Each question is evaluated on a Likert scale between 0 (none) and 4 (extreme). An increase in the score in WOMAC indicates more or worse symptoms, maximum restrictions, and poor health (19).

Proprioception Measurement

Proprioception was evaluated by a Baseline bubble inclinometer (model 12-1056, Fabrication Enterprises; White Plains, New York) with the active angle repetition test in a closed kinetic chain position, with the individual standing. The inclinometer was placed on the distal part of the tibial tuberosity. The individual was asked to perform a single leg squat from the full knee extension position while standing. He was asked to stay at 30° knee flexion and return to full knee extension, keeping his position for 5 seconds. This movement was repeated three times. Then, without giving the stop command, the individual was asked to reach the targeted 30° knee flexion as before. In the same way, this movement was repeated three times. To prevent possible loss of balance during the test, the individual was allowed to receive support with the help of one hand. The difference between the targeted angle and the angle made by the individual in each test repetition was determined as "absolute angular error". The arithmetic mean of the difference between the targeted angle and the angle made by the individual was calculated as "The Relative Angular Error (RAE)" and recorded (20,21).

Muscle Strength Test

The strength of the quadriceps femoris muscle was measured in "Kilogram (kg)" with a Hand-Held Dynamometer (model-01165, Lafayette Instrument®, Lafayette IN, USA). For the test, the individual was seated in a standard chair. Knee extension strength was measured with a dynamometer placed two fingers above the ankle from the front of the leg. The individual was asked to bring the knee from 90° flexion to knee extension with maximum force. Measurements were made three times. The individual was allowed to rest for 120 seconds between measurements. The highest muscle strength measurement value was recorded (22).

Exercise Adherence Rating Scale

The individual's level of exercise compliance was evaluated with the EARS. EARS consists of six items that individuals can answer themselves. Each item is scored between 0 and 4. The scoring of the 1st, 4th, and 6th items is done in reverse. Individuals who score high on the scale also have high exercise compliance (23).

Short Form 12

The SF-12 evaluates individuals' quality of life. The scale has sub-dimensions similar to SF-36. Items related to physical and emotional roles are answered as yes/no. Other items are Likert type, with response options ranging from three to six. Physical dimension-12 and mental dimension-12 scores range from 0 to 100. Higher scores indicate better health (24).

Telemedicine Satisfaction and Usefulness Questionnaire

The TSUQ evaluated individuals' satisfaction levels and usability concerning telerehabilitation." Each item in the questionnaire is evaluated with a 5-point Likert scale. TSUQ's total score ranges from 21 to 105 (25).

Statistical Analysis

All analysis was conducted by SPSS (Statistical Package for Social Sciences) for Windows v25.0 (SPSS Inc, IBM Corp, Armonk, New York). In the statistical analysis test decision, the conformity of all the data to the normal distribution was examined by conducting the One-sample Kolmogorov–Smirnov test. Parametric and non-parametric tests were used according to the homogeneity of the data. Independent Sample t-test was used to compare independent group differences when parametric test assumptions were met; when parametric test assumptions were not met, the Mann-Whitney U test was used to compare independent group differences. In addition, chi-square analysis was used for categorical variables in independent group comparisons. In dependent group comparisons, when parametric test assumptions are provided, the Paired t-test is used; when parametric test assumptions are not met, the Wilcoxon signed-rank test is used. The statistical significance level was set at $p<0.05$.

RESULTS

Patient Characteristics

The study was completed with 49 patients (41.08±9.8 years, 25 female, 24 male). Table 1 shows the demographic and clinical characteristics of the participants. There was no significant difference in participants' baseline data.

Pain

The change in pain scores is given in Table 2. In group comparisons, the r-VAS value improved significantly in the telerehabilitation group (TRG) ($p<0.001$) and conventional home exercise rehabilitation group (CRG) ($p<0.01$) after treatment compared to pretreatment. There was a significant improvement in a-VAS values in both groups ($p<0.001$). The a-VAS values showed more significant differences in TRG in the adjusted analyses, comparing the difference in change between the initial and final assessments of the groups ($p=0.03$). However, no significant difference was found in other parameter comparisons between groups ($p>0.05$).

Function

The analyses of the WOMAC scores of the groups are summarized in Table 2. We found significant in-group improvement in all WOMAC subscores and total scores ($p<0.01$). In between-group analysis, no significant difference was found in any of the parameters ($p>0.05$).

Quality of Life

Data on health-related quality of life are presented in Table 2. We reported a significant improvement in SF-12 physical component summary (PCS) and SF-12 mental component summary (MCS) scores only in TRG in group comparisons ($p<0.01$). No significant difference was found in any of the comparisons between groups. ($p>0.05$).

Strength-Proprioception

Objective muscle strength and joint proprioception measurement values are given in Table 3. Except for the left hamstring strength values, there was a significant improvement in TRG within the group in other values ($p<0.01$). In intragroup comparisons, considerable progress was found in CRG in other values except for right quadriceps femoris muscle strength ($p<0.05$). In the intergroup comparison, a more significant improvement in right hamstring muscle strength was found in TRG after treatment ($p<0.05$). The corrected analysis showed a significant difference in favor of TRG in the right quadriceps femoris muscle strength ($p<0.01$). There was no significant difference between the groups in other muscle strength measurements ($p>0.05$).

Significant improvements in proprioception measures were reported within groups ($p<0.01$). Only right extremity proprioception showed no significant improvement in CRG ($p>0.05$). In comparisons between groups in proprioception measurements, a more significant decrease in TRG was found on both sides ($p<0.05$).

Motivation-Satisfaction-Usability

EARS and TSUQ values are given in Table 4. TRG showed significantly greater motivation and exercise adherence for EARS between the groups ($p<0.01$). When TSUQ values were analyzed in TRG, the median value was 87. More than half (52%) of the participants in TRG scored above the median.

Table 1. Demographic and clinical characteristics of the participants

	Telerehabilitation (n=25)	Standard rehabilitation (n=24)	p
Gender (female/male, %)	44/56	58.3/41.7	0.316[a]
Age (years, mean±SD)	38.36±9.84	43.91±9.1	0.062[b]
BMI (kg/m², mean±SD)	27.13±5.4	26.94±4.09	0.895[c]
Living area (urban/rural, %)	88/12	70.8/29.2	0.171[d]
Education status (primary/high school and above, %)	24/76	37.5/62.5	0.305[a]
Working status (working/not working, %)	68/32	54.2/45.8	0.320[a]
Smoking (yes/no, %)	32/68	29.2/70.8	0.830[a]
Presence of chronic disease (present/absent, %)	24/76	29.2/70.8	0.682[a]
Symptom duration (months, mean±SD)	16.56±18.25	11.7±12.58	0.208[b]
Affected side (right/left, %)	52/48	62.5/37.5	0.458[a]

n: the number of participants, SD: standard deviation, BMI: body mass index, kg: kilogram, m: metre, a: Pearson Chi-Square test, b: Mann-Whitney U test, c: independent sample t test, d: Fisher's Exact test

Table 2. Patient self-reported outcome measures between and within groups

		Telerehabilitation (n=25)	Standard rehabilitation (n=24)	P (between group)
r-VAS*	Before treatment (mean±SD)	3.66±2.48	2.64±1.91	0.16[a]
	After treatment (mean±SD)	2.1±1.96	1.95±2.01	0.773[a]
	Δ (mean)	-1.56	-0.68	0.089[a]
	p (within group)	**0.000473[b]**	**0.008[b]**	
a-VAS*	Before treatment (mean±SD)	7.42±1.92	6.47±1.67	0.054[a]
	After treatment (mean±SD)	4.78±1.84	4.75±2.15	0.808[a]
	Δ (mean)	-2.64	-1.72	**0.03[a]**
	p (within group)	**0.000049[b]**	**0.000088[b]**	
WOMAC-pain*	Before treatment (mean±SD)	39±16.58	30.62±19.24	0.115[a]
	After treatment (mean±SD)	25±16.61	24.16±21.45	0.546[a]
	Δ (mean)	-14	-6.45	0.07[a]
	p (within group)	**0.0001[b]**	**0.002[b]**	
WOMAC-stiffness*	Before treatment (mean±SD)	25±17.67	23.43±19.61	0.838[a]
	After treatment (mean±SD)	11±15.44	15.1±17.28	0.370[a]
	Δ (mean)	-14	-8.33	0.109[a]
	p (within group)	**0.001[b]**	**0.001[b]**	
WOMAC-function*	Before treatment (mean±SD)	31.64±16.43	33.32±19.78	0.711[a]
	After treatment (mean±SD)	24.28±14.73	29.63±23.35	0.787[a]
	Δ (mean)	-7.35	-3.69	0.352[a]
	p (within group)	**0.004[b]**	**0.002[b]**	
WOMAC-total*	Before treatment (mean±SD)	32.62±15.4	31.94±18.85	0.992[a]
	After treatment (mean±SD)	23.32±14.3	27.68±22.92	0.795[a]
	Δ (mean)	-9.29	-4.25	0.161[a]
	p (within group)	**0.001[b]**	**0.003[b]**	
SF-12 PCS**	Before treatment (mean±SD)	35.27±8.1	38.44±9.78	0.223[d]
	After treatment (mean±SD)	39.75±6.92	40.65±10.07	0.716[d]
	Δ (mean)	4.47	2.21	0.246[a]
	p (within group)	**0.005[c]**	0.142[c]	
SF-12 MCS**	Before treatment (mean±SD)	39.97±10.41	39.29±10.41	0.697[a]
	After treatment (mean±SD)	46.27±8.67	42.81±9.43	0.197[a]
	Δ (mean)	6.3	3.52	0.254[a]
	p (within group)	**0.008[b]**	0.067[b]	

n: the number of participants, SD: standard deviation, Δ: mean difference, r-VAS: Visual Analog Scale for rest, a-VAS: Visual Analog Scale for activity, WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index, SF-12 PCS: short form 12 physical component summary, SF-12 MCS: short form 12 mental component summary, a: Mann-Whitney U test, b: Wilcoxon signed-rank test, c: Paired t test, d: independent sample t test, *: Lower values=Better, **: Higher values=Better

Table 3. Objective measurement scores between and within groups

		Telerehabilitation (n=25)	Standard rehabilitation (n=24)	P (between group)
HHD-QF right extremity**	Before treatment (kg, mean±SD)	21.73±7.64	22.64±5.96	0.645[a]
	After treatment (kg, mean±SD)	24.59±6.86	23.86±5.96	0.695[a]
	Δ (mean)	2.85	1.21	**0.007[d]**
	p (within group)	**0.002[b]**	0.062[b]	
HHD-QF left extremity**	Before treatment (kg, mean±SD)	22.27±7	22.83±6.18	0.769[a]
	After treatment (kg, mean±SD)	25.58±6.86	25.25±5.42	0.851[a]
	Δ (mean)	3.3	2.41	0.285[d]
	p (within group)	**0.005[b]**	**0,00004[c]**	
HHD-H right extremity**	Before treatment (kg, mean±SD)	13.97±4.7	11.7±4.62	0.095[a]
	After treatment (kg, mean±SD)	15.35±5.28	12.4±4.66	0.035[a]
	Δ (mean)	1.38	0.7	0.435[d]
	p (within group)	**0.003[c]**	**0.016[c]**	
HHD-H left extremity**	Before treatment (kg, mean±SD)	13.28±4.53	11.41±4.48	0.171[d]
	After treatment (kg, mean±SD)	14.62±4.97	12.35±4.71	0.136[d]
	Δ (mean)	1.33	0.93	0.638[d]
	p (within group)	0.052[b]	**0.002[b]**	
Proprioception right extremity*	Before treatment (°, mean±SD)	4.29±2.28	5.01±4.04	0.984[d]
	After treatment (°, mean±SD)	2.42±1.21	4.14±2.83	**0.042[d]**
	Δ (mean)	-1.86	-0.86	**0.024[d]**
	p (within group)	**0.000319[c]**	0.217[c]	
Proprioception left extremity*	Before treatment (°, mean±SD)	7.83±3.73	6.49±3.66	0.211[a]
	After treatment (°, mean±SD)	3.21±1.64	4.33±1.96	**0.035[a]**
	Δ (mean)	-4.62	-2.16	**0.01[d]**
	p (within group)	**0.000018[c]**	**0.005[b]**	

n: the number of participants, kg: kilogram, °: degree, SD: standard deviation, Δ: mean difference, HHD-QF: Hand Held Dynamometer Quadriceps Femoris muscle measurement, HHD-H: Hand Held Dynamometer Hamstring muscle measurement, a: independent sample t test, b: paired t test, c: Wilcoxon signed-rank test, d: Mann-Whitney U test, *: lower values=better, **: higher values=better

Table 4. Changes in motivation, satisfaction between and within the groups

		Telerehabilitation (n=25)	Standard rehabilitation (n=24)	p (between group)
EARS**	After treatment (mean±SD)	15.44±4.26	10.62±5.53	**0.004[a]**
TSUQ**	Post-treatment (median)	87		
	Below the median value (n/%)	12/48		
	Median value and above (n/%)	13/52		

n: the number of participants, SD: standard deviation, EARS: exercise adherence rating scale, TSUQ: telemedicine satisfaction and usefulness questionnaire, a: Mann-Whitney U test, **: higher values=better

DISCUSSION

The present study aimed to evaluate the effect of telehealth-based rehabilitation on patient-reported outcomes and objective clinical measurements in individuals with degenerative meniscal tears. Our research showed that telerehabilitation did not provide an additional advantage in subjective parameters (rest-VAS, WOMAC, and SF-12) assessing pain, function, and quality of life. However, in objective measurements, it was observed that the telehealth-based exercise group improved more in activity pain, quadriceps femoris, hamstring muscle strength and proprioception sense. Finally, it was observed that the participation and satisfaction of individuals who received telerehabilitation were higher.

The clinical benefits and cost-satisfaction advantages of remote rehabilitation applications were widely known (26,27). The effectiveness of the exercise program with telehealth in knee osteoarthritis and total knee arthroplasty groups has been demonstrated (26,28). However, no other studies have shown the effectiveness of telerehabilitation in individuals with degenerative meniscal tears. Our study provided an additional opportunity to observe the achievements of telemedicine in terms of patient-based and objective measurements. Because sometimes, clinical improvements are only observed with objective measurement results (29). Patients' statements regarding their symptoms may not reflect the actual outcomes. Since monitoring changes in parameters such as pain and quality of life are associated with psychosocial status, it suggests the importance of considering objective and subjective evaluation parameters together (30). Indeed, the results of our study showed that telerehabilitation did not provide an additional advantage in subjective parameters (rest-VAS, WOMAC, and SF-12) assessing pain, function, and quality of life. However, in objective measurements, it was observed that the telehealth-based exercise group improved more in activity pain, quadriceps femoris, hamstring muscle strength, and proprioception sense. Finally, it was observed that the participation and satisfaction of individuals who received telerehabilitation were higher. It can be communicated that the additional advancements obtained from the 8-week exercise program in the telerehabilitation group were reflected in the clinician-based measurements but not in the individual rest-pain, function, and quality of life reports, despite the increased participation and satisfaction. Strength and proprioception gains achieved in dynamometer and goniometer-based measurements may not have been achieved as functional gains due to the lack of improvement in pain and, therefore, may not have contributed positively to the physical and psychological components of quality of life.

There were significant improvements in both groups in terms of rest pain. However, there was no difference between groups. This result showed that increased participation and satisfaction with telerehabilitation were more beneficial for strength-proprioception gains than pain. A comprehensive systematic review showed that most studies did not emphasize any additional advantage of telerehabilitation on pain (31). It may be advantageous to include education-based pain management with a fear-avoidance model or cognitive behavioral therapy to provide more advancements with telerehabilitation in terms of pain (30,32). A similar study also emphasized the superiority of a training program that promotes physical activity and exercise for individuals with knee osteoarthritis (33).

The superiority of telerehabilitation was not demonstrated in pain and function parameters evaluated with WOMAC. No functional gain might be related to the patient's pain levels. Although it was observed that the patients in the telerehabilitation group improved muscle strength and proprioception, it demonstrates the importance of pain in functional gain. A large meta-analysis has shown that telerehabilitation is more effective in pain and functional gain among post-arthroplasty cases (34). However, these studies include older individuals with more disabilities, where improvements are essential even in basic daily activities. In our research, it was inconceivable to achieve functional gains on WOMAC regarding the relatively young sample. Because WOMAC is a PROM that evaluates disability in older individuals, especially those containing basic and instrumental daily living activities (19,35). In this respect, conducting the study with more specific PROMs would provide indications for future studies.

There was no difference between the two groups in terms of SF-12 results. It should be emphasized that quality of life is a more suitable parameter for longer-term gains. The effect of symptomatic gains on quality of life can be considered in the longer term. Telerehabilitation did not provide an additional advantage regarding the quality of life in individuals with knee osteoarthritis with more advanced symptoms, which is the closest case group (36). Moreover, it should be emphasized that these results are in parallel with our results since they include quality-of-life findings, including a 6-month follow-up. In addition, telerehabilitation was not found to be more effective in quality of life in individuals with total knee arthroplasty compared to the conventional program (37).

Our study demonstrated an additional advantage of telerehabilitation regarding clinician-based strength and proprioception measurements. Among these measurements, it was observed that more improvements were recorded in the right extremity quadriceps femoris and hamstring and both extremity proprioception measurements. A recent randomized controlled study focused on the advantage of virtual reality-based telerehabilitation in proprioception in individuals with total knee arthroplasty (38). In this context, the fact the exercises such as "mini squats", which are included in our exercise program in the current case group, where proprioceptive losses are likely to occur through meniscus degeneration, contain more basic multimedia narration with video and in this respect, more learnable for patients, may have provided more gains in a proprioceptive sense. Finally, a study similar to our hamstring and quadriceps gains has been shown in the literature in individuals with total knee arthroplasty (34,39). The fact that telerehabilitation provides more advantages in quadriceps muscle strength may have been achieved through the video advantage of telerehabilitation, especially in exercises where strengthening is more effective by waiting for a specific time in certain positions. An objective pain assessment may be possible with an algometer. In this respect, a subjective measurement parameter evaluated with VAS in PROMs can be compared with the objective.

Limitations

Some limitations of the study should be mentioned. The first is the absence of evaluator blindness. This situation brings to mind the possibility of bias risk, according to PEDro and Cochrane (40). In this respect, performing objective measurement results by a single blind evaluator can minimize the risk of measurement error or bias. However, the available facilities did not allow blinding in this trial. Second, individuals are evaluated with less specific meniscus assessment PROMs rather than WOMAC and VAS. This situation was due to the need for more Turkish standardized assessment tools. Finally, the clinical comparison could only be constructed with knee osteoarthritis and arthroplasty groups, as there were no other studies on the effectiveness of telerehabilitation in the meniscus. However, considering the significant difference in disability and mean age distribution of individuals, this showed that the clinical features of each case group were suitable for a stratified comparison.

CONCLUSION

Our study showed that telerehabilitation did not provide an additional advantage in subjective parameters (rest-VAS, WOMAC, and SF-12) evaluating pain, function, and quality of life. However, in objective measurements, it was observed that the remote rehabilitation group improved more in activity pain, quadriceps femoris, hamstring muscle strength, and proprioception sense. Finally, as expected, it was observed that the participation and satisfaction of individuals who received telerehabilitation were higher. It can be said that the additional gains obtained from the 8-week exercise program in the telerehabilitation group were reflected in the clinician-based measurements but not in the rest pain, function, and quality of life reports, despite the increased participation and satisfaction.

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Conflict of interest: *The authors have no conflicts of interest to declare.*

Ethical approval: *The study was carried out in accordance with the ethical principles and the Helsinki Declaration. Informed consent of the patients was obtained. The study protocol was approved by the ethics committee of Muğla Sıtkı Koçman University (Decision dated 05/01/2022 and numbered 1/IV). The study protocol was registered (ClinicalTrials.gov Identifier: NCT05233839).*

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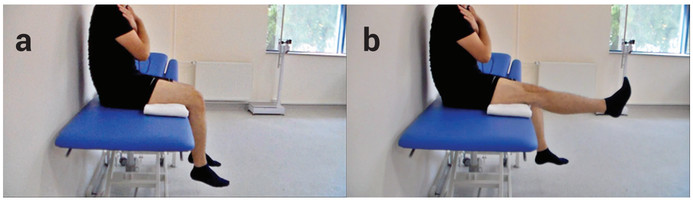
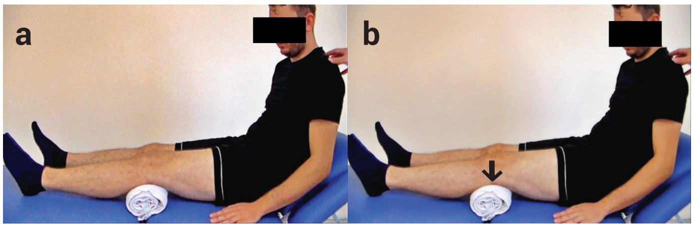
Additional File 1

Home Exercises

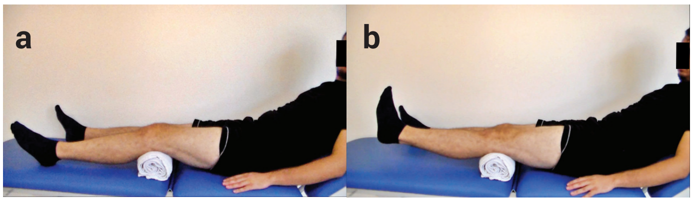
Exercise 1: Knee extension in sitting position



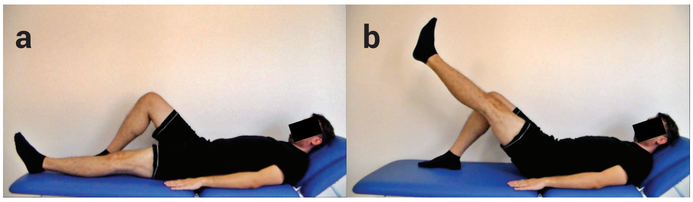
Exercise 2: Isometric knee extension with towel compression below the knee in the long sitting position



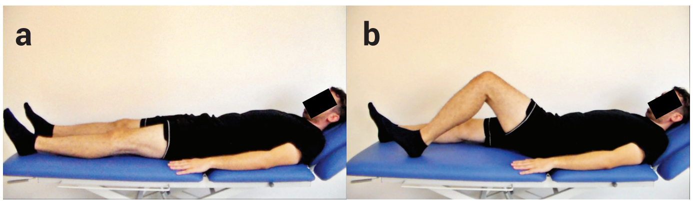
Exercise 3: Terminal knee extension in long sitting position



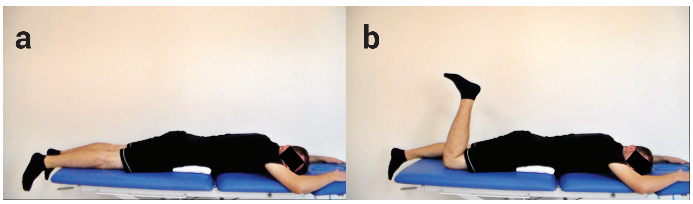
Exercise 4: Straight leg raise in supine position



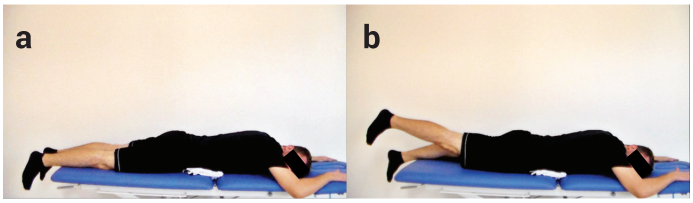
Exercise 5: Heel shift in supine position



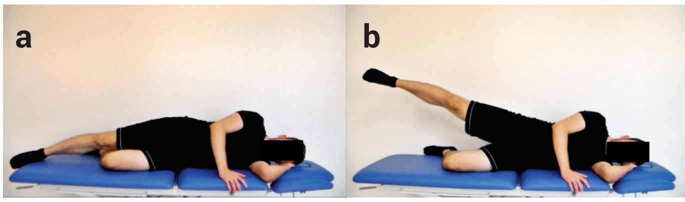
Exercise 6: 90° knee flexion in prone position



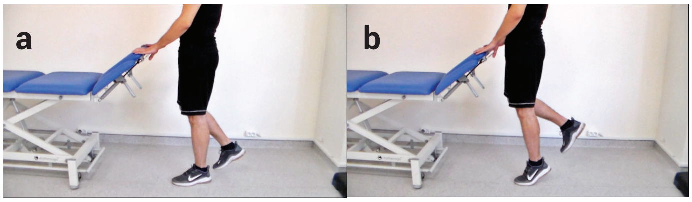
Exercise 7: Hip extension with knee extended in prone position



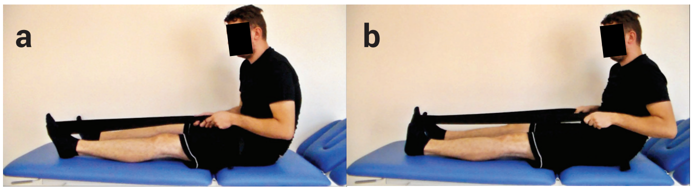
Exercise 8: Hip abduction in side lying position



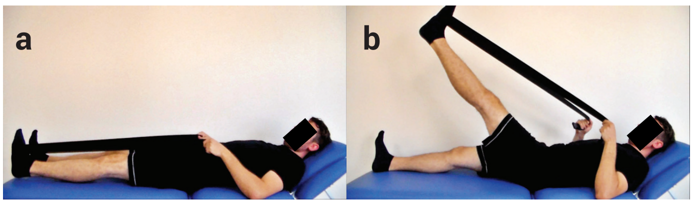
Exercise 9: Standing toe raise



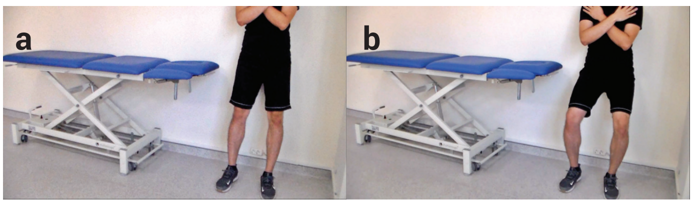
Exercise 10: Gastrosoleus stretching with rigid sheet in long sitting position



Exercise 11: Hamstring stretching with rigid sheet in supine position



Exercise 12: Half squat with sliding back on wall



Additional File 2

Useful Suggestions for Knee Pain

1. Go up and down as few stairs as possible and use the elevator if available.

2. Avoid activities such as crossing legs, tucking legs under, and sitting on the floor. Choose a seat that is a high chair or sofa. Do not sit on low and soft sofas. When sitting, put your feet a little forward and try not to bend your knees too much. When standing up after sitting, try to get support from somewhere with your hands.

3. Sit on a stool when praying.

4. When using the toilet, use a European (sitting) toilet. Do not use squat toilets.

5. If you are overweight, consult a specialist to lose weight and do the exercises we recommend regularly. Excess weight puts excessive strain on your knee joint and causes further wear on your joint surfaces. So be careful about losing weight.

6. Do not stand still for long periods of time. If you are in a situation where you have to stand for a long time, if there is a small elevation where you are every 5 minutes, put your feet on that elevation in order to let your knees rest. If there is no elevation, bend one leg slightly from the knee and rest that knee. Or, with a cane, you can move the cane to the right and left side by side, allowing your knees to rest.

7. If you are a smoker, stop smoking. Smoking and cigarette smoke will adversely affect blood circulation and prevent adequate nutrition of your knee joint. As a result, the healing of your knee will really slow down.

8. When you have knee pain, place a cold pack wrapped in a towel on your knee for 5 minutes. Meanwhile, breathe calmly into your lower abdomen for 4 seconds and exhale slowly for 8 seconds. Get rid of bad thoughts, do an activity such as listening to calming music, drinking tea, watching beautiful scenery, thinking about a good moment.

9. Do not do movements that cause pain in your knee. When your pain starts, take a break from your work and rest for a while.

10. Do not walk for a long time. Walks should not exceed 15-20 minutes. If you have to walk for a long time, walk with a cane on the painless side. Use soft-soled shoes. The ground you walk on should be soft ground suitable for walking. Do not walk on extremely rough roads.

11. Do the recommended exercises regularly. These exercises will strengthen your muscles, accelerate nutrition and healing of your knee joint, and make you feel more energetic.

12. Remember, the only treatment for your knee pain before surgery and without adverse effects is regular exercise and following the recommendations.

We wish you good health.