



# Biopsychosocial model-based exercise improves muscle strength, proprioception, pain, function, and quality of life in rheumatoid arthritis patients with knee involvement: a randomized controlled clinical trial

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## Abstract

This randomized controlled study aims to evaluate the effects of BETY (*Bilişsel Egzersiz Terapi Yaklaşımı*-Cognitive Exercise Therapy Approach in English) as a biopsychosocial model-based exercise approach on knee joint proprioception and other biopsychosocial characteristics through telerehabilitation in individuals with Rheumatoid Arthritis (RA). The study included 19 female (10 Training Group, 9 Control Group) individuals diagnosed with RA. Individuals participated in BETY group sessions via telerehabilitation for one hour, three days a week for three months. The primary outcome measures were the BETY-Biopsychosocial Questionnaire (BETY-BQ) and Proprioception assessment via Biodex System III Isokinetic Dynamometer and the secondary outcome measures were the McGill Pain Questionnaire- Short Form, Western Ontario-McMaster University Osteoarthritis Index, Health Assessment Questionnaire, Falls Efficacy Scale, World Health Organization Quality Of Life Scale-Short Form (WHOQOL-BREF), 6-Min Walk Test, Time Up And Go Test and 10-Step Stair Climbing Test were used. There were no differences between the groups in terms of demographic characteristics. Improvements were found in favor of the post-treatment training group in TUG, 10-SCT, 6MWT distance, BETY-BQ sleep, WHOQOL-BREF social relations, knee proprioception, and muscle strength measurements ( $p < 0.05$ ). In this study, BETY was presented to the literature with its positive impact on muscle strength and proprioception, functional capacity, pain, mood, quality of life, and biopsychosocial status in RA patients with knee involvement.

*Trial registration:* NCT06887725.

**Keywords** Biopsychosocial model · Knee joint · Proprioception · Quality of life · Rheumatoid arthritis · Telerehabilitation

## Introduction

Rheumatoid Arthritis (RA) is a chronic and systemic autoimmune disease characterized by synovial hyperplasia, pannus formation, inflammation, cartilage and bone destruction [1].

In individuals diagnosed with RA, knee joint involvement is familiar with a rate of 70–80% and may be observed significantly in the early stage of the disease or later stages [2]. In these individuals, the sense of proprioception is essential in performing activities of daily living due to fall prevention.

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**Related Congress Abstract Publication:** A related abstract of this study was previously presented at the 9th National 1st International Rheumatological Rehabilitation Congress 2024. The full bibliographic information is as follows: *Sakgöz A, et al. "S03. Investigation of the Effects of Cognitive Exercise Therapy Approach (BETY) in Individuals with Knee Rheumatoid Arthritis Pilot Study." Journal of Exercise Therapy and Rehabilitation. 2024;Sup (6).*

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In RA, which is characterized by chronic inflammatory processes, changes in contact areas due to increased joint fluid in the knee joint may cause proprioceptive disorders [3]. It is known that knee extension and flexion strength are lower in RA groups compared with healthy controls [4]. In parallel with this condition, accompanying biopsychosocial effects such as anxiety, depression, pain, functional losses, and fatigue experienced by individuals diagnosed with RA bring biopsychosocial-based exercise approaches to the forefront in non-pharmacologic treatments [5]. Recent studies and EULAR recommendations emphasize that individuals in this group should be addressed from a biopsychosocial perspective in disease management strategies [6, 7]. On the other hand, although it is stated that the common goal of non-pharmacological treatments is to contribute to biopsychosocial improvement in the patient, it is emphasized that evaluation and treatment approaches with biopsychosocial content are insufficient [8, 9].

However, biopsychosocial model-based exercise interventions are rarely encountered in the literature despite the biopsychosocial effects such as pain, fatigue, functional losses, anxiety, and depression experienced by individuals.

The Cognitive Exercise Therapy Approach (*Bilişsel Egzersiz Terapi Yaklaşımı*-BETY) is an innovative exercise approach based on the biopsychosocial model developed with the participation of individuals with rheumatism in exercise sessions for many years [10–13]. BETY has been applied face-to-face for many years in individuals with rheumatologic diseases and has been moved to telerehabilitation during the COVID-19 pandemic. The telerehabilitation effect of BETY has moved to the level of evidence in systemic sclerosis [12] and in individuals living with HIV [14].

The aim of this study was to evaluate the effects of a biopsychosocial model-based exercise approach on knee joint proprioception and other biopsychosocial characteristics through telerehabilitation in individuals with RA.

## Methods

### Trial design

This study was planned as a randomized controlled trial with two parallel groups. Groups were randomly assigned using the simple randomization and closed envelope method. The researchers performing the assessments and statistical analyses were blinded to the group intervention details. The trial was registered (NCT06887725) and was completed between December 2022 and December 2024. This study was approved by the Hasan Kalyoncu University Faculty of Health Sciences Non-Interventional Research Ethics

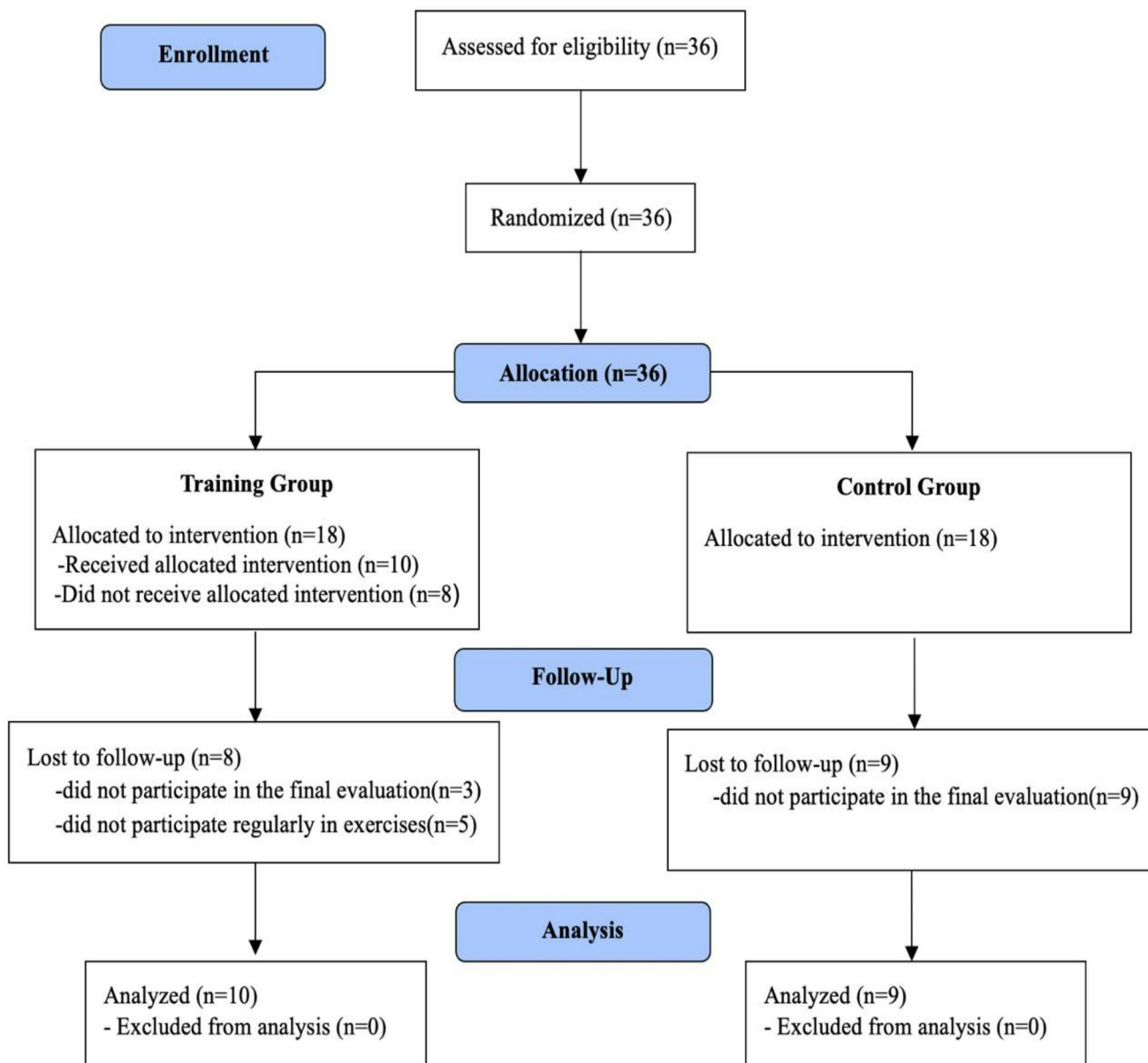
Committee (approval number: 2022/140 approval date: 12.12.2022). Participants gave informed consent to participate in the study before taking part. The study protocol and reporting are in agreement with the CONSORT 2025 statement (EQUATOR Network), and the checklist is presented as Supplementary File 1.

### Participants

Individuals diagnosed with RA according to the 2010 ACR/EULAR criteria [15] and followed up at the Rheumatology Outpatient Clinic of the research center who voluntarily agreed to participate in the study were included in the study. The inclusion criteria were being able to walk, being between 40 and 65 years of age, being literate, and being able to use technological devices. Exclusion criteria were acute inflammatory pathology of the knee joint, knee arthroplasty surgery, intra-articular corticosteroid use in the last 3 months, participation in an exercise program in the last 3 months, advanced musculoskeletal, cardiac or peripheral vascular disease, significant system or organ failure, and disease affecting cognitive function such as Alzheimer's disease or dementia (Fig. 1). The study was conducted following the Declaration of Helsinki. All patients provided signed informed consent to participate. Two different power analyses were performed based on the primary outcomes of the study. G\*Power 3.1 was used in these analyses. Based on right 30-degree knee proprioception after exercise training, the  $\alpha$  level was calculated as 0.05 and the power ( $1-\beta$ ) as 0.79. The effect size was calculated as 0.76. Based on BETY-BQ final scores, power ( $1-\beta$ ) was calculated as 0.81 with an  $\alpha$  level of 0.05. The effect size was calculated as 0.82.

### Interventions

Individuals are taught function-oriented core stabilization exercises (FoGSE) targeting their complaints before being recruited to BETY group exercise sessions [13]. Individuals diagnosed with RA with knee involvement were subjected to tests to be used for assessment purposes in a face-to-face interview. Stabilization rules for the neck, scapula, thorax, lumbopelvic neutral spine, and respiratory control parameters required for function-oriented core stabilization exercises were taught. Individuals enrolled in chronic pain management were given the responsibility to apply the pain coping strategy when pain occurred during the day. After this process, individuals were included in the routine BETY exercise group for one session. Thus, individuals were introduced to the face-to-face structure of the sessions they would experience through the Zoom platform.



**Fig. 1** Flow diagram of the RA patients

After the first information and practice session, individuals attended the online training group three days a week. After the evaluations, they were informed about the exercise program to be carried out over a video conferencing platform (Zoom) for 3 months. The online sessions lasted 60 min in total and consisted of the following sections:

– 10 min: Warm-up (Dance therapy - a structured process of authentic movement).

– 40 min: Main exercise (core stabilization exercises in standing, supine, prone, side lying, and sitting position), cognitive restructuring (replacement of negative and positive cognitions) with repetition of pain management training combined with exercise with affirmations in side lying.

– 10 min: Cooling down (Dance therapy - a structured process of authentic movement and dramas).

In this study, individuals with rheumatoid arthritis who did not participate in BETY sessions were grouped as the control group (CG). CG continued only their medical treatment and did not receive any intervention. Three months later, the same assessments were made for both groups. Individuals in both groups continued their pharmacologic treatment during this three-month cross-sectional period.

## Outcomes

### Primary outcomes

#### BETY-Biopsychosocial Questionnaire (BETY-BQ)

BETY-BQ is a 30-item Likert-type scale developed through repeated statistics of feedback expressing the characteristics of improvement reported by individuals with rheumatism who have participated in BETY exercise sessions for many years [16]. It evaluates the individual in terms of biopsychosocial aspects with the sub-headings of pain, functionality-fatigue, emotion-state, sociability, sexuality, and sleep. It is scored between 0 and 120. A high score indicates a low biopsychosocial status [17].

#### Proprioception assessment

All measurements were performed by a sports physician using a Biodex System 3 Pro<sup>®</sup> isokinetic device (Biodex Medical Systems Inc., Shirley, NY, USA). The evaluation was conducted at 30° and 60° knee flexion angles. Prior to testing, the device was calibrated following the standard protocol. The participant's torso and the thigh of the test limb were secured to the seat using straps. The test limb was positioned on the dynamometer's force arm and stabilized with a Velcro strap just above the ankle.

A detailed explanation of the testing procedure was provided. The dynamometer passively moved the participant's knee from a 90° flexion position to the target angle and held it there for 5 s. During this period, the participant was instructed to memorize the position of the knee. The dynamometer then passively moved the limb at a constant angular velocity of 30°/s while the participant remained relaxed and pressed a button to stop the movement when they believed the target angle had been reached. This procedure was repeated three times for each target angle.

The setup was then adjusted to test the contralateral limb: the dynamometer arm and direction were modified accordingly, the opposite limb was secured, and the same testing protocol was repeated three times for each target angle.

### Secondary outcomes

#### Muscle strength assessment

Muscle strength was assessed using the Biodex System 3 Pro<sup>®</sup> isokinetic device (Biodex Medical Systems Inc., Shirley, NY, USA). A 10-minute warm-up walk preceded each assessment, and participants performed knee flexor and extensor maximal concentric isokinetic muscle strength tests at angular velocities of 180°/s (10 repetitions) and

60°/s (5 repetitions) with a 30-second rest interval. Peak torque (PT) and average power (AP) were recorded in Newtons per meter (No) and watts per meter (W). Participants received prior training in maximal strength training and verbal encouragement during the tests [12].

#### McGill Pain Questionnaire - Short Form

The form consists of three parts; 11 of the 15 descriptive word groups in the first part evaluate the sensory and 4 evaluate the perceptual dimension of pain (0=none, 1=Mild, 2=Moderate, 3=Very). The second part of the form includes five-word groups ranging from "mild pain" to "unbearable pain" to determine the severity of the patient's pain. In the third part, the patient's current pain intensity is assessed using a visual analog scale (VAS) [18].

#### Western Ontario-Mcmaster University Osteoarthritis Index (WOMAC)

WOMAC assesses pain, endurance and physical functioning, functional status, and stiffness. The items are scored from 0 to 4 according to the degree of difficulty and perceived pain and stiffness; the greater the total score, the greater the severity of the disease [19].

#### Health Assessment Questionnaire (HAQ)

The scale consists of 8 categories: dressing, general care, eating, walking, hygiene, grip strength, and activities outside the home. It is scored between 0 and 3. High scores indicate low functionality [20].

#### Falls Efficacy Scale (FES)

The scale assesses a person's perception of stability and fear of falling during daily activities indoors. It consists of 10 items, and answers are scored between 1 and 10. A score above 70 indicates a fear of falling [21, 22].

#### World Health Organization Quality Of Life Scale-Short Form (WHOQOL-BREF)

The WHOQOL-BREF scale consists of 26 questions, 24 of which perceived quality of life and 2 of which question perceived health status. It consists of 4 domains: physical, psychological, social relations, and environmental. Since each domain independently expresses the quality of life in its own domain, domain scores are calculated between 4 and 20. The higher the score, the better the quality of life [23].

## 6-Min Walk Test

Following the American Thoracic Society guidelines, individuals walked in a 30-meter straight corridor for 6 min. At the beginning and end of the test, dyspnea levels were determined according to the Borg dyspnea scale; blood pressure, pulse rate, and oxygen saturation were measured with a pulse-oximeter device [24].

## Time Up and Go Test (TUG)

This test measured the time (sec.) for individuals to get up from the chair, walk a distance of 3 m, and sit back down. A trial test was performed once. Then, the test was performed twice, and the average of the two measurements was taken [25].

## 10-Step Stair Climbing Test

This test evaluates the individual's stair climbing activity, lower extremity strength, and dynamic balance. The individual was asked to ascend and descend the stairs in the fastest way and this time (sec) was measured with a stopwatch [26].

## Statistical methods

SPSS 22.0 (Statistical Package for the Social Sciences) software was used for data analysis. Descriptive statistics for numerical data included arithmetic mean ( $\bar{X}$ ) and standard deviation (SD), while categorical data included frequency (n) and percentage (%) values. The distribution characteristics of the data were evaluated using the Kolmogorov-Smirnov test. Since descriptive data such as age, height, and weight showed a normal distribution, Student's t-test (unpaired t-test) was used for the comparison of two groups. Since other parameters did not show a normal distribution, the Mann-Whitney U test was preferred for intergroup comparisons, and the Wilcoxon Signed Rank test was preferred for intragroup comparisons.

Cohen's d effect size coefficient was calculated to evaluate the magnitude of change between pre- and post-treatment measurements of the groups. If the calculated effect size (d) value was below 0.20, it was interpreted as a small effect; around 0.50 as a moderate effect; and above 0.80 as a large effect. In all analyses, the significance level was set at  $p < 0.05$ .

## Results

There was no significant difference between the two groups according to demographic characteristics ( $p < 0.05$ ) (Table 1).

While there was no difference between TG and CG before treatment; TUG, 10 SCT, 6MWT walking distance, BETY-BQ sleep score, WHOQOL-BREF Social Relationship, Knee joint proprioception Right knee 30° and Right knee 60° values, Knee strength Peak Torque for Ext 180°/sec speed left knee, Flex 180°/sec speed left knee, Ext 60°/sec speed right knee and Ext 60°/sec speed left knee values improved after treatment ( $p < 0.05$ ). 6DKT end-of-walk BORG score and Knee joint proprioception Right knee 60° values were found to be different before treatment, while the two groups showed similar characteristics after treatment ( $p > 0.05$ ). Knee joint proprioception Left knee 60° values showed a difference between the groups before and after treatment ( $p < 0.05$ ) (Table 2).

TG and CG before and after treatment were analyzed; CF McGill Sensory score, 6DYT Walking distance and Knee joint proprioception Right knee 60° values in CG in-group changes; TG within-group changes in CF McGill VAS scores, TUG, 10 BMI, WOMAC Osteoarthritis Index Pain, Function, Total scores, 6MWT Walking distance, FES, BETY-BQ's Pain, Functionality, Mood and Total scores, WHOQOL-BREF's Physical health and Social relationship scores, Total work 60°/sec right knee extension score ( $p < 0.05$ ) (Table 3) (Fig. 2).

## Discussion

In this study, which evaluated the effects of biopsychosocial model-based exercise training through telerehabilitation 3 days a week for 3 months on knee joint proprioception in individuals with RA, it was observed that exercise training improved biopsychosocial status and quality of life compared to the control group.

RA needs exercise training as a non-pharmacologic treatment, as in other rheumatologic diseases. In recent years, EULAR emphasizes exercise approaches based on the biopsychosocial model [7]. In our study, BETY, an exercise approach based on the biopsychosocial model, was used as it is included in the management of rheumatologic diseases such as Systemic Sclerosis, Ankylosing Spondylitis, Sjögren's Disease, and Psoriatic Arthritis in the literature [10–13].

In proprioception measurements, the control group initially obtained worse results than the training group in 60° right and left knee proprioception errors. After training, although the control group showed improvement in

**Table 1** Demographic characteristics of groups and comparison between groups

	Training Group (n=10)		Control Group (n=9)		t-test	
	X±SD	Min-Maks	X±SD	Min-Maks	t	P*
Age (years)	52,50±5,32	46,00–61,00	52,33±5,75	46,00–60,00	0,07	0,948
Height (m)	1,64±0,05	1,55–1,70	1,60±0,05	1,53–1,68	2,02	0,059
BT Weight (kg)	73,90±14,96	55,00–103,00	72,00±16,93	43,00–93,00	0,26	0,798
AT Weight (kg)	71,20±14,50	53,00–102,00	74,22±17,36	45,00–95,00	-0,41	0,684
BT BMI (kg/m <sup>2</sup> )	27,49±5,58	19,00–36,50	28,07±5,75	17,90–36,50	-0,22	0,827
	n (%)		n (%)		Pearson Chi-square	P**
Sex (Females)	10 (100)		9 (100)		-	-
Marital status						
Single	3 (30)		2 (22,2)		0,148	0,556
Married	7 (70)		7 (77,8)			
Occupation						
Officer	1 (10)		0 (0)		1,953	0,377
Retired	4 (40)		2 (22,2)			
House wife	5 (50)		7 (77,8)			
Non-smoker	9 (90)		8 (88,9)		0,006	0,737
Comorbidity						
None	4 (40)		5 (55,6)		2,351	0,503
HT	0 (0)		1 (11,1)			
DM	1 (10)		1 (11,1)			
Others	5 (50)		2 (22,2)			
Knee involvement						
Right	1 (10)		0 (0)		1,228	0,541
Left	2 (20)		3 (33,3)			
Bilateral	7 (70)		6 (66,7)			

60° right knee proprioception error, improvements were observed in 30° and 60° right knee proprioception errors in the training group. Although the left knee proprioception of the training group improved compared to baseline, it was not statistically significant. These results may be attributed to the fact that the individuals in the training group had nearly twice as good the proprioceptive sensory values at baseline compared to those in the control group. In addition, all individuals were right-dominant, which may have been a factor affecting the observation of significant improvement in proprioception only in the right knee. To the best of our knowledge, our study is the first study to show the effect of biopsychosocial model-based exercise intervention on knee joint proprioception in individuals with knee involvement diagnosed with RA. Therefore, our study may provide a basis for future exercise interventions in terms of their benefits.

In muscle strength measurements, the training group showed an increase in peak torque in right and left knee extension at 60°/sec and left knee extension and flexion at 180°/sec compared to the control group. In contrast, in the control group, a significant decrease was observed in right and left knee extension peak torque values at both speed levels within the group. The total work value of the BETY Training group for the right knee extension increased after exercise training at 60°/sec. The increase in knee extension

strength in this group was especially related to the function-oriented core stabilization exercises applied in BETY training, starting from the closed kinetic chain form and gradually increasing and progressing with the exercise band. In a study conducted by Tüfekçi et al. in individuals diagnosed with systemic sclerosis, knee muscle strength was evaluated using the same isokinetic device and protocol, and BETY sessions were applied through telerehabilitation as in our study. At the end of the study, muscle strength values of the control group deteriorated, whereas no deterioration was observed in the exercise group; muscle strength was preserved, and improvements were found in some parameters [12]. According to Tüfekçi et al., in general, no statistically significant improvement was observed in the BETY group after treatment with the same measurement protocol, whereas in our study, significant results were observed despite a smaller sample size. On the other hand, no statistical difference was observed in HAQ, which evaluates activities of daily living. This result may be because the individuals included in our study had knee involvement.

In our study the TUG test, which is a widely used assessment tool, showed more favorable results in the BETY training group compared to the control group. The significant increase in knee extension peak torque values observed in our training group was thought to affect the sitting-standing component of the TUG test especially.

**Table 2** Comparison of measurements between groups

		Training Group (n=10)		Control Group (n=9)		Mann-Whitney U Testi	
		X±SD	Min-Maks	X±SD	Min-Maks	Z	p
McGill Pain Questionnaire-SF	BT	8,50±10,61	0,00–32,00	10,00±6,40	0,00–21,00	-1,15	0,252
	AT	9,50±11,85	0,00–35,00	5,44±5,48	0,00–15,00	-0,25	0,805
TUG (s)	BT	7,72±1,24	5,58–9,47	8,42±1,36	5,86–10,30	-1,17	0,257
	AT	6,60±0,58	6,08–7,62	8,86±1,54	6,07–10,90	-4,34	0,000*
10-SSCT (s)	BT	11,83±2,33	8,66–17,20	11,90±1,36	10,06–14,13	-0,08	0,939
	AT	9,72±1,56	7,58–12,87	12,75±2,48	9,78–18,46	-3,23	0,005*
WOMAC Total	BT	31,25±23,56	4,16–64,58	22,68±10,82	7,29–43,75	-0,37	0,713
	AT	21,87±18,14	0,00–53,10	24,65±18,35	8,33–68,75	-0,08	0,935
6 min Walk Test							
Walking Distance (meter)	BT	453,00±65,29	390,00–600,00	475,44±49,89	379,00–540,00	-0,83	0,416
	AT	488,50±52,39	400,00–580,00	419,78±41,52	360,00–480,00	3,14	0,006*
End of walk BORG	BT	2,70±0,67	1,00–3,00	0,61±0,93	0,50–3,00	-2,50	0,012*
	AT	1,40±0,66	0,50–2,00	0,61±1,05	0,00–3,00	-0,47	0,637
HAQ	BT	0,95±0,82	0,00–2,37	0,46±0,44	0,00–1,37	-1,31	0,189
	AT	0,73±0,61	0,00–1,75	0,65±0,57	0,25–2,00	-0,04	0,967
FES	BT	24,00±10,71	10,00–46,00	15,67±6,42	10,00–25,00	-1,61	0,108
	AT	17,00±5,46	10,00–28,00	14,67±7,70	10,00–34,00	-1,48	0,139
BETY-BQ							
Sleep	BT	1,90±1,52	0,00–4,00	1,89±1,45	0,00–4,00	-0,09	0,931
	AT	1,10±0,99	0,00–3,00	2,22±1,20	0,00–4,00	-2,01	0,044*
Total	BT	60,10±25,62	20,00–114,00	51,89±17,34	27,00–76,00	-0,41	0,683
	AT	39,00±21,82	9,00–79,00	54,44±15,88	37,00–78,00	-1,59	0,111
WHOQOL-BREF							
Social Relations	BT	53,33±22,64	16,67–100,00	53,96±14,87	33,33–75,00	-0,29	0,772
	AT	72,50±18,02	50,00–100,00	50,67±16,54	25,00–83,33	-2,39	0,017*
Knee joint proprioception							
Right knee 30 °	BT	6,51±2,81	2,70–12,00	10,00±4,39	4,00–16,70	-2,09	0,052
	AT	4,54±2,31	1,70–8,70	8,01±3,87	5,00–15,70	-2,41	0,028*
Left knee 30 °	BT	6,37±2,81	0,00–14,30	7,90±4,20	3,00–16,70	-0,79	0,440
	AT	4,54±2,31	4,70–10,30	7,91±4,45	0,70–14,70	-0,49	0,634
Right knee 60 °	BT	6,26±3,06	2,30–13,00	12,30±4,56	6,70–20,70	-3,42	0,003*
	AT	5,40±3,33	1,30–10,70	9,51±3,93	5,00–16,30	-2,47	0,024*
Left knee 60 °	BT	6,75±2,61	2,70–11,30	10,10±3,64	3,00–15,00	-2,33	0,033*
	AT	6,02±4,33	1,30–14,30	8,37±4,21	2,70–14,00	-1,20	0,249
Peak Tork (Nm)							
Ext 180°/sec speed left knee	BT	45,24±9,79	29,30–59,50	45,41±10,79	23,00–60,30	-0,04	0,972
	AT	53,70±10,14	40,50–71,20	39,14±7,75	26,40–49,10	3,49	0,003*
Flex 180 °/sec speed left knee	BT	27,32±10,39	12,90–44,50	20,47±8,24	5,80–30,60	1,58	0,132
	AT	26,74±5,84	19,70–38,20	20,73±5,76	10,30–26,20	2,25	0,038*
Ext 60 °/sec speed right knee	BT	75,09±26,53	18,40–116,90	82,14±22,57	57,80–123,40	-0,62	0,543
	AT	87,34±19,38	54,00–120,10	65,41±13,37	41,50–85,20	2,84	0,011*
Ext 60 °/sec speed left knee	BT	77,22±20,54	46,80–115,10	68,43±18,78	43,40–98,90	0,97	0,346
	AT	86,43±19,91	57,30–135,30	58,27±14,58	42,60–83,30	3,48	0,003*

TUG: timed up and walk test, 10-SSCT: 10-Step Stair Climbing Test, HAQ: Health Assessment Questionnaire, FES: Fall Efficacy Scale, BETY-BQ: BETY-Biopsychosocial Questionnaire, WHOQOL-BREF: World Health Organization Quality Of Life Scale-Short Form, BT: before treatment, AT: after treatment, sec: seconds, n: number of people, X: mean, Min: Minimum, Max: Maximum, SD: Standard deviation, \*t-test  $p < 0.05$

Chronic pain is one of the most important markers of chronic inflammation in individuals with RA. In our study, McGill-SF, WOMAC pain score, and pain items of BETY-BQ were analyzed, and the differences between the training and control groups were evaluated. WOMAC pain

score and BETY-BQ pain scores improved after the training, while worsening was observed in the control group after 3 months. In our study, while the baseline VAS values were quite low in both groups, the BETY-BQ pain score was close to the high score. The decrease in the BETY-BQ

**Table 3** Within group comparisons of measurements

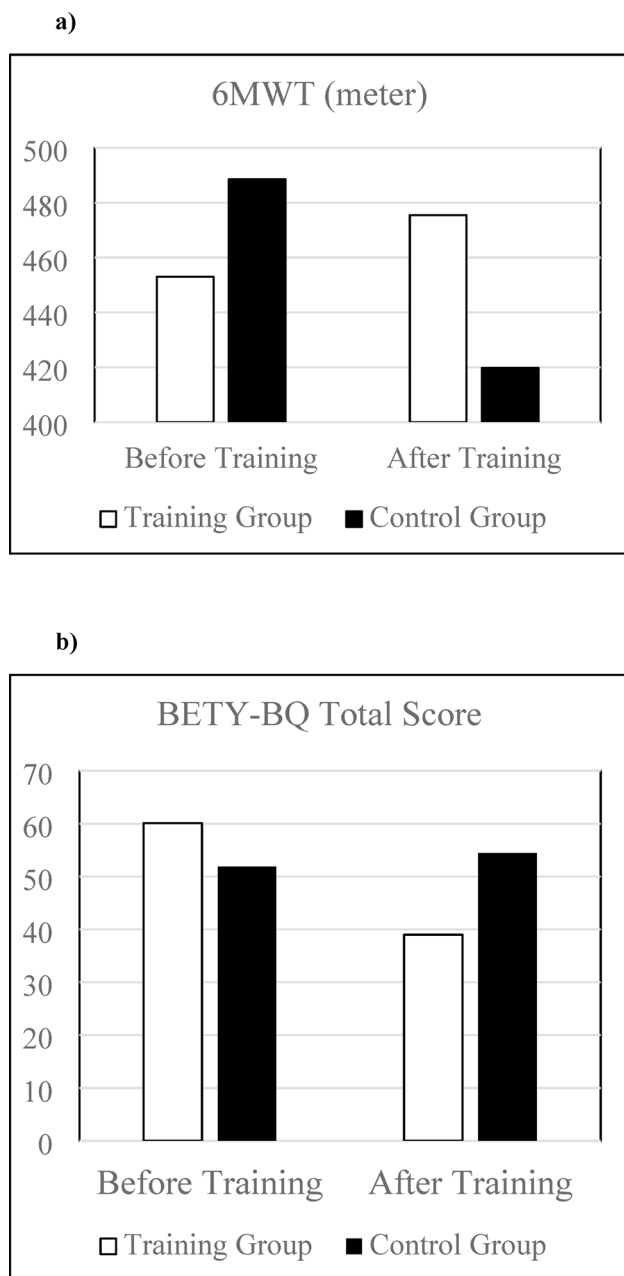
	Training Group (n=10)			Control Group (n=9)				Wilcoxon Signed Rank
	D±SD	z	p	Cohen	D±SD	z	p	Cohen
McGill Pain Questionnaire-SF								
Sensorial	-0,40±5,80	-0,24	0,812		3,44±4,30	-2,04	0,042*	0,80
Perceptual	-0,60±2,76	-0,74	0,461		1,11±3,92	-1,19	0,236	
Total	-1,00±8,10	-0,42	0,678		4,56±6,88	-1,61	0,107	
Existing Pain	0,60±0,97	-1,73	0,084		0,33±1,00	-1,00	0,317	
VAS	1,90±2,48	-2,04	0,042*	0,77	-0,27±2,34	-0,34	0,735	
TUG (s)	1,12±1,14	3,12	0,012*	0,99	-0,44±1,39	-0,96	0,365	
SCT (s)	2,11±1,90	3,51	0,007*	1,11	-0,85±1,72	-1,48	0,177	
WOMAC								
Pain	2,70±3,06	-2,04	0,041*	0,88	-1,11±3,59	-0,72	0,472	
Stiffness	0,80±1,62	-1,46	0,144		-0,67±1,58	-1,20	0,230	
Functionality	5,50±6,65	-1,99	0,046*	0,83	1,56±7,91	-0,48	0,632	
Total	9,38±11,32	-1,99	0,047*	0,83	-1,97±13,45	-0,30	0,767	
6MWT-Walking Distance	-35,50±46,63	-2,41	0,039*	0,76	55,67±62,10	2,69	0,028*	0,90
HAQ	0,22±0,50	-1,40	0,161		-0,20±0,49	-1,19	0,235	
FES	7,00±8,30	-2,10	0,035*	0,84	1,00±6,95	-0,63	0,528	
BETY-BQ								
Pain	2,50±4,12	-2,11	0,035*	0,61	-1,00±4,50	-0,70	0,483	
Functionality	7,00±9,74	-1,99	0,047*	0,72	-1,11±6,59	-0,24	0,812	
Mood	8,50±9,80	-2,71	0,007*	0,87	-0,33±8,49	-0,07	0,944	
Sociability	1,70±4,32	-1,13	0,257		0,67±2,96	-0,26	0,796	
Sexuality	1,50±2,72	-1,58	0,115		0,00±2,65	-0,33	0,739	
Sleep	0,80±1,55	-1,47	0,143		-0,33±0,87	-1,13	0,257	
Total	21,10±26,06	-2,07	0,038*	0,81	-2,56±17,19	-0,77	0,441	
WHOQOL-BREF								
General Health	2,50±27,51	-0,43	0,666		1,39±18,16	-0,11	0,914	
Physical Health	-13,21±11,79	-2,50	0,012*	1,12	3,16±9,53	-0,65	0,513	
Psychological Health	-7,08±12,27	-1,56	0,120		1,54±14,34	-0,35	0,726	
Social Relations	-19,17±24,55	-2,09	0,037*	0,78	3,30±17,89	-0,63	0,527	
Environment	-8,13±13,68	-1,66	0,096		-0,43±15,07	-0,21	0,833	
Knee joint proprioception								
Right knee 60 °	0,86±2,66	1,02	0,334		2,79±3,31	2,53	0,035 *	0,84
Ext 60 °/sec speed right knee	-47,56±53,04	-2,84	0,020*	0,90	-18,22±71,86	-0,76	0,469	

TUG: timed up and walk test, 10-SSCT: 10-Step Stair Climbing Test, WOMAC: Western Ontario-Memaster University Osteoarthritis Index, 6MWT: 6 min Walk Test, HAQ: Health Assessment Questionnaire, FES: Fall Efficacy Scale, BETY-BQ: BETY-Biopsychosocial Questionnaire, WHOQOL-BREF: World Health Organization Quality Of Life Scale-Short Form, BT: before treatment, AT: after treatment, sec: seconds, n: number of people, X: mean, Min: Minimum, Max: Maximum, \* Wilcoxon Signed Rank  $p < 0.05$

pain score after training in the group participating in exercise training is remarkable. WOMAC evaluates pain at the time of the function, and BETY-BQ evaluates the cognitive aspect of pain, which proves that the exercise training group showed multidimensional improvement in terms of pain. The BETY-BQ, used in our study, evaluates pain from a cognitive perspective and includes statements revealing its relationship with mood, which coincides with this cognitive improvement. Therefore, the data obtained show that the cognitive aspect of pain is important for individuals diagnosed with RA. These results interpreted the BETY pain management strategy as effective in the cognitive management of individuals' pain.

Considering the biopsychosocial characteristics of individuals diagnosed with RA, the effect on mood is remarkable [27]. Due to the small number of cases in our study, when the BETY-BQ's mood and total scores were examined, the exercise group's improvement was significant. It was observed that the decrease in the BETY-BQ total score in the training group reflected the improvement in the functionality and mood subscales.

In our study, the WHOQOL was used to assess quality of life. Following the 3-month training period, the social relationship sub-parameter in the evaluations of the training group increased significantly compared to the control group. The structured group exercises conducted through



**Fig. 2** Changes in the 6-minute walk test and BETY-BQ total scores of individuals diagnosed with RA with knee involvement

telerehabilitation in the training group may explain this effect on socialization.

While the results of the measurements evaluating the functionality of individuals diagnosed with RA were similar in both groups at the beginning, improvement was observed in most parameters in the exercise training group compared to the control group and within itself. In the control group, while the measured values did not change after 3 months, a decrease in the 6-minute walk test walking distance was observed. When the fear of falling was examined in both groups, an improvement was observed in the training group.

In BETY sessions, exercises are performed in various positions, including back, side lying, prone, sitting, and standing. Core stabilization is maintained throughout all exercises and combined with breathing. In this way, the elicitation of isolated movement has a reinforcing effect on the deep sensation of the joints to perform the movement correctly. The improvement in the fear of falling can be interpreted as a result of the balanced contraction response created by core stabilization.

### Strengths and limitations

The study examined the change in biopsychosocial characteristics and knee joint proprioception with an exercise approach based on the biopsychosocial model. Previous studies have not evaluated the knee joint proprioception and related biopsychosocial characteristics of individuals with rheumatoid arthritis. Our previous experience with BETY indicated that this is pioneering research in this field. Besides the fact that our study comprised female subjects, other limitations of our study include the small sample size, the evaluation of individuals diagnosed with RA between the ages of 45–65 years only in the cross-sectional period, and the inability to make comparisons with individuals with another connective tissue disease with knee involvement. However, our results showed that even the number of RA patients receiving BETY via tele-rehabilitation 3 days a week for 3 months was sufficient to observe a positive effects. In addition, the fact that the study was conducted with the telerehabilitation method made it impossible to compare the method with face-to-face rehabilitation. On the other hand, the fact that we did not investigate the long-term status of the individuals we followed up with for 3 months can also be considered a limitation.

### Conclusion

Although RA is a well-known disease in terms of disease management among rheumatologic diseases, the lack of studies examining the biopsychosocial dimension of exercise approaches, which are among the most common non-pharmacologic treatments, is striking. It is expected that knee joint proprioceptive sensation is affected, especially in individuals with RA with knee involvement. This proprioceptive effect may negatively affect many functional activities by disrupting the proper traction angles of the muscles surrounding the knee joint. However, the lack of studies in the field is remarkable. Therefore, examining the effect of exercise training on knee joint proprioception sensation based on the biopsychosocial model in individuals with RA

with knee involvement led to the conduct of this randomized controlled study and revealed the unique value of the study.

In our study, BETY was presented to the literature with positive contributions to the improvement of muscle strength and proprioceptive input, functional capacity, pain, mood, quality of life, biopsychosocial status, and socialization in individuals with RA with knee involvement. These findings support that biopsychosocial model-based exercise approaches integrated into disease management in RA patients with knee involvement from an early stage, before the development of negative joint proprioception, play a critical role not only in terms of functionality but also in terms of biopsychosocial status and quality of life.

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**Data availability** The data supporting this study's findings are available from the corresponding author upon reasonable request.

## Declarations

**Conflict of interest** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Ethical approval** This study was approved by the Hasan Kalyoncu University Faculty of Health Sciences Non-Interventional Research Ethics Committee (approval number: 2022/140). Participants gave informed consent to participate in the study before taking part.

**Consent to participate** All the participants were informed about the study procedures and provided written consent. Furthermore, the study

data were collected per the requirements of the Turkish National law (the law on the protection of personal data).

**Declaration of AI** This study was conducted and written completely without the assistance of artificial intelligence (AI) applications.

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