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RESEARCH ARTICLE

COMPARISON OF THE SUPERIORITY OF ISOMETRIC AND ISOTONIC STRENGTHENING EXERCISES FOR QUADRİCEPS WITH RESPECT TO PAIN, QUALITY OF LIFE, AND FUNCTIONAL CAPACITY OF PATIENTS WITH CHONDROMALACIA PATELLAE

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ABSTRACT

Purpose: This study aims to investigate the superiority of different exercise modalities, including isotonic and isometric strengthening for quadriceps, over each other and their effect on pain, quality of life and functional capacity in patients diagnosed with chondromalacia patellae (CMP).
Material and Methods: This study was designed as a prospective study in 30 patients (15 patients in isometric, 15 patients in isotonic group) and 15 healthy volunteers aged 20–50 years who were diagnosed with CMP based on physical examination and magnetic resonance imaging and had pain complaints. Pain level was evaluated with Visual Analogue Scala (VAS), functional capacity with Lysholm scale, and quality of life with Short Form-36(SF-36). Q-angle, and thigh circumference were evaluated before and after exercise in all patients.
Results: In patients with CMP, there were significant differences in Q-angle, pain, functional capacity, and some subcomponents of the SF-36 quality of life after performing isometric or isotonic exercises compared with the control group ($p<0,05$). There were no significant differences in thigh circumference and other parameters of certain SF-36 quality of life components ($p>0,05$). In the evaluation of the isotonic and isometric exercise groups, there were no significant difference in the assessment of Q-angle, thigh circumference, pain, functional capacity, and quality of life of patients with CMP ($p>0,05$).
Conclusion: Isometric and isotonic quadriceps strengthening exercises are not superior to each other in terms of pain, functional capacity, and quality of life in CMP treatment.

Keywords: Cartilage, chondromalacia patellae, exercise, knee, patellofemoral pain syndrome

INTRODUCTION

Chondromalacia patellae (CMP) is a common condition in patients who present to health units with anterior knee pain (1). Patellofemoral pain syndrome (PFPS) is the most common type of pain in runners with an incidence rate of 17%; it is limited to the anterior knee or the area behind the patella between the patella margins (2). Although PFPS and CMP are often regarded as the same disease, there is still a controversy regarding the subject. It is caused by decreased quadriceps muscle strength, altered mechanical loading, lower extremity kinematics, and differentiation in muscle activation patterns during running (2). Patellofemoral malalignment is a factor

that affects the development of the disease, and Superolateral Hoffa's Fat Pad edema is a strong indicator of severe CMP (1). The most common complaint in patellofemoral disease is pain that occurs medial to the joint line behind the patella, and sometimes in the popliteal fossa (3).

In the diagnosis of CMP, physical examination, certain special tests, magnetic resonance (MRI) with high imaging sensitivity in pathological diagnosis, and arthroscopy, which is the gold standard in the diagnosis of cartilage lesions, are used (4).

Conservative options are primarily preferred in treatment approaches (5,6). The literature includes methods such as patellar taping; quadriceps, vastus medialis obliquus, hamstring, anterior tibialis, and gluteal muscle strengthening; stretching structures such as the iliotibial band and lateral retinaculum; modification of activities; biofeedback; neuromuscular electrical stimulation; therapeutic ultrasound; thermotherapy; knee supports; foot orthoses; and appropriate shoes (5-7).

Exercises to strengthen the quadriceps muscle are essential in CMP treatment. Studies show that general strengthening exercises for lower extremity muscles are effective on pain and functional insufficiency (6,8,9,10). Stretching exercises for hamstrings, lateral retinaculum, iliotibial band, and gastrocnemius muscles as well as strengthening exercises are more effective (6,9,10,11).

Isometric and isotonic exercises for quadriceps muscles are effective in CMP treatment; however, there is no study in the literature which evaluates their superiority to each other. The purpose of this study was to compare the superiority of quadriceps strengthening isometric and isotonic exercises over each other in terms of pain, quality of life and functional capacity in patients with CMP.

MATERIAL AND METHODS

This study was conducted between 2014-2016 in Namık Kemal University Faculty of Medicine, Department of Physical Medicine and Rehabilitation. Overall, after Power Analysis evaluation 30 patients (15 patients in isometric, 15 patients in isotonic group) diagnosed with CMP aged 20–50 years and 15 healthy individuals matched in terms of age, sex, and body mass index were included in the study. The anamnesis and physical examination of the patients (Clark test, McConnel test, Zohler sign and Frund sign) were performed by the Physical Medicine and Rehabilitation physician, and MRI was performed for diagnostic purposes. Among the patients who had unilateral or bilateral anterior knee pain for >3 months, who did not receive physical therapy and rehabilitation treatment in the last 3 months, and who described anterior or retropatellar pain in at least two activities (climbing up and down stairs, squatting, running, kneeling, and jumping), patients with swelling or fibrillation/fissuring pathology in the patella cartilage based on MRI were included in the study (12). Those with orthopedic, neurological (peripheral neuropathy and multiple sclerosis), or endocrinological disease that may cause pain, those with presence of ≥105% joint effusion in the midpatellar environment based on radiological examination, those with meniscus and ligament injuries in the knee, those who have had intraarticular injection, those with inflammatory, infectious joint pathology, those with malignancy history, and pregnant women were excluded from the study. MRI findings of 490 patients with anterior knee pain aged 20–50 years were examined, and the presence of CMP was found in 50 patients (10.2%).

The study was approved by Non-Interventional Clinical Research Ethics Committee (protocol number: 07/30/2015; 2015.80.07.03). Before the study, informed consent indicating the purpose of the study was obtained, and four questionnaire forms regarding pain, quality of life, functional capacity, and sociodemographic data were provided to be filled under the supervision of the physician.

The sociodemographic data questionnaire comprising questions regarding the patient's age, sex, weight, height, body mass index (BMI), exercising habits, forms and frequency, smoking and alcohol use history, and family history was filled.

The Q angle is a unit used as a measure of the tendency of the patella to move sideways when the quadriceps muscle is contracted, and used as an evaluation criterion in the diagnosis and treatment of patellofemoral pain (13).The Q-angle, which helps to determine the trajectory of the patellofemoral joint, is the angle between the midpoint of the anterior-superior iliac spine and the patella and the lines connecting this point with the tuberositas tibia (13). The Q angle (normal range between 13°- 18°) was measured using a goniometer after the patient was placed in the supine position and the quadriceps muscle was relaxed. Q angles of all groups were measured and noted before and after treatment (13).

Thigh circumference is the unit of measurement used in the evaluation of patellofemoral pain before and

after treatment, which allows to evaluate the volume of the quadriceps muscle and whether there is atrophy (14). All individuals were marked 10 cm above the upper edge of the patella, and their thigh circumference was measured in centimeters before and after treatment (12).

The visual analog scale (VAS) is one of the most commonly used methods in pain assessment and provides quick and easy assessment (12). Scoring is made between 0 and 10 at 1-cm intervals on a 10 cm horizontal line. 0 point at the beginning of the scale is "no pain," and 10 points represents the most severe pain level the patient can imagine. Patients indicate the severity of pain by marking a point on the line. VAS scoring was used for the patient and control groups before and after treatment.

Short Form-36 (SF-36) scale was used in this study to evaluate the quality of life of the participants (15). Under the title of physical component, four subgroups are evaluated, including physical functioning (PF) (restriction in physical activity owing to health problems), physical role (PR) (restriction in activities of daily living owing to health problems), bodily pain (BP), and general health (GH) (general evaluation of a person), and under the title of mental component, four subgroups are evaluated, including vitality (V), general mental health (GMH), social functioning (SF), and emotional role (ER) (restriction in daily living activities owing to mental health problems). In this scale which examines health under eight components, high scores indicate the state of well-being and low scores indicate poor health.

Lysholm Knee Scale was used for functional capacity (functional disability); the validity and reliability study of this scale in Turkey was conducted by Çelik et al.(16) in 2012. The Lysholm Knee score scale is an eight-item questionnaire. It is an assessment criterion that has a scale of 0 to 100 points, with higher scores indicating worse functional capacity. 25 points are pain, 15 are locking, 10 are swelling, 25 are instability, 10 are climbing stairs, 5 are limping, 5 are using of support and 5 are squatting (17). Patients diagnosed with CMP were randomized based on the order of their application to the polyclinic; quadriceps strengthening isometric exercises were assigned to the first 15 and quadriceps strengthening isotonic exercises to the other 15. Knee range of motion exercises by minimizing gravity were assigned to the 15 healthy subjects, the control group, and a 2-month home exercise program was initiated to increase gradually. Target heart rate during exercise was determined with the Karvonen formula. Reserve heart rate is calculated by subtracting the resting heart rate from the maximum heart rate. The percentage of functional capacity to be exercised is multiplied by the value found. By adding the resting heart rate to the obtained values, the desired target heart rate range in the exercise is found as follows (18,19):

Maximum heart rate = 220–age

Target heart rate range=[(Max heart rate-Resting heart rate) x %intensity] + Resting heart rate

Patients filled sociodemographic data forms and SF-36 quality of life index, VAS, and Lysholm Scale before and after treatment. At the end of the first month of the study, the patient and control group were contacted by phone regarding the continuity of treatment.

Exercise Procedures

Similar to the literature, an exercise program including 8-week quadriceps strengthening isometric and isotonic exercises was applied to the groups (20). Knee isometrics with towel press (Figure 1A), terminal knee extension (Figure 1B) exercises were applied to the group who received quadriceps strengthening isometric exercise. Isotonic knee extension (Figure 1C) and semisquat (Figure 1D) exercises were applied to the group that received quadriceps strengthening isotonic exercises (12,21). The program was started with two sets per day for each exercise performed five times in each set and increased by five repetitions for each exercise every 2 days (12). Maximum volumetric contraction was used for isometric exercise load progression. Accordingly, we assumed that the contraction that the patient could do with all his/her strength was 100%. 60% of the maximum volumetric contraction was used in the first half of the 8 weeks and 70% for the second half of the 8 weeks.

Power Analysis

Sample size was calculated using SPH analytic (version 3.0, Georgia, United States of America) The incidence of pain reduction after exercise was determined as the primary outcome. For this purpose, we used the study of Bakhtiary et al. (12). In this study, they found a decrease of 26.19% in VAS values in the group given isometric exercise and a decrease of 26.31% in the group given isotonic exercise. Using the reduction in VAS values in this study, it was determined that both groups recruited 14 patients, with alpha error 5%, beta error 20%, and

80% power. Considering that a 10% patient loss may occur, in addition to this rate, the plan was designed with 15 patients in one of the two groups and 15 healthy volunteers in the control group.

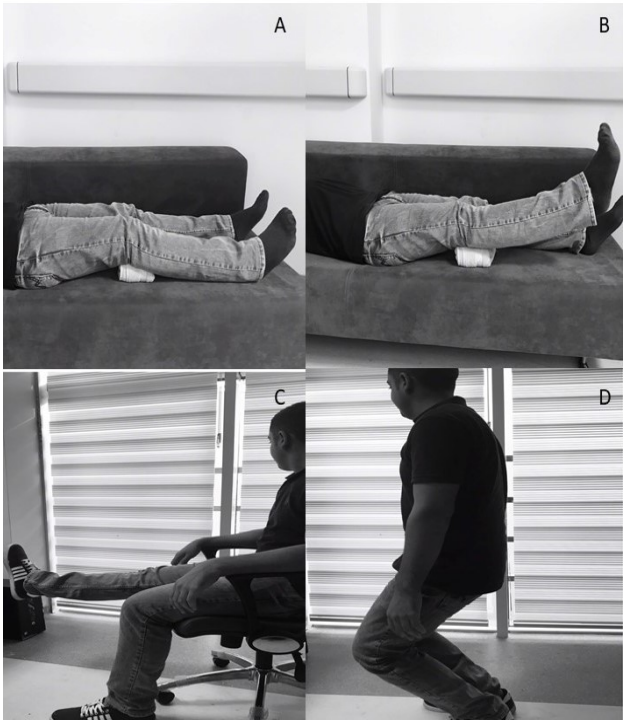

Figure 1. Knee isometric exercises with towel press **(A)** and terminal knee extension **(B)** while lying down; Knee isotonic exercises with knee extension **(C)** and semisquat **(D)**

Statistical Analysis

All variables were summarized based on the groups and pre/post-treatment status. Distribution results of continuous variables were expressed as mean ± standard deviation and median (min–max), and the distribution of categorical variables were expressed as number and percentage. Chi-square test was used in the analysis of categorical variables. While testing the statistically significant difference between the groups in terms of continuous variables (3 groups), normal distribution of the variables was checked; One-way analysis of variance (ANOVA) was used for the variables with normal distribution, and Kruskal–Wallis test, a nonparametric alternative, was used for the variables without normal distribution. Multiple comparisons were made in cases with significant differences. For paired group comparisons such as “before and after” for variables, t-test was used for dependent groups or the Wilcoxon rank test, a nonparametric alternative, was used. p value of <0.05 for the differences was considered statistically significant. Bonferroni correction was used in multiple comparisons after ANOVA. International Business Machines Statistical Package for the Social Sciences (IBM SPSS) ver. 20 package software was used for the analysis of the data.

RESULTS

Three groups, categorized as isometric exercise group, isotonic exercise group, and control group, were evaluated. Age, weight, height, BMI, smoking, and alcohol use rates were similar in all three groups. There was no statistically significant difference ($p>0.05$).

In the isometric exercise group, 40% of the patients were grade 1, 20% were grade 2, 20% were grade 3, and 20% were grade 4. In the isotonic group, 33% were grade 1, 20% were grade 2, 26.7% were grade 3, and 20% were grade 4.

In the evaluation of isometric exercises based on pre/post-treatment status in patients with CMP, the improvement in physical functionality, BP, GH, GMH, and mental component parameters of the SF-36 quality of life assessment were statistically significant ($p<0.05$), whereas there was no significant change in the Q-angle, thigh circumference, VAS, Lysholm functional capacity test, and other parameters of the SF-36 quality of life assessment ($p>0.05$) (Table 1,2,3,4).

In the evaluation of isotonic exercises based on pre/post-treatment status in patients with CMP, the decrease in the pain scale and the improvement in thigh circumference, Q-angle, BP, physical functionality, GH, and social functionality parameters of the SF-36 quality of life assessment were significant ($p<0.05$), whereas there was no significant change in Lysholm functional capacity test, and other parameters of the SF-36 quality of life assessment ($p>0.05$). (Table 1,2,3,4)

Similar results were obtained for isotonic and isometric exercises in the Q-angle, thigh circumference, pain, Lysholm functional capacity test, and SF-36 quality of life assessment in patients with CMP (Table 1,2,3,4).

Compared with the control group, isometric or isotonic exercises resulted in significant changes ($p>0.05$) in Q-angle, VAS, Lysholm functional capacity test, physical functionality, BP, social functionality, and physical component parameters of the SF-36 quality of life assessment in patients with CMP, whereas there was no significant change ($p>0.05$) in thigh circumference, GH, vitality, ER, MH, and mental component parameters of the SF-36 quality of life assessment (Table 1,2,3,4).

Table 1. Distribution of Pretreatment and Post-Treatment Q-Angle and Thigh Circumference Measurements by Treatment Groups

Q-ANGLE		**Pretreatment** Mean ± SD Med (Min–Max)	**Post-Treatment** Mean ± SD Med (Min–Max)	**p ~**
	Isometric exercise group (Group 1)	19.12 ± 1.03 19.01 (17.00-20.00)	18.72 ± 1.73 19.05 (14.00-20.00)	0.324 *
	Isotonic exercise group (Group 2)	19.05 ± 1.23 19.06 (16.02-21.03)	18.12 ± 1.75 19.03 (15.04-20.02)	**0.049** *
	Control group (Group 3)	12.12 ± 3.12 11.02 (8.00-18.00)	12.33 ± 2.92 12.08 (8.00-18.00)	0.546 *
	p (for 3 groups)	**<0.001** **	**<0.001** **	
	p (Group 1 vs. Group 2)	NS ** ***	NS ** ***	
	p (Group 1 vs. Group 3)	**<0.001** **	**<0.001** **	
	p (Group 2 vs. Group 3)	**<0.001** **	**<0.001** **	
THIGH CIRCUMFERENCE	**Isometric exercise group (Group 1)**	46.12 ± 4.02 45.02 (40.55-54.05)	48.02 ± 5.94 47.04 (41.00-60.00)	0.088 *
	Isotonic exercise group (Group 2)	44.55 ± 5.02 43.52 (37.00-54.05)	46,62 ± 5,22 46.03 (39.02-58.04)	**0.001** *
	Control group (Group 3)	45.32 ± 5.44 44.02 (36.04-57.04)	45.71 ± 5.11 44.01 (39.04-57.05)	0.316 *
	p (for 3 groups)	0.677 **	0.509 **	
	p (Group 1 vs. Group 2)	-	-	
	p (Group 1 vs. Group 3)	-	-	
	p (Group 2 vs. Group 3)	-	-	

~p < 0.05, NS: Non Significiant *Paired t-test, **ANOVA, Bold font: Statistically significant.

Table 2. Distribution of Pre- and Post-Treatment VAS and Lysholm Test Measurement Results by Treatment Groups

VAS TEST		**Pretreatment** Mean ± SD Med (Min–Max)	**Post-Treatment** Mean ± SD Med (Min–Max)	**p ~**
	Isometric exercise group (Group 1)	6.53 ± 2.21 6.05 (3.00-10.00)	5.84 ± 2.51 5.00 (0.00-9.00)	0.259 *
	Isotonic exercise group (Group 2)	6.23 ± 1.92 7.00 (2.00-8.00)	4.56 ± 2.04 5.00 (0.00-8.00)	**0.001** *
	Control group (Group 3)	0.00 (0.00-2.00)	0.35 ± 1.05 0.00 (0.00-4.00)	0.180 *
	p (for 3 groups)	**<0.001** **	**<0.001** **	
	p (Group 1 vs. Group 2)	NS ** ***	NS ** ***	
	p (Group 1 vs. Group 3)	**<0.001** **	**<0.001** **	
	p (Group 2 vs. Group 3)	**<0.001** **	**<0.001** **	
LYSHOLM TEST	**Isometric exercise group (Group 1)**	56.12 ± 25.15 54.07 (12.04-92.04)	64.1 ± 17.4 64.0 (34.0-89.0)	0.142 *
	Isotonic exercise group (Group 2)	59.05 ± 21.11 60.04 (27.05-90.04)	66.12 ± 16.10 62.05 (35.04-90.05)	0.116 *
	Control group (Group 3)	97.95 ± 8.01 100.00 (69.06-100.04)	98.15 ± 7.56 100.05 (71.04-100.04)	0.317 *
	p (for 3 groups)	**<0.001** **	**<0.001** **	
	p (Group 1 vs. Group 2)	NS ** ***	NS ** ***	
	p (Group 1 vs. Group 3)	**<0.001** **	**<0.001** **	
	p (Group 2 vs. Group 3)	**<0.001** **	**<0.001** **	

~p < 0.05, *Paired t-test, **ANOVA, Bold font: Statistically significant

Table 3. Distribution of Pre- and Post-Treatment SF-36 Quality of Life Form "Physical Role (PR)," "Bodily Pain (BP)," "General Health (GS)," and "Physical Functioning (PF)" Subgroup Measurement Results by Treatment Groups

SF-36 Quality of life form, Physical role (PR) subgroup		**Pretreatment** Mean ± SD Med (Min–Max)	**Post-treatment** Mean ± SD Med (Min–Max)	**p ~**
	Isometric exercise group (Group 1)	31.45 ± 12.24 27.51 (17.71-47.11)	32.74 ± 12.85 27.52 (17.72-56.92)	0.763 *
	Isotonic exercise group (Group 2)	34.72 ± 15.92 37.72 (17.73-56.93)	31.45 ± 14.72 27.55 (17.73-56.93)	0.375 *
	Control group (Group 3)	54.32 ± 7.83 56.95 (27.53-56.95)	50.45 ± 14.22 56.95 (17.73-56.95)	0.458 *
	p (for 3 groups)	**<0.001 ****	**0.001 ****	
	p (Group 1 vs. Group 2)	NS ** ***	NS ** ***	
	p (group 1 vs. group 3)	**<0.001 ****	**0.003 ****	
	p (group 2 vs. group 3)	**0.001 ****	**0.007 ****	
SF-36 Quality of life form, "Bodily Pain (BP)" subgroup	**Isometric exercise group (Group 1)**	35.23 ± 8.72 37.22 (19.92-51.12)	41.23 ± 10.12 41.83 (19.92-62.12)	**0.014 ***
	Isotonic exercise group (Group 2)	40.82 ± 11.23 37.62 (24.92-62.12)	45.82 ± 10.22 46.12 (24.12-62.12)	**0.049 ***
	Control group (Group 3)	55.22 ± 8.63 55.42 (33.42-62.12)	54.33 ± 8.92 55.43 (37.62-62.12)	0.715 *
	p (for 3 groups)	**<0.001 ****	**0.002 ****	
	p (group 1 vs. group 2)	NS ***	NS ***	
	p (group 1 vs. group 3)	**<0.001 ****	**0.002 ****	
	p (group 2 vs. group 3)	**0.001 ****	**0.049 ****	
SF-36 Quality of life form General Health (GS) subgroup	**Isometric exercise group (Group 1)**	37.92 ± 9.75 37.73 (18.64-52.92)	43.22 ± 10.93 42.45 (25.84-60.19)	**0.013 ***
	Isotonic exercise group (Group 2)	41.16 ± 7.92 40.13 (28.15-52.92)	45.54 ± 6.59 48.23 (35.34-54.42)	**0.041 ***
	Control group (Group 3)	48.36 ± 7.64 43.43 (38.64-60.13)	50.24 ± 9.22 52.92 (32.93-62.54)	0.317 *
	p (for 3 groups)	**0.006 ****	0.115 **	
	p (Group 1 vs. Group 2)	NS ** ***	-	
	p (Group 1 vs. Group 3)	**0.005 ****	-	
	p (Group 2 vs. Group 3)	NS ** ***	-	
SF-36 Quality of life form "Physical Function (FF)"subgroup	**Isometric exercise group (Group 1)**	31.72 ± 11.54 29.72 (14.92-52.83)	36.32 ± 10.00 38.13 (17.63-52.84)	**0.043 ***
	Isotonic exercise group (Group 2)	35.86 ± 9.35 36.02 (23.44-52.83)	40.64 ± 9.12 36.04 (29.73-52.87)	**0.026 ***
	Control group (Group 3)	52.84 ± 4.55 52.89 (44.45-57.06)	53.45 ± 5.34 54.95 (38.12-57.05)	0.484 *
	p (for 3 groups)	**<0.001 ****	**<0.001 ****	
	p (Group 1 vs. Group 2)	NS ** ***	NS ** ***	
	p (Group 1 vs. Group 3)	**<0.001 ****	**<0.001 ****	
	p (Group 2 vs. Group 3)	**<0.001 ****	**<0.001 ****	

~p < 0.05, *Paired t-test, **ANOVA, ***NS: Nonsignificant, Bold font: Statistically significant.

Table 4. Distribution of Pre- and Post-Treatment SF-36 Quality of Life Form "Vitality (V)," "Social Functioning (SF)," "Emotional Role (ER)," "General Mental Health (GMH)," "Physical Component" and "Mental Component" Subgroup Measurement Results by Treatment Groups

SF-36 Quality of life form "Vitality (V)" subgroup		**Pretreatment** Mean ± SD Med (Min–Max)	**Post-Treatment** Mean ± SD Med (Min–Max)	**p ~**
	Isometric exercise group (Group 1)	39.45 ± 13.95 36.56 (20.97-70.85)	45.45 ± 15.76 39.67 (27.16-70.85)	0.146 *
	Isotonic exercise group (Group 2)	45,65 ± 13,45 45.87 (20.92-70.88)	48.02 ± 12.34 52.12 (27.14-64.66)	0.458 *
	Control group (Group 3)	53.86 ± 9.94 55.22 (36.54-67.76)	55.35 ± 9.82 58.36 (36.55-70.84)	0.575 *
	p (for 3 groups)	**0.012 ****	0.107 **	
	p (Group 1 vs. Group 2)	NS ** ***	-	
	p (Group 1 vs. Group 3)	**0.009 ****	-	
	p (Group 2 vs. Group 3)	NS ** ***	-	
SF-36 Quality of life form "Social Functioning. (SFo) "subgroup	**Isometric exercise group (Group 1)**	35.72 ± 10.94 35.02 (18.74-56.84)	46.34 ± 12.12 51.44 (18.75-56.84)	0.100 *
	Isotonic exercise group (Group 2)	36.84 ± 13.02 35.04 (13.27-56.89)	42.74 ± 9.84 40.56 (29.62-56.86)	**0.049 ***
	Control group (Group 3)	46.36 ± 12.14 51.47 (18.72-56.83)	51.74 ± 8.13 56.87 (35.02-56.89)	**0.020 ***
	p (for 3 groups)	**0.041 ****	**0.012 ****	
	p (Group 1 vs. Group 2)	NS ** ***	NS ** ***	
	p (Group 1 vs. Group 3)	NS ** ***	**0.026 ****	
	p (Group 2 vs. Group 3)	NS ** ***	**0.035 ****	
SF-36 Quality of life form "Emotional Role (ER)" subgroup	**Isometric exercise group (Group 1)**	28.96 ± 14.94 24.89 (9.25-55.94)	39.35 ± 15.06 40.3 (9.24-55.96)	0.114 *
	Isotonic exercise group (Group 2)	32.04 ± 17.56 40.34 (9.22-55.98)	34,67 ± 18,23 32.64 (9.23-55.97)	0.618 *
	Control group (Group 3)	46.67 ± 17.54 55.94 (9.23-55.94)	48.45 ± 13.53 55.97 (20.92-55.94)	0.680 *
	p (for 3 groups)	**0.008 ****	0.071 **	
	p (Group 1 vs. Group 2)	NS ** ***	-	
	p (Group 1 vs. Group 3)	**0.010 ****	-	
	p (Group 2 vs. Group 3)	**0.049 ****	-	
SF-36 Quality of life form "General Mental Health (GMH)" subgroup	**Isometric exercise group (Group 1)**	41.03 ± 11.44 35.94 (24.72-61.34)	49,64 ± 9,02 47.24 (35.93-61.34)	**0.004 ***
	Isotonic exercise group (Group 2)	47.26 ± 10.14 47.23 (30.34-61.36)	50.45 ± 6.54 50.05 (38.74-61.33)	0.095 *
	Control group (Group 3)	50.03 ± 7.54 50.04 (33.12-61.34)	50.02 ± 9.04 52.84 (33.15-64.15)	0.994 *
	p (for 3 groups)	**0.045 ****	0.967 **	
	p (Group 1 vs. group 2)	NS ** ***	-	
	p (Group 1 vs. Group 3)	**0.040 ****	-	
	p (Group 2 vs. Group 3)	NS ** ***	-	
SF-36 Quality of life form "Physical Component" subgroup	**Isometric (Group 1)**	33.85 ± 11.56 34.45 (10.36-55.65)	35.75 ± 10.05 33.05 (21.24-57.05)	0.484 *
	Isotonic (Group 2)	37.54 ± 11.25 35.14 (21.23-55.45)	40.05 ± 10.25 38.54 (23.35-61.34)	0.241 *
	Control (Group 3)	54.75 ± 6.22 56.12 (40.57-62.55)	53.45 ± 8.94 55.43 (35.12-67.64)	0.638 *
	p (for 3 groups)	**<0.001 ****	**<0.001 ****	
	p (Group 1 vs. Group 2)	NS ** ***	NS ** ***	
	p (Group 1 vs. Group 3)	**<0.001 ****	**<0.001 ****	
	p (Group 2 vs. Group 3)	**<0.001 ****	**<0.001 ****	
SF-36 Quality of life form "Mental Component" subgroup	**Isometric (Group 1)**	38.34 ± 12.12 35.84 (17.83-58.53)	48.22 ± 9.02 48.54 (32.82-65.14)	**0.043 ***
	Isotonic (Group 2)	42.56 ± 11.25 42.34 (23.88-62.79)	45.94 ± 10.32 46.44 (29.42-62.84)	0.303 *
	Control (Group 3)	46.76 ± 12.74 51.24 (17.02-59.64)	49.87 ± 9.57 52.64 (31.52-62.99)	0.305 **
	p (for 3 groups)	0.170 **	0.545 **	
	p (Group 1 vs. Group 2)	-	-	
	p (Group 1 vs. Group 3)	-	-	
	p (Group 2 vs. Group 3)	-	-	

~p < 0.05, *Paired t-test, **ANOVA, ***NS: Nonsignificant, Bold font: Statistically significant.

DISCUSSION

The purpose of this study was to compare the superiority of quadriceps strengthening isometric and isotonic exercises over each other in terms of pain, quality of life, and functional capacity in patients diagnosed with CMP. Isometric or isotonic exercises resulted in significant changes in Q-angle, VAS, Lysholm functional capacity test, physical functionality, BP, social functionality, and physical component parameters of the SF-36 quality of life assessment in patients with CMP.

Macmull et al.(22) detected CMP at a rate of 71% in women and 29% in men, and Baczkowicz et al. (23) detected CMP at a rate of 65% in women and 35% in men. Atbaşı et al. (24) detected CMP in 4.13% (5/121) male patients with anterior knee pain in Turkey. In our study, MRI findings of 490 patients with anterior knee pain aged 20–50 years were examined, and the presence of CMP was found in 50 patients (10.2%) (28 females [56%]); 22 males [44%]), which was similar to the literature.

Studies have shown that the Q-angle and knee joint strength are correlated, whereas the increased Q-angle is a predisposing factor for knee joint problems and sports injuries (25). In our study, the Q-angle decreased after treatment in the isometric and isotonic exercise groups and control group. There was no difference when the groups were compared in terms of change in Q angle. In a study conducted by Bakhtiary et al. (12) on 32 female patients, a decrease in Q-angle was detected; this decrease was statistically more significant in the isotonic exercise group than in the isometric exercise group. This difference may have resulted from the presence of both male and female patients in the isometric and isotonic exercise groups in our study.

In our study, there was an increase in the thigh circumference in both groups following treatment, which was statistically more significant in the isotonic group. Despite this significant increase, both groups were statistically similar to each other. Bakhtiary et al. (12) found a more significant increase in thigh circumference in the isotonic exercise group. This may be because Bakhtiary et al. (12) included young university students in their study, but we included individuals aged 20-50 in our study.

In the study by Bakhtiary et al. (12) on patients diagnosed with CMP, there was a decrease in VAS values in isometric and isotonic exercise groups, but no significant difference between exercise modalities. In three studies that evaluated the effect of quadriceps strengthening isotonic exercises on VAS, Khayambashi et al. (26) found a 53% decrease in pain intensity, Eapen et al. (27) 28%, and Dolak et al. (28) 38%. In our study, the decrease in VAS values (27.4%) after treatment was significant in the isotonic group, and there was a statistically significant difference between both exercise modalities and the control group. There was no difference when the groups were compared in terms of decrease of VAS values. The effect of exercises on pain was consistent with that reported in the literature.

Fabiana et al. (29) showed that electrical stimulation to the vastus medialis increased functional capacity compared with the control group; Alaca et al. (30) showed that isokinetic quadriceps strengthening exercises increased functional capacity compared with the control group; and Chen-Yi Song et al. (31) showed that isotonic exercises increased functional capacity compared with the control group. Dolak et al. (28) showed that isometric exercises provided functional recovery. In our study, although isometric or isotonic quadriceps strengthening exercises significantly improved functional capacity in patients with CMP compared with control groups, no significant difference was found between each other.

In our study, the quality of life was evaluated using the SF-36 scale, and it was found that isometric or isotonic exercises resulted in positive gains by causing significant differences in physical functionality, PR, BP, social functionality subgroups, and physical component group compared with the control group. In the GH, vitality, ER, and GMH subgroups and the mental component group, there was a statistical similarity between both exercise modalities and the control group. In addition, there was no significant difference in any parameter of the quality of life assessment between isometric and isotonic exercise groups. In our study, there was a statistically significant difference in post-treatment physical functionality, BP, GH, GMH, and mental component parameters compared with pretreatment scores for isometric exercises. In isotonic exercises, there was a statistically significant difference in post-treatment scores for physical functionality, GH, and social functionality parameters compared with the pretreatment scores. Eapen et al. (27) found statistically significant increases in post-treatment scores of physical component, BP, and mental component in the quality-of-life assessment in the group which received three-week quadriceps strengthening isotonic exercises. This evaluation

indicates a correlation in our study, as there was a statistically significant difference in physical component and BP scores for isotonic exercises compared with the control group. Khayambashi et al. (26) found that the quality of life increased significantly in the group that received isotonic exercise. Calatayud et al. (32) reported that preoperative isometric exercises significantly improved the quality of life (SF-36) in patients with knee osteoarthritis who were scheduled to undergo planned total knee replacement. The study by Burich et al. (33) with 33 participants on aerobic and anaerobic exercises and the effect of isotonic knee strengthening exercises on aerobic capacity showed no significant change in SF-36 subgroups following aerobic exercises, whereas there was an increase in all subgroups in the group in which aerobic and isotonic exercises were used together, although this increase was significant only in the GH subgroup. In our study, this evaluation indicated a correlation because there was a statistically significant difference in the GH subgroup for isotonic exercises following treatment compared with pretreatment scores. Sevimli et al. (33) evaluated the effects of aquatic, isometric strengthening and aerobic exercises on physical and psychological parameters in female patients diagnosed with fibromyalgia, and there was no statistically significant change for isometric exercises in the physical and mental component scores in the evaluation of quality of life (SF-36). In this study, similar changes were observed in the mental component scores and post-treatment physical component scores in the isometric group compared with the control group.

The limitations of our study are the small number of patients, the short duration of treatment, and the absence of long-term exercise effects.

CONCLUSION

In conclusion, isometric or isotonic exercises resulted in significant changes in Q-angle; pain; functional capacity; and the PR, physical functionality, BP, social functionality, and physical component parameters of SF-36 quality of life assessment in patients with CMP compared with the control group, whereas they did not result in significant changes in thigh circumference and the GH, vitality, ER, GMH, and mental component parameters of SF-36 quality of life assessment.

When the isotonic and isometric exercises were evaluated together, similar results were obtained in the assessment of Q-angle, thigh circumference, pain, functional capacity, and quality of life of patients with CMP.

Although we recommend quadriceps strengthening exercises in patients with CMP, the effectiveness of isometric and isotonic exercises should be demonstrated with long-term comprehensive studies with larger patient groups.

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