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Effectiveness of isokinetic exercise on pain and function in patients with total knee arthroplasty

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Abstract

Aim: Relief of pain and physical function improvements normally happen in 6 to 12 months following total knee arthroplasty (TKA). Nevertheless, pain persists in some patients even after one year. Likewise, functional improvement is insufficient. We have evaluated the effectiveness of an isokinetic strengthening program on post-operatively (1-9 years) knee pain, functional limitation, level walking and stair climbing in patients with TKA at late period.

Materials and Methods: Twenty-five women patients with TKA were assigned into isokinetic training (study group) or the control groups. Patients answered WOMAC questionnaire and performed Stair Climbing Test. Quadriceps and hamstring muscle strength were evaluated isokinetically at 60 and 180°/sec angular velocity. All tests were evaluated before & after intervention and at follow-up three months later. Only the study group performed isokinetic training five days a week for two weeks while both groups received home-based exercise program.

Results: Knee pain at rest and during walking statistically decreased in both groups as per the evaluations at before & after intervention and 3-month follow-up. Comparison of WOMAC scores in two groups revealed only a statistically significant decrease in the study group among the after intervention & follow-up values. Although the increase at 60°/sec extension and flexion PT values in the study group was greater than that in the control group, there was no pointed difference between both groups.

Conclusion: Strengthening of the knee muscles with isokinetic exercise reduces pain and improves functionality more than the home-based exercise program does.

Registration: The study was approved by the Ethics Committee in the University of Health Sciences, Diskapi Training and Research Hospital (Protocol #34/09 Dated 16.01.2017).

Introduction

In advanced knee osteoarthritis (OA) patients, surgical treatment is required if recovery is not achieved with conservative treatment. The most commonly used procedure is total knee arthroplasty (TKA). Typically, significant improvements in pain and function are observed at 6 and 12 month after recovery [1]. That said, despite the reduction in knee pain after TKA, 37% of patients do not yet have adequate functional recovery after one year [2]. Some patients still have residual knee pain and functional limitations. Quadriceps strength after TKA has been shown to play an important role in functional recovery [3]. There are several studies in the literature in which muscle strength of knee quadriceps muscle in patients with TKA is measured with isokinetic devices [3-8]. Conversely, there is no study in which patients with TKA having knee pain and loss of function in late period were treated by strengthening quadriceps and hamstring muscles with an isokinetic dynamometer. TKA reduces knee pain but if post-operatively knee training is not adequately performed, knee motion range (ROM) restriction and muscle weakness occur that reduce the success of the prosthesis [2], leading to impairment in daily living activities and physical functions of the patient. Occasionally, weakness may persist in quadriceps muscle strength after TKA and functional disability may occur in daily activities such as walking and stair climbing [6]. Strengthening exercises are recommended for reducing knee pain, increas-

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ing the strength of the knee muscles and the ROM [9]. In our study, we investigated the effects of isokinetic exercise program on patients who had knee pain and functional limitation after TKA. Unlike other studies, we also measured the pre-exercise value of the ratio of flexion to extension peak torque (PT) in the knee with TKA. We aimed to reveal the effect of isokinetic exercise on afore-mentioned ratio and total knee function, as well. It was intended in the Study to demonstrate objectively with isokinetic data the necessity of exercise, which is generally prescribed following TKA but not always followed by patients.

Material and Methods

This study was designed as a prospective randomized controlled study. Thirty-five patients aged in between 55 to 80 years, who admitted to the clinic between January 2017-August 2017 with knee pain and had TKA for at least one year were included in the Study. All these patients were agreed to participate in the Study. Patients were allocated by randomization and all have given their informed consent for participation. Simple randomization was used to divide the study's participants into two groups. Farther, the study was approved by the Ethics Committee in the University of Health Sciences, Diskapi Training and Research Hospital (Date:16.01.17 , Protocol #34/09).

The exclusion criteria are as the following,

1. Those who underwent both hip and knee arthroplasty were not included in the Study.

2. Those who developed complications such as infection and relaxation after arthroplasty and those who have undergone revision were not included in the Study.

3. The following situations where isokinetic tests are contraindicated -Repetitive subluxation or dislocation of the tested joint acute muscle spasm, -Limited range of motion of the joint, -Effusion and severe pain in the joint, -Severe osteoporosis around the joint, -Malignancy in the bone structure or joint, -Immediately after surgical procedures

4. Those with serious neurological, psychiatric and metabolic diseases were not included in the study.

All patients underwent a tricompartmental, cemented TKA with a medial parapatellar surgical approach. While the study had started with 35 patients (18 in study, 17 in control), it was finalized with 25 patients (15 in study, 10 in control).

Knee ROM measurements were made using goniometer. Active knee flexion ROM were measured in the supine position with a long axis goniometer. Data were recorded on degrees of maximum flexion up to 135° where fully extended knee was set as the neutral position (zero degree). Further, weekly habits of walking and knee exercise were questioned and knee deformities were noted.

Functional testing

Patients' functional assessment was done with the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). Each completed the WOMAC questionnaire on a self-administered basis. The questionnaire is composed of 24 items assessing three subscales: pain (five items), stiffness (two items) and physical function (17 items). The scores were summed up and expressed as a percentage as global score [10]. The Visual Analogue Scale (VAS) was used to measure the knee pain while resting and walking. Stair Climbing Test (SCT) measures the time it takes to ascend and descend 12-step staircase with a rise of 18 cm and run of 28 cm. Patients were instructed to complete the test as quickly as they felt safe and comfortable. One handrail was allowed if required [11]. Quadriceps and hamstring muscular strength during knee extension and flexion movement were assessed using a Biodex System 3 dynamometer (Biodex® Corp., NY, USA). Three isokinetic tests were performed at the beginning of the study, at the end of a 2-week exercise program and at the end of the study (after 3 months) at 60 ° / sec and 180 ° / sec angular velocity. First three times were submaximal warm-up repetitions, and then 5 and 10 maximal effort repetitions were done with a 10-second rest period between each repetition. The test was carried out first on the dominant side, then on the other knee after 5 minutes of rest. Patients were instructed to straighten their leg, "as forceful and as fast as possible". Isokinetic knee extensor and flexor mean peak torque (PT) was determined and standardized to body weight (BW). The ratio of the unilateral agonist /antagonist of TKA knee was determined with the extension / flexion PT. Normally this ratio must be 1.66. The increased rate of this measure is considered as weakness of the flexor muscles (hamstring muscle) [12]. All tests were done by one no blinded observer.

Intervention procedure

Muscle strengthening exercise program was performed with Biodex Dynamometer in the study group. Each set consisted of 5, 10, 15, 20 repetitions of concentric (Con/Con) contraction in angular velocities 60, 90, 120, 180 °/sec. The start and stop angles for extension and flexion were 20°-80 °. Rest interval was 10 seconds between sets and 10 minutes between right and left leg training. A home-based exercise program including isometric strengthening, ROM and stretching was instructed to both groups (study and control) for three months, five days a week, 1 session a day, 10 repeats for each exercise [11]. A clinically significant difference between groups was defined as 20 Nm difference in extensor torque [6]. Patients having pain complaints were given paracetamol 1500 mg daily.

Statistical analysis

Mean Standard Deviation, Median, Minimum, Maximum values are given in the descriptive statistics for continuous data, and percent values are given in the cut data. Mann-Whitney U test was used for comparison of measured variables (age, BMI, TKA duration) and Chi square / Fisher's Exact test was used for comparison of nominal (intermittent) variables in the study and control groups.

Friedman's test was used in both groups to compare the measured parameters before, after, and 3 months after the intervention. The time-varying differences of the measured variables at three different times were calculated and the differences in the groups were examined by the Mann-Whitney U test. Variance Analysis of Repeated Measurements was used to evaluate the difference of extension and flexion values measured at 60 and 180 degrees

in both groups. The statistical significance was accepted as $p<0.05$.

Results

While there was no significant difference between the groups in terms of age, BMI, TKA duration values (p=0.2850, p=0.367, p=0.311, respectively), considerable distinctions were reached in knee flexion ROM scores of the patients. Here, ROM angle was low in the study group (p=0.005) (Table 1). Eight (53.3%) patients had bilateral TKA, five (33.3%) had right TKA and two (13.3%) had left TKA in the study group whereas five (50%) had bilateral TKA, three (30%) had right TKA and two (20%) had left TKA in the control group. Apparently, there was no difference in the right, left, and bilateral rates of TKA sides between the groups (p = 1.000). In the study group, weekly walking habit period was more than 3 hours in 11 patients (73.3%) and less than 3 hours in 4 patients (26.7%). In the control group, that was more than 3 hours in 9 (90 %) patients and less than 3 hours in 1(10%) patient. In a word, no difference was found between the groups (p=0.615) Weekly knee training habit period was more than 3 hours in 5 patients (33.3 %) and less than 3 hours in 10 patients (66.7%) in the study group. Correlatively, that was more than 3 hours in 1 patient (10%) and less than 3 hours in 9 patient (90%) in the control group. That is, there was no variation between the groups (p=0.345) Further, no difference was found between the groups in knee valgus deformity (p=1.000) as there was only one patient (6.7%) with valgus deformity. Knee pain at rest and during walking decreased statistically in both groups in the evaluations before, after and 3 months after the intervention (p < 0.001). Both groups indicated statistically significant SCT values before, after and 3 months after the intervention (p=0.008 for both groups). There was no difference between SCT evaluations comparing to two groups with each other (p=0.605 for "before-after", p=0.643 for "after-follow up", p=0.531 for "before-follow up") Concerning the WOMAC scores, there was a noticeable decrease in the study group comparing "before-after intervention" and "before intervention–in follow-up" (p=0.001 and p < 0.001, respectively) while a remarkable decrease was observed only in "before intervention-in follow-up" in the control group (p=0.016) (Table 2). VAS score of pain during movement was statistically, significantly lower in the study group than in the control group after intervention (p=0.004). VAS score of pain during rest was statistically significantly lower in the study group than in the control group after intervention (p=0.01) When the two groups were compared in terms of WOMAC scores, a statistically significant decrease was found only in the study group among "after intervention-in follow-up" values (p=0.002) (Table 3). For the study and control groups, mean baseline extensor torques were 49.84±18.21 Nm at 60°/sec and 64.32±19.29 Nm where mean baseline flexor torques were 16.21±6.55 Nm at 60°/sec and 20.76±9.98 Nm, respectively. In the study group, 60 ° / sec extension PT values after intervention and in follow-up were significantly increased compared to "before intervention" (p <0.001, p <0.001, respectively). However, in the control group, there was no significant increase after intervention and in follow-up. There was a significant difference of 60 ° / sec extension PT values before intervention between the study and control groups. That was higher in the control group. 60 ° / sec extension PT values after intervention were not different between both groups. Similarly, 60 ° / sec flexion PT values in the study group after intervention and in follow-up were significantly increased compared to before intervention (p < 0.001, p < 0.001, respectively). In the control group, there was no significant increase after intervention and in follow up. Comparing two groups, there was no difference in 60 ° / sec flexion PT values before / after intervention and in follow-up. In the study group, 180 ° / sec extension PT values after intervention and in follow up were pointedly increased compared to before intervention. Besides, there was no significant increase after intervention and in follow-up in the control group. Comparing the study and control groups, no difference was found in terms of 180 ° / sec extension PT values before / after intervention and in follow-up. Congruently, 180 ° / sec flexion PT values after intervention and in follow-up were significantly increased in the study group and there was no significant increase after intervention and in follow up in the control group. Comparing two groups, again no difference was found in terms of 180 ° / sec flexion PT values before / after intervention and in follow-up. (Table 4). 60 ° / sec extension / flexion PT ratio in the study group was significantly decreased after intervention compared to before intervention while the decreases in follow-up values were not notable. Referring the control group, there was no difference between before / after intervention and in follow-up values. In comparison of two groups, there was no difference in the subject ratio between before / after intervention and follow-up neither. 180 ° / sec extension / flexion PT ratio in both groups was not substantially different before / after intervention and in follow-up. Again, in comparison of two groups, there was no difference in the subject ratio before intervention / after intervention and follow-up (Table 4).

Discussion

There are various studies in the literature in which knee extension, flexion and strength of patients with OA are tested by isokinetic dynamometer and received treatment as isokinetic exercise [3, 13-15]. Increasing muscle power with progressive strength exercise has been shown to increase muscle isometric strength, thereby reducing pain and improving ROM and function [16]. However, except this study, there is no other study showing the effectiveness of isokinetic exercise program (strengthening flexor and extensor muscles) on pain and function in patients with mid-term TKA. We also examined the ratio of quadriceps extensor and hamstring flexor strengths. The important determinant of functional recovery after TKA is quadriceps strength. In both groups, we observed that majority of the patients had more than 3 hours of walking habits per week, while they had minimal knee exercise habits. Advanced age of patients, sarcopenia, and avoidance of knee movements due to pain and lack of exercise are associated with reduced quadriceps strength [6]. Pua et al. found a strong correlation between knee extensor strength, physical function and standing balance [15]. Schaumburger et

Table 1. Comparison of age, duration and BMI of patients

	Study Group (n=15)		Control Group (n=10)		
	Mean ± SS	Median (Min-Max)	Mean ± SS	Median (Min-Max)	p*
Age (year)	68.27±7.12	67 (59-80)	64.30±7.60	64.5 (52-75)	0.285
BMI	36.31±5.43	35.4 (28-45)	33.75±2.71	34.7 (28.3-36.4)	0.367
Duration (month)	47.60±29.43	48 (12-108)	54.20±20.36	50 (12-80)	0.311
Flexion ROM (degree)	106.33±16.08	100 (80-130)	123.50±13.34	130 (100-140)	0.005

SS; Standard Deviation, Min; Mininum, Max; Maximum, ROM; Range of motion *Mann-Whitney U Test

Table 2. Comparison of VAS values, Stair Climbing Test and WOMAC scores

	Study Group (n=15)		Control Group (n=10)	
	Mean ± SD	Median (Min-max)	Mean ± SD	Median (Min-max)
		Walking VAS		
Before intervention	62.00±19.71	70 (20-80)	57.00±20.03	60 (20-80)
After intervention	38.67±13.02	40 (20-60)	44.00±18.38	40 (20-70)
Follow up	37.33±13.87	40 (20-60)	40.00±16.33	40 (20-70)
p*	0.000		0.000	
		Resting VAS		
Before intervention	4.40±2.23	5 (0-8)	2.90±2.33	2.5 (0-7)
After intervention	3.07±1.58	3 (0-6)	2.70±2.31	2 (0-6)
Follow up	2.80±1.42	3 (0-5)	2.4±1.95	2 (0-5)
p*	0.00		0.444	
		SCT (sec)		
Before intervention	16.54±4.96ô	14.4 (11-27)	12.54±5.66	10.7 (7.3-27)
After intervention	13.26±5.41	11 (7-27)	10.65±4.91	8.2 (6.1-22)
Follow up	13.22±5.53	11 (8-27)	10.97±8.21	6.9 (6.4-33)
p*	0.008		0.008	
		WOMAC		
Before intervention	81.13±18.94	87 (43-106)	68.31±15.81	66.2 (40.9-89.1)
After intervention	64.33±17.41	69 (27-93)	57.37±13.44	60.2 (33.3-70.1)
Follow up	65.84±17.57	70 (29-95)	54.80±12.83	57 (33.3-68)
p*	0.000		0.018	

VAS; Visual Analogue Scale, CRT; SCT; Stair Climbing Test, WOMAC; The Western Ontario and McMaster Universities Osteoarthritis Index
* Friedman Test

al. investigated the relationship between BMI, treatment satisfaction and clinic outcomes in 40 patients with mid-term TKA and satisfaction decreased when the BMI was $\geq$ 25 but there was no difference between isometric parameters [5]. In our study, all patients had a BMI of $\geq$25 where we consider has momentous negative effects on physical function. Franklin et al. included 8050 patients with primary unilateral TKA in the prospective study between 2000 and 2005 [2]. It was stated that after TKA, 31% of the patients had no or minimal functional improvement at 12 months. Sixty-three % of patients reported significant improvement in physical function. BMI $\geq$40 and quadriceps weakness have been associated with bad prognosis. In our study, knee pain at rest and during walking decreased statistically after intervention and at 3-months follow-up evaluation. There was no difference in SCT values in both groups. In the study group, WOMAC scores were statistically and significantly reduced after the isokinetic exercise program and at 3-months follow-up examination. However, in the control group, scores were statistically and significantly reduced only at 3-months follow-up examination. While WOMAC scores in both groups were noticeably improved comparing to before treatment, the improvement was more significant in the study than that in the control group. In our study group, increase of 60 °/sec extension and flexion PT values after the isokinetic exercise program were more than in the control group. However, there was no statistically significant difference when comparing the two groups. In both groups, 180 °/sec extension and flexion PT values showed similar increases and there was no statistically significant increase. Isokinetic tests at angular velocity of 60 °/sec are more significant in showing muscle strength improvement. Mizner et al. initiated postsurgical rehabilitation in 40 patients (22 males and 18 females) 4 weeks after unilateral TKA operation [3]. Patients underwent pain and swelling controls in their operated knee, ROM improving stretching and patellar mobilization and lower extremity strengthening exercises were applied every other day for 6 weeks. The Kin Com device measured isometric muscle strength in this study. At last follow-up, pain symptoms were reported to be 63% better than in pre-operative period. They noticed improvements in Timed Up and Go (TUG) and SCT Tests. It was reported that there was a correlation between Quadriceps power and all functional tests. In our study, quadriceps muscle strength and functionality in both groups increased following the exercise program but muscle strength seems to be improved more in the study than in the control group.

Table 3. Comparison of the differences in VAS values, Stair Climbing Test and WOMAC scores

	Study Group (n=15)		Control Group (n=10)		
	Mean ± SD	Median (Min-Max)	Mean ± SD	Median (Min-Max)	p*
Walking VAS					
Before intervention - After intervention	-23.33±11.13	-30 (-40 – 0)	-13.00±6.75	-10 (-20 – 0)	0.010
Before intervention – Follow up	-24.67±14.07	-20 (-50 – 0)	17.00±13.37	-15 (-50 – 0)	0.080
After intervention- Follow up	-1.33±6.39	0 (-20 – 10)	-4.00±12.65	0 (-40 – 0)	0.892
Resting VAS					
Before intervention - After intervention	-1.33±0.89	-1 (-3 – 0)	-2.00±0.63	0 (-1 – 1)	0.004
Before intervention – Follow up	-1.60±1.35	-1 (-5 – 0)	-0.50±1.18	0 (-3 – 1)	0.036
After intervention- Follow up	-0.27±1.09	0 (-4 – 1)	-0.30±1.06	0 (-3 – 1)	0.935
SCT (sec)					
Before intervention - After intervention	-3.28±4.35	-2.4 (-15 – 2)	-1.89±1.80	-1.5 (-5 – 0.3)	0.605
Before intervention – Follow up	-3.32±3.71	-2 (-11 – 1)	-1.57±2.95	-2.4 (-4.7 – 6)	0.643
After intervention- Follow up	-0.04±1.92	0 (-3 – 4)	0.33±3.94	-0.7 (-3.6 – 11)	0.531
WOMAC score					
Before intervention - After intervention	-16.80±4.63	-15 (-25)- (-11)	-10.94±13.47	-12.9 (-34)-(13)	0.261
Before intervention – Follow up	-15.29±4.49	-15(-22)-(-7)	-13.5±12.27	-16.4(-34)-(6)	0.892
After intervention- Follow up	1.51±2.71	3 (-4)- (4.6)	-2.56±2.51	-1.9(-7)-(0.4)	0.002

VAS; Visual Analogue Scale, SCT; Stair Climbing Test, WOMAC; The Western Ontario and McMaster Universities Osteoarthritis Index;
* Mann-Whitney U Test

Table 4. Comparison of peak torque values for a leg with total knee artroplasty along with time and between groups

		Time (T)			
		Before intervention	After intervention	Follow up	
	Group (G)		Mean ± SD		
60°/sec extention PT(Nm)	Study	49.84±18.21	59.99±18.17	61.52±17.91	G; F(1,36)=2.719, p=0.108 T; F(2,72)= 17.872, p=0.000 GxT; F(2,72)= 3.889, p=0.025
	Control	64.32±19.29	66.16±18.97	70.43±20.99	
60°/sec flexion PT	Study	16.21±6.55	25.66±9.82	24.80±9.72	G; F(1,36)=0.068 p=0.796 T; F(2,72)= 15.132, p=0.000 GxT; F(2,72)= 3.390, p=0.039
	Control	20.76±9.98	24.03±10.66	23.98±9.15	
180°/sec extention PT	Study	34.30±9.41	40.29±12.01	39.65±9.76	G; F(1,36)=2.545 p=0.119 T; F(2,72)= 11.870, p=0.000 GxT; F(2,72)= 0.325, p=0.724
	Control	40.63±9.68	45.18±13.15	44.22±10.27	
180°/sec flexion PT	Study	16.57±4.79	19.71±6.04	19.56±5.91	G; F(1,36)=0.354 p=0.555 T; F(2,72)= 5.693, p=0.005 GxT; F(2,72)= 0.615, p=0.543
	Control	18.45±4.54	20.25±4.95	19.77±4.23	
Extention/Flexion PT 60°/sec	Study	3.28±1.15	2.54±0.79	2.74±0.97	G; F(1,36)=2.07, p=0.159 T; F(2,72)= 5.790, p=0.005 GxT; F(2,72)= 0.299, p=0.742
	Control	3.51±1.19	3.06±1.09	3.12±0.97	
Extention/Flexion PT 180°/sec	Study	2.12±0.43	2.12±0.50	2.12±0.53	G; F(1,36)=1.262 p=0.269 T; F(2,72)= 0.018, p=0.982 GxT; F(2,72)= 0.027, p=0.973
	Control	2.23±0.34	2.25±0.40	2.46±0.46	

PT; Peak torque, Nm; Newton meter, (Interaction term) statistically significant (GxT; F()= p<0.05)

We also tested the extensor/flexor PT ratio after exercise program, which was not included in other studies. This ratio is important for the coordinated functioning of the flexor hamstring muscle together with the extensor quadriceps muscle, which are agonist and antagonist muscles for functions [12]. In our study, we investigated whether the ratio required for extensor/flexor PT 1.66 was improved by isokinetic exercise program. Extension/flexion PT ratios at 60 °/sec measured at three different times in both groups showed similar changes. We think that isokinetic and home exercise improves the ratio of extensor/flexor PT, which leads to improvement in SCT and WOMAC test, indicating knee function. Bastiani et al. compared muscle performance regarding total function and strength of the knee flexor and extensor muscles in individuals with knee OA and patient with TKA [17]. This study shows that despite replacing the joint with prosthesis, some of the patients still had problems such as muscle weakness and contracture, reduced range of motion, difficulty in walking and limitation of daily life activities. Marmon et al. evaluated the isokinetic and isometric muscle strength in the post-operative 6th month of 24 patients with TKA and compared them to 18 controls without knee pain [18]. TKA patients showed weaker performance than the control group on TUG, SCT, 6-Minute Walk tests and weaker peak extensor power, which was correlated with the functional performance measures for the TKA group. Berman et al. indicate that the hamstring muscle regains strength

in the post-operative period in 6-12 months after TKA whereas the quadriceps mechanism still showed a residual deficit after two years follow-up evaluation [7]. For that reason, Bergman claimed that knee extensor / flexor ratio is impaired, which also affects the knee function and gait. The ratio of flexion/extension returned to normal values after quadriceps muscle rehabilitation. Patients with a nearly balanced quadriceps-to-hamstring ratio walked with a more symmetrical gait pattern. Aquino et al [8] measured knee extensor/flexor maximum torque by an isokinetic device and they found that muscle strength of patients with TKA was significantly lower than controls. They emphasized the importance of showing the ratio of extensor / flexor muscles with isokinetic test in patients with TKA and recovering with a rehabilitation program. In our study, although increase in extension and flexion PT values within 10-day isokinetic strengthening exercise program using the Biodex dynamometer was greater than home exercise program, there was no difference. However, the increases in muscle strength have not been persisting in 3-months follow-up evaluations in both groups. In the systematic review of randomized controlled studies of rehabilitation after elective primary unilateral TKA, effects of physiotherapy exercises on function, quality of life, walking, and ROM and muscle strength exercises were evaluated after discharge from hospital. As a result, physiotherapy exercise programs based on functional activities provide short-term benefits in the early period compared to traditional home programs [19]. Limitations of our study are limited numbers of patients, unsimilarity of TKA durations (1-9 years) and short duration (10 days) of isokinetic exercise program due to the insurance payment.

Conclusions

The results indicate that strengthen of the knee extensor and flexor muscles with isokinetic exercise reduces pain and improves functionality more than the home exercise program. In both groups, exercises led to a significant increase in muscle strength, decreased knee pain and to improved function in the short term. Therefore, it can be mentioned that home exercise program is also effective, whereas the effects were not observed in long term follow-up. The extensor / flexor PT ratio was also improved in both groups; which again contributes to improvement in knee function. In our study, patients were evaluated in the late period. It will be more appropriate for the patients to be taken into the rehabilitation program in the post-operative early period (4-8 week), in order for the prosthesis to be successful.

Ethics approval

The study protocol received institutional review board approval and all participants provided informed consent in the format required by the clinical research ethics committee of University of Health Sciences, Diskapi Yildirim Beyazit Education and Research Hospital. Consent to participate: All participants provided informed consent in the format required by the clinical research ethics committee of University of Health Sciences, Diskapi Yildirim Beyazit Education and Research Hospital.

Consent for publication

All participants provided informed consent in the format required by the clinical research ethics committee of University of Health Sciences, Diskapi Yildirim Beyazit Education and Research Hospital.

Availability of data and material

The authors confirm that the data supporting the findings of this study are available within the article.

Conflicts of interest/Competing interests

The authors declare no conflict of interest.

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Authors contributions

DD has drafted the article and revised it critically for important intellectual content. NT has made substantial contributions to conception and design. NO, YT and ZA have contributed with acquisition of data, or analysis and interpretation of data. All authors have seen and approved the final version of the manuscript, and all subsequent versions.

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