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Original Article

Effects of isokinetic muscle strengthening on balance, proprioception, and physical function in bilateral knee osteoarthritis patients with moderate fall risk

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ABSTRACT

Objectives: This study aims to assess the effects of isokinetic quadriceps and hamstring strengthening exercises on balance, proprioception, and physical function in patients with moderate-to-severe knee osteoarthritis and moderate fall risk.

Patients and methods: Between November 2011 and December 2012, a total of 39 participants (30 females, 9 males; mean age 61.7±8.6 years; range, 18 to 79 years) with Grade 2 or 3 knee osteoarthritis according to the Kellgren-Lawrence radiographic grading system and moderate risk of fall with active knee pain were included in this study. All participants received isokinetic quadriceps and hamstring strengthening exercises for six weeks. Pre-treatment quadriceps and hamstring muscle strength (peak torque and total work value) and quadriceps to hamstring muscle strength ratio at angular velocities of 60°/sec and 180°/sec, range of motion (ROM), average proprioceptive errors at 15-45° and 30-60°, the Berg Balance Scale (BBS) scores, the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) subscale scores, the Visual Analog Scale (VAS) scores, and physical function tests results were compared with the post-treatment results. The correlations of pre- and post-treatment BBS and average proprioceptive error at 15-45° and 30-60° changes to other pre- and post-treatment clinical measurements changes were calculated.

Results: Post-treatment quadriceps and hamstring muscle strength at angular velocities of 60°/sec and 180°/sec and quadriceps to hamstring muscle strength ratios at angular velocity of 60°/sec, ROM, average proprioceptive errors at 15-45° and 30-60°, BBS scores, WOMAC subscale scores, VAS scores, and physical function tests significantly improved compared to the pre-treatment results (p<0.001). Statistically significant correlations were found between the pre- and post-treatment BBS score changes and pre- and post-treatment VAS (p=0.015), WOMAC-Pain (p=0.017), WOMAC-Physical Function (p=0.005) scores and Timed Up and Go Test (p=0.036) scores.

Conclusion: Inclusion of isokinetic quadriceps and hamstring strengthening exercises into the rehabilitation programs for the patients with knee osteoarthritis may improve the quality of life and contribute to the decreased risk of fall.

Keywords: Balance; isokinetic muscle strengthening; osteoarthritis; proprioception.

Osteoarthritis (OA) is a slowly progressive degenerative joint disease characterized by the destruction of articular cartilage and remodeling of the periarticular bone. Symptomatic OA with a prevalence of 5 to 7% in the adult population is a common chronic disease leading to functional impairment.[1] The knee joint is the most commonly affected joint by symptomatic OA.[2]

Many studies have demonstrated that impaired proprioception may cause degenerative joint diseases.[3-6] In patients with symptomatic OA, the risk of fall increases due to the combined effect of impaired proprioception and quadriceps to hamstrings muscle strength ratio and balance.[3] Similarly, in a study, increase in the quadriceps muscle strength has shown to decrease the risk of fall.[7] Therefore, improvements

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in proprioception, balance and physical function have a significant role in increased quality of life due to the decreased risk of fall in OA patients. There are several studies showing that isokinetic muscle strengthening exercises improve proprioception, balance and physical function.[8-14]

In this study, we aimed to assess the effect of quadriceps and hamstring strengthening on proprioception, balance, and physical function specifically in patients with Grade 2 or 3 knee OA, according to the Kellgren-Lawrence (KL) radiographic grading system and moderate risk of fall.

PATIENTS AND METHODS

This prospective clinical study was conducted at Dışkapı Yıldırım Beyazıt Training and Research Hospital between November 2011 and December 2012. A written informed consent was obtained from each participant. The study protocol was approved by the local Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

A total of 39 participants (30 females, 9 males; mean age 61.7±8.6 years; range, 18 to 79 years) with Grade 2 or 3 knee OA according to the KL radiographic grading system and moderate risk of fall with active knee pain were included in this study. All patients attended to the musculoskeletal outpatient clinic for knee pain. Inclusion criteria were as follows: *(i)* diagnosis of primary OA according to the American College of Rheumatology (ACR) criteria,[15] *(ii)* Grade 2 or 3 bilateral OA according to the KL radiographic grading system, *(iii)* history of fall and Berg Balance Scale (BBS) score[16,17] between 20 and 40, *(iv)* Mini-Mental Test (MMT) score of ≥23,[18,19] and *(v)* active knee pain in the last month (Visual Analog Scale [VAS] score >3).[20] Exclusion criteria were as follows: *(i)* diagnosis of secondary OA, *(ii)* severe knee trauma, knee surgery, intraarticular knee joint injections of hyaluronic acid and/or steroids in the last six months, *(iii)* presence of active synovitis, *(iv)* any concurrent neurological (i.e., Parkinson's disease, Alzheimer's dementia, or polyneuropathy), endocrine (i.e., diabetes mellitus) and/or vestibular disorders which may affect physical function, pain or joint proprioception, *(v)* an advanced chronic disease which may affect general health status (i.e., heart failure, chronic obstructive lung disease, and cancer), *(vi)* any hearing or visual impairment, *(vii)* any chronic inflammatory disorder of the knee joint (i.e., rheumatoid arthritis, ankylosing spondylitis, psoriatic arthritis, and chronic reactive arthritis).

Sociodemographic data of each participant were recorded. Subsequently, all patients underwent comprehensive physical examination and range of motion (ROM) measurement by a rehabilitation specialist using a standard goniometer. The MMT was performed by a psychologist. The VAS and Western Ontario and McMaster Universities Osteoarthritis Index-Pain (WOMAC-P)[21,22] were used to assess pain; the WOMAC-Physical Function (WOMAC-PF), Timed Up and Go Test (TUG), Five Times Sit to Stand Test (5XSST), and Six-Minute Walk Test (6MWT) were used to assess physical function; the WOMAC-Stiffness (WOMAC-S) was used for joint stiffness and BBS was used to assess balance. The muscle strength at angular velocities of 60°/sec and 180°/sec and average proprioceptive errors at 15-45° and 30-60° were assessed using the Biodex System 3 Pro Multi-Joint System (Biodex Medical Systems; Shirley, NY, USA) isokinetic dynamometer. All assessments were repeated following the completion of the exercise program. The body mass index (BMI) was calculated as kg/m^2.

The MMT is an easily applicable 30-point questionnaire used to measure cognitive impairment. Scores that are equal or greater than 23 shows normal cognition.[17,18] The VAS score ranges from 0 to 10 with 0 indicating no pain and 10 indicating the most severe pain ever experienced.[20]

The WOMAC is used to assess pain, stiffness, and physical function.[21,23] All participants were asked to rate the pain at five activities, stiffness at two situations and physical function at 17 activities.

The BBS is used to assess a person's balance abilities while performing functional tasks.[16,17] It comprises 14 items and a score was given from 0 (unable) to 4 (independent) for each item. Based on the total score obtained from this test, the results were interpreted as follows: "high risk of fall" (0-20 points); "moderate risk of fall" (21-40 points); "low risk of fall" (41-56 points).[23,24] The Turkish validity and reliability of all the tests were checked.

The TUG was used to assess functionality. The participants were asked to stand up from a standard chair when they hear the start command, walk three meter at a steady pace, turn around, walk back and sit down. The required time to perform this task was recorded in sec using a stopwatch.[25]

Using the 5XSST, the participants were asked to sit with their back against the back of the chair and arms folded across their chest, stand up from the chair and sit down five times as quickly as they could.

A stopwatch was started at the start command and stopped at the moment that they sit the chair for the last time.[26]

The 6MWT is an objective index of exercise tolerance.[27,28] It is easy to perform without requiring any special equipment. A 30-meter long hallway was marked with three-meter intervals and a stopwatch was used during the test. The participants were instructed to wear comfortable clothing and appropriate shoes. A light meal was allowed and all were advised not to exercise vigorously within two hours of the beginning of the test. Blood pressure and pulse measurements were performed before and after the test. The participants were asked to walk across the 30-meter long hallway for six minutes and were allowed to use their usual walking aids such as cane. Following the completion of the test, the distance walked was recorded in meters. The walking speed was calculated in meters per sec.

Isokinetic assessment

The isokinetic muscle strength was assessed using the isokinetic dynamometer. Accessories appropriate for the extension and flexion of the knee joint were mounted on the device, and the device was checked for calibration errors. The participants were provided information with respect to how the test would be conducted and its purposes.

The participants were instructed to sit with backrest at a 90° angle on the chair and gripped the sides of the chair simultaneously. The body and thigh were stabilized by stabilization straps and foot were positioned in the lever arm and stabilized at the malleolar level. During the test, angular velocities of 60°/sec and 180°/sec were preferred as being commonly used angular velocities. The test was started at maximum flexion and followed by several submaximal repetitions to warm up. The knee was flexed to 90° and remained in this position for 10 sec. The participants completed three maximal repetitions at an angular velocity of 60°/sec and 3 maximal repetitions at an angular velocity of 180°/sec. Angular velocities were changed after 20-sec rest intervals. The data obtained from the measurements at two angular velocities and included in the analyses were as follows: quadriceps peak torque (PT) value (newton-meter), hamstring PT value (newton-meter), quadriceps to hamstring ratio, and hamstring-quadriceps total work (TW) values (joules).

Proprioception was assessed using the isokinetic dynamometer. Measurements were performed at constant ambient temperature and in a quiet medium. Isokinetic dynamometer set-up was mentioned above. A trial was conducted with eyes open. Initially, the leg was positioned at the reference angle of 15° for 10 sec. Then, the participants were blindfolded. The knee was passively flexed 45° and the participants were asked to memorize this position. The knee remained in this position for 10 sec, and the leg was passively repositioned at the reference angle of 15° and remained in this position to rest for 10 sec. Then, the subjects were asked to place their leg at the memorized angle by themselves. Once the subjects placed their legs at the angle that they memorized, the angle reached was recorded. The same procedure was repeated for reference angle of 30° and target angle of 60°. The measurements were repeated three times with five-min intervals and the average of three values were calculated. The difference between the calculated values and actual target values was found and the average proprioceptive error was calculated without taking into consideration that whether this value was positive or negative.

Interventions

The participants were instructed not to use non-steroidal anti-inflammatory drugs during the study. After the calculation of isokinetic muscle strength, quadriceps to hamstring ratio and average proprioceptive error, the patients were given isokinetic muscle strengthening exercises three times a week for six weeks. The participants performed 10 concentric-concentric flexion and extension contractions at 45°/sec, 60°/sec, 75°/sec, 90°/sec, 120°/sec, 150°/sec and 180°/sec angular velocity. Twenty-sec rests were allowed between each angular velocity. Five-min rest was allowed between the right and left knees.

Statistical analysis

Statistical analysis was performed using IBM SPSS version 23.0 software (IBM Corp., Armonk, NY, USA). The Shapiro-Wilk test was used to analyze whether the continuous variables were normally distributed. Normally distributed data were compared using the dependent t-test. Non-normally disturbed were compared using the Wilcoxon signed-rank test. Descriptive statistics for continuous variables were expressed in mean ± standard deviation (SD) and median (min-max) values, while the categorical variables were expressed in number and percent. The dependent t-test was used to compare mean pre-treatment and post-treatment measurements. The Wilcoxon signed-rank test was used to compare median pre-treatment and post-treatment measurements. The Spearman's correlation test was used to correlate continuous variables. The post-hoc power analysis was performed to identify the power of the study using G*Power version 3.1.9.2. A p value of <0.05 was considered statistically significant.

Table 1. Demographic and clinical characteristics of patients

	n	%	Mean±SD	Median	IQR
Age (year)			61.7±8.6		
Sex					
Male	9	23.1			
Female	30	76.9			
Weight (kg)			79.3±8.6		
Height (m)			1.59±0.09		
Body Mass Index (kg/m²)			31.7±5.4		
Duration of the disease (month)				36	1-120
Mini-Mental Test				27	20-30

SD: Standard deviation; IQR: Interquartile range.

Table 2. Pre- and post-treatment K-L grades, ROM, and walking speed measurements, BBS, TUG, 6MWT, 5XSST, VAS, WOMAC A, S and PF scores

	Pre-treatment			Post-treatment				Change		
	Mean±SD	Median	IQR	Mean±SD	Median	IQR	*p*	Mean±SD	Median	IQR
K-L		2	2 - 3		2	2 - 3	1.000		0	0 - 0
ROM (°)	109.0±11.3			117.5±10.2			<0.001*	8.5±6.1		
BBS		35	25 - 39		38	30 - 43	<0.001*		2	1 - 8
Walking speed (m/sec)		0.93	0.28 - 1.8		1.1	0.5 - 2.3	<0.001*		0.2	0.04 - 0.9
TUG (sec)			8.9	6.4-46	7.2	5.4 - 13.4	<0.001*		-1.4	-34.8 - -0.1
6MWT (sec)			336	102-622	408	196 - 812	<0.001*		68	12 - 308
VAS (cm)			70	30-100	20	0 - 80	<0.001*		-40	-70 - -10
WOMAC-P			3	1.8-4.4	1.8	0.8 - 3	<0.001*		-1.2	-2.4 - -0.4
WOMAC-S			3	1.5-4	1	1 - 2	<0.001*		-1	-2 - 0
WOMAC-PF			3	1.75-4.1	2	1 - 2.6	<0.001*		-1.1	-2.5 - -0.2

SD: Standard deviation; IQR: Interquartile range; K-L: Kellgen-Lawrence; ROM: Range of motion; BBS: Berg balance scale; TUG: Timed up and go test; 6MWT: Six-minute walk test; 5XSST: Five times sit to stand test; VAS: Visual Analog Scale; WOMAC-P: Western Ontario and McMaster Universities Osteoarthritis Index-Pain; WOMAC-S: Western Ontario and McMaster Universities Osteoarthritis Index-Stiffness; WOMAC-PF: Western Ontario and McMaster Universities Osteoarthritis Index-Physical Function; * p<0.05, significant difference between the pre- and post-treatment results; Mean±SD: The p value corresponds to dependent t-test comparing the pre- and post-treatment measurements; Median (IQR): The p value corresponds to the Wilcoxon signed-rank test comparing the pre- and post-treatment measurements.

Table 3. Pre- and post-treatment PT and TW measurements in flexion and extension at angular velocities of 60°/sec and 180°/sec

	Pre-treatment		Post-treatment			Change	
	Median	IQR	Median	IQR	*p**	Median	IQR
PT-E (180°/sec)**	34.8	20.7 - 71.7	50.8	23.1 - 110.6	<0.001	12.7	-3.8 - 43.7
PT-F (180°/sec)**	15.7	8.7 - 43.8	24.5	14 - 72	<0.001	7.1	-9.8 - 44.1
TW-E (180°/sec)**	242	110.8 - 1146.7	367.8	98.9 - 1041.6	<0.001	76.6	-105.1 - 462.3
TW-F (180°/sec)**	26.4	1.9 - 398.8	97.5	8.1 - 617.2	<0.001	56.5	-97.9 - 411.9
PT-E (60°/sec)**	61.2	20.2 - 124.1	72.1	43.2 - 156.8	<0.001	14.1	-22.6 - 63.8
PT-F (60°/sec)**	20.1	7.2 - 59.7	32.1	12.0 - 91.1	<0.001	12.8	-15.6 - 63.7
TW-E (60°/sec)**	242.9	95.8 - 504.4	300.9	173.6 - 552.1	<0.001	65.1	-251 - 250.6
TW-F (60°/sec)**	68.8	0.3 - 326.3	127.9	19.1 - 505.1	<0.001	72.1	-64.3 - 240.4

PT: Peak torque; TW: Total work; IQR: Interquartile range; PT-E: Peak torque-extension; PT-F: Peak torque-flexion; TW-E: Total work-extension; TW-F: Total work-flexion; * p<0.05: Significant difference between the pre- and post-treatment results; ** Data are presented in median (IQR). The p value corresponds to the Wilcoxon signed-rank test comparing the pre- and post-treatment measurements.

RESULTS

Our sample of 39 participants provided a power of 86.1% at a significance level of 5% and an effect size of 0.5. We used pre- and post-treatment agonist-to-antagonist ratio at an angular velocity of 60°/sec to calculate the effect size. The mean BMI was 31.7±5.4 kg/m^2 and the mean MMT score was 27 (range, 23 to 30). Clinical and demographic characteristics of the patients are shown in Table 1.

Table 4. Pre- and post-treatment agonist-to-antagonist ratio at angular velocities of 60 and 180°/sec and average proprioceptive error at 15-45° and 30-60°

	Pre-treatment			Post-treatment				Change		
	Mean±SD	Median	IQR	Mean±SD	Median	IQR	*p*	Mean±SD	Median	IQR
Agonist/antagonist (180°/sec)†	51.3±13.2			54.8±15.3			0.259	3.5±19.1		
Agonist/antagonist (60°/sec)†	37.6±12.6			47.7±14.5			<0.001*	10.1±12.0		
Average proprioceptive error (15-45°)‡		7.2	3 - 17.1		5.1	2.2 - 9.2	<0.001*		-1.9	-12.6 - 1.3
Average proprioceptive error (30-60°)‡		4.3	1.8 - 13.6		3.3	1.7 - 6.5	<0.001*		-1.1	-11.1 - 1.3

SD: Standard deviation; IQR: Interquartile range; * p<0.05, significant difference between the pre- and post-treatment results; † Data are presented in mean (SD). The *p* value corresponds to dependent t-test comparing the pre- and post-treatment measurements; ‡ Data are presented in median (IQR). The p value corresponds to Wilcoxon signed-rank test comparing the pre- and post-treatment measurements.

Table 5. Correlations of changes in BBS and average proprioceptive error at 15-45° and 30-60° to changes in other clinical measurements after treatment and MMT

	Average proprioceptive error at 15-45°		Average proprioceptive error at 30-60°		Berg Balance Scale	
	r	*p*	r	*p*	r	*p*
Agonist/antagonist (180°/sec)†	-0.008	0.963	0.281	0.083	-0.016	0.923
Agonist/antagonist (60°/sec)†	0.060	0.715	0.018	0.912	-0.103	0.533
PT-E (180°/sec)†	0.008	0.962	0.063	0.705	0.134	0.417
PT-F (180°/sec)†	0.083	0.615	0.092	0.579	0.065	0.695
TW-E (180°/sec)†	0.112	0.495	0.186	0.257	0.295	0.068
TW-F (180°/sec)†	0.006	0.969	0.142	0.388	0.167	0.308
PT-E (60°/sec)†	0.225	0.169	0.211	0.198	0.127	0.440
PT-F (60°/sec)†	0.232	0.155	0.124	0.452	-0.052	0.753
TW-E (60°/sec)†	0.159	0.333	0.051	0.756	0.263	0.106
TW-F (60°/sec)†	0.161	0.327	0.220	0.179	0.064	0.697
WOMAC-P†	0.274	0.092	0.278	0.087	-0.379	0.017*
WOMAC-S†	0.122	0.461	0.010	0.952	-0.246	0.131
WOMAC-PF†	0.160	0.330	0.046	0.779	-0.442	0.005*
Walking speed (m/sec)†	0.067	0.684	-0.033	0.841	-0.089	0.590
TUG (sec)†	0.200	0.223	0.041	0.803	-0.336	0.036*
6MWT (sec)†	0.022	0.896	-0.096	0.561	-0.135	0.413
5XSST (sec)†	0.226	0.166	0.003	0.987	-0.061	0.714
ROM (°)†	-0.165	0.314	-0.221	0.175	0.262	0.107
VAS (cm)†	0.295	0.068	0.089	0.592	-0.386	0.015*
MMT†	0.505	<0.001*	0.294	0.069	-0.066	0.691

BBS: Berg Balance Scale; MMT: Mini-Mental Test; PT-E: Peak torque-extension; PT-F: Peak torque-flexion; TW-E: Total work-extension; TW-F: Total work-flexion; WOMAC-P: Western Ontario and McMaster Universities Osteoarthritis Index-Pain; WOMAC-S: Western Ontario and McMaster Universities Osteoarthritis Index-Stiffness; WOMAC-PF: Western Ontario and McMaster Universities Osteoarthritis Index-Physical Function; TUG: Timed up and go test; 6MWT: Six minute walk test; 5XSST: Five times sit to stand test; ROM: Range of motion; VAS: Visual analog scale; * p<0.05, significant difference between the pre- and post-treatment results; † Spearman's correlation test was used to analyze correlations.

Post-treatment ROM measurements and 6MWT results were improved significantly compared to pre-treatment values ($p<0.001$). Post-treatment TUG, 5XSST results and BBS, VAS, WOMAC-Pain (WOMAC-P), WOMAC-Stiffness (WOMAC-S), WOMAC-Physical Function (WOMAC-PF) scores significantly decreased, compared to pre-treatment values ($p<0.001$) (Table 2).

Post-treatment PT and TW values during flexion and extension at angular velocities of 60°/sec and 180°/sec significantly increased, compared to the pre-treatment values ($p<0.001$) (Table 3).

The post-treatment agonist-to-antagonist ratio at an angular velocity of 60°/sec significantly increased, compared to the pre-treatment values ($p<0.001$), whereas the increase in the post-treatment agonist-to-antagonist ratio at an angular velocity of 180°/sec was not statistically significant ($p=0.259$). The post-treatment average proprioceptive errors at 15-45° and 30-60° significantly decreased, compared to the pre-treatment values ($p<0.001$) (Table 4).

There were statistically significant, but poor negative correlations between the change in BBS, and both changes in the WOMAC-P ($r=-0.379$) and TUG ($r=-0.336$) after treatment. There was a statistically significant and moderate negative correlation between change in BBS and change in WOMAC-PF ($r=-0.442$) after treatment. There was statistically significant and moderate positive correlation between change in the average proprioceptive error at 15-45° after treatment and MMT scores ($r=0.505$) (Table 5).

DISCUSSION

The primary objective of this study was to investigate the relationship between knee joint proprioception, hamstrings and quadriceps muscle strengths, physical function and balance in OA patients with moderate risk of fall. The study results demonstrated that quadriceps and hamstring strengthening in a six-week program of regular isokinetic exercise had significant effects on balance, proprioception and physical function even in patients who has KL Grade 2 or 3 OA with moderate risk of fall (BBS score of 21-40). Thus, we suggest that there is a relationship between balance, proprioception, and quadriceps and hamstring muscle strengths in OA patients.

In this study, significant changes were observed both in the ROM and in WOMAC subscale scores. Steultjens et al.[11] demonstrated that knee ROM in OA patients was a significant risk factor for disability. A total of 25% of the post-treatment change in functionality and disability scores such as WOMAC were linked to the ROM changes.[11] Therefore, changes in some of the WOMAC subscale scores may be attributed to the improvement in ROM.

Loss or impairment of proprioception was reported to be associated with a decreased gait speed, a decreased total duration of walking, and impaired gait rhythm in OA patients.[29-31] In addition, Sharma et al.[32] analyzed the association between proprioceptive precision and physical function in patients with OA and found a significant association between proprioception and the 5XSST results. In a study conducted by Bouët et al.,[12] cycling exercises were found to be associated with an improved proprioception. Van der Esch et al.[14] conducted a study in 33 OA patients aged between 45 and 79 years and reported a significant correlation between functional deterioration and both impaired knee proprioception and decreased quadriceps and hamstrings muscle strength. In our study, isokinetic exercises were associated with significant improvements in both average proprioceptive errors and function tests. Based on these findings, overall muscle strengthening exercises may increase physical function by improving proprioception in patients with OA.

Whipple et al.[13] compared patients with a history of fall to the patients without a history of fall regarding the strength of knee flexors, knee extensors, ankle dorsiflexors and plantar flexors. The strength of all of the examined muscles was found to be significantly lower in patients with a history of fall, compared to the patients without a history of fall. In our study, significant improvements in quadriceps and hamstring muscle strength due to isokinetic exercises led to the improvements in BBS. Furthermore, a statistically significant correlation was found between the improvement in BBS scores and pain/functionality. Improvement in balance may improve the quality of life, by reducing pain and increasing functionality.

In a study including 95 elderly patients, Lord et al.[33] reported that impaired proprioception and impaired vibration sense substantially affected postural stability. Colledge et al.[34] also reported that impaired proprioception substantially affected postural stability. Our study showed that isokinetic exercises improved proprioception and balance at the same time. This finding further supports the fact that isokinetic exercises improve both balance and proprioception.

In their study, Berg et al.[24] reported that a BBS score equal or less than 40 was an important risk factor in terms of prediction of fall risk. Our study demonstrated that, in patients with BBS scores between 20-40 (moderate fall risk), isokinetic strengthening exercises contributed to the improved balance and reduced number of falls. The inclusion of the patients in this study with BBS scores between 20-40 better emphasized the effects of muscle strengthening exercises on balance and falls.

In a study including 104 patients with knee OA who were candidates for knee arthroplasty, Pua et al.[35] found a significant association between balance and physical function which was dependent on the knee extensor strength. Similarly, in our study, we found that muscle strengthening exercises improved balance, walking speed, and physical function.

In a study conducted by Kim et al.,[36] impaired balance and postural instability were reported in patients with knee OA. In our study, significant balance improvements were observed in OA patients with impaired balance following isokinetic strengthening of quadriceps and hamstring muscles. These results emphasized the importance of quadriceps and hamstrings strengthening in patients with OA.

Samut et al.[8] found a significant decrease in the VAS and WOMAC subscores and a significant increase in the functionality and muscle strength in both isokinetic end aerobic exercise group. This study and our study support that regular muscle strengthening exercises improve functionality and reduce pain.

In their study, Tuna et al.[9] investigated whether femoral cartilage thickness changed with muscle strengthening exercises. The authors found a positive correlation between the femoral cartilage thickness and muscle strength at three months. They also found a significant decrease in the VAS scores; however, they failed to show a significant change in the WOMAC subscores with isokinetic exercises.[9] One of the limitations of this study was that the patients performed only a single day of isokinetic exercise program with 30°/sec, 60°/sec, 90°/sec and 180°/sec angular velocities. Then, the patients moved on a home-based exercise program. This may be insufficient to improve the WOMAC subscores. In our study, the patients performed isokinetic exercise program with 45°/sec, 60°/sec, 75°/sec, 90°/sec, 120°/sec, 150°/sec and 180°/sec angular velocities three times a week for six weeks. A more intensive exercise program may be more helpful in terms of WOMAC subscores. Overall isokinetic exercise programs may be useful in different ways such as femoral cartilage thickness in OA patients.

A study conducted by Kucuk et al.,[10] 45 OA patients were divided into three exercise groups (isokinetic, isometric, and aerobic) and exercises were given five days a week for four weeks. They found improvements in the VAS, WOMAC, Lequesne scores, and quadriceps PT values in all groups with the highest improvement in isokinetic exercise group. They found a significant improvement in the hamstring muscle strength only in the isokinetic group. The Hamstring-to-quadriceps ratio remained unchanged in the isokinetic group, whereas this ratio decreased in other groups.[10] In our study, we found significant improvements in the VAS, WOMAC subscores, hamstring, quadriceps PT values and, even in hamstring-to-quadriceps ratio after isokinetic exercises. It is possible that a more intensive exercise program can be effective in more parameters.

Ay et al.[37] conducted a study with three groups in which 60 knee OA patients received home-based strengthening exercise program. They found statistically significant improvements in the VAS, WOMAC subscores, and functional tests after a three-month exercise program.[37] Similarly, we found significant improvements in the VAS, WOMAC subscores, and functional tests after isokinetic strengthening program. This finding highlights the importance of strengthening exercises in reducing pain and stiffness and improving functionality.

In a study conducted by Bugdayci et al.,[38] 147 knee OA patients were divided into two groups as faller and non-faller. They found that WOMAC subscores were significantly worse in patients with a fall history than patients without a fall history. In our study, the patients were given a isokinetic strengthening exercise program. We found significantly improvements in the WOMAC-P, WOMAC-S and WOMAC-PF, and balance of OA patients. This finding shows the effect of balance over pain, stiffness, and physical function. The muscle strengthening exercise can improve balance by reducing pain and stiffness and increasing physical function.

In our study, a potential effect of cognitive functions on the test results was also taken into consideration. The MMT was administered to each participant by our clinical psychologist and a significant correlation was found between the MMT scores and changes in the average proprioceptive errors at 15-45°. These results suggested that cognitive functions might have affected the test results.

On the other hand, this study has some limitations. Since patients with KL Grade 1 and 4 OA patients were excluded, our results cannot be generalized to all OA patients. In addition, joint position test used in our study did not cover all aspects of proprioception. Also, further large-scale studies including a control group receiving no exercise intervention may strengthen the results.

In conclusion, balanced strengthening of knee flexors and extensors in patients with knee OA may result in improvements with respect to pain, stiffness, ROM, balance, proprioception and functionality, and in a decrease in the risk of fall. Balanced strengthening of knee flexors and extensors exercises can be eligible therapeutic options for knee OA patients. However, long-term studies with a larger sample size are required to confirm these findings.

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