Comparison of the Therapeutic Effects Between Isokinetic and Isotonic Strength Training in Patients After Total Knee Replacement

A Prospective, Randomized Controlled Trial

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Background: Rebuilding the strength of the quadriceps as soon as possible after total knee replacement (TKR) is important so as to restore gait stability. To date, there are no standard postoperative strength training programs during the early recovery stage after TKR.

Purpose: To compare the therapeutic effects between isokinetic and isotonic strengthening in patients after TKR.

Study Design: Randomized controlled trial; Level of evidence, 1.

Methods: From April 2018 to August 2020, 37 patients met the inclusion criteria and were randomly assigned to perform either 4-week isokinetic or isotonic strength training programs. Other components of the rehabilitation program were kept the same between the 2 groups. All cases were evaluated by the Timed Up and Go (TUG) test, peak torque of knee extension and flexion (60 and 120 deg/s), 36-item Short Form Health Survey (SF-36), and Western Ontario and McMaster Universities Arthritis Index (WOMAC).

Results: After undergoing a 4-week strength training regimen, significant improvements in the TUG test were noted in both groups; however, the time improvement in the isotonic group did not reach the minimal detectable change. All peak torque measurements improved in the isokinetic group but not in the isotonic group for knee flexion at 60 deg/s. The pain subdomain, physical domain, mental domain, total SF-36 score, and WOMAC index all improved significantly in both groups after training. Both training groups improved significantly in peak torque of knee strength, TUG test, and functional scores, but the differences between isokinetic and isotonic training were not statistically significant.

Conclusion: The study findings showed that a 4-week strengthening exercise program in the early postoperative stage, involving either isokinetic or isotonic training, resulted in significant improvements in patients undergoing TKR.

Registration: NCT02938416 (ClinicalTrials.gov identifier).

Keywords: isokinetic; isotonic; total knee replacement; osteoarthritis; Timed Up and Go test; WOMAC

Total knee replacement (TKR) is generally considered to be the last resort but an effective treatment option for patients with advanced knee osteoarthritis (OA).[27] Proper postoperative rehabilitation programs remain important toward assisting in functional recovery for patients receiving TKR.[1] Among the various components that make up rehabilitation programs, strengthening exercises targeting muscles surrounding the replaced knee joint, particularly the quadriceps femoris, are of paramount importance.[28] Quadriceps weakness is usually present in patients experiencing progression of knee OA, with further exacerbation after TKR.[30] Rebuilding strength in the quadriceps after TKR is closely related to postoperative functional recovery and gait stability.[23]

Among the several training modes surrounding muscle strengthening, isokinetic strengthening has been one that

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is considered to be effective. Past literature has proven its efficacy in patients undergoing anterior cruciate ligament repair,[21] with burn injury,[10,11] ankle instability,[29] OA knee,[9,14] and even stroke.[6,19] During isokinetic strengthening exercise, the angular velocity of the joint movement is kept consistent throughout the range of motion, while the trainee attempts to push the lever arm of the isokinetic dynamometer as hard as possible. In contrast, isotonic training involves straining the muscles while moving the joints and applying a constant amount of resistance. Compared with traditional isotonic strengthening, the benefits of isokinetic strengthening exercise include the precise reproducibility of exercise training, the real-time visual biofeedback, and the conveniences in monitoring participant performance.[17] Although conventional strengthening programs for lower limbs have been proven to be beneficial in several studies for patients receiving TKR,[7,25] there is currently only 1 report regarding isokinetic strengthening programs for this specific group of patients.[5]

This prospective, randomized controlled study was designed to determine whether isokinetic or isotonic training is better for patients undergoing TKR in the early recovery stage. We hypothesized that isokinetic training would confer greater benefits than isotonic training regarding the recovery of peak torque of knee motion as well as functional restoration in patients after TKR surgery.

METHODS

Participant Recruitment

This was a prospective, single-blinded, randomized controlled trial; the study protocol received approval from an institutional ethics committee from a medical center in Taichung. The participants undergoing TKR in our study had undergone TKR for knee OA between April 2018 and August 2020 at a single tertiary medical center. All participants signed an informed consent document before entering the study.

The study inclusion criteria were patients with a degenerative OA knee who had undergone unilateral TKR 1 month earlier and were also able to complete the Timed Up and Go (TUG) test. Patients with any of the following

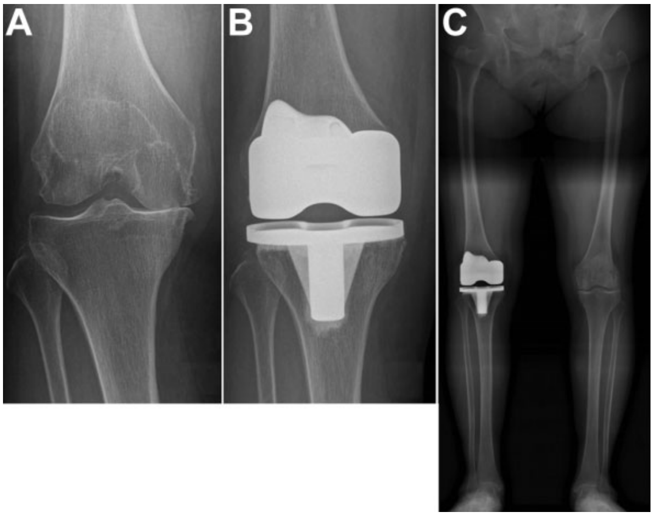

Figure 1. (A) Preoperative radiograph showing advanced osteoarthritis in a right knee. (B) Knee and (C) standing long-leg radiographs after total knee replacement.

conditions were excluded: (1) obesity (body mass index >35 kg/m^2), (2) previous fracture of lower limbs or other conditions that would affect gait pattern, (3) any causes of chronic lower limb pain other than OA knee, (4) diabetic polyneuropathy, (5) cardiovascular diseases that prohibit the patient from exercise training, (6) poor cognitive function or cooperation, and (7) fever or any signs of systemic and local infection during the study period.

A total of 76 consecutive patients underwent TKR performed by a single surgeon using the medial parapatellar arthrotomy through midline skin incision. The U2 Knee (United Orthopedic), a posterior stabilized prosthesis, was used in all participants (Figure 1). All TKRs including femoral, tibial, and patellar components after bone cut and patellar resurfacing in this study were fixed with cement. The alignment of these TKRs was performed using the mechanical alignment technique.

The flowchart of patient enrollment is shown in Figure 2. From the 76 patients, 39 were excluded, and the remaining 37 patients were randomly assigned to either the isokinetic

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Ethical approval for this study was obtained from Taichung Veterans General Hospital (reference No. CF12251B-8).

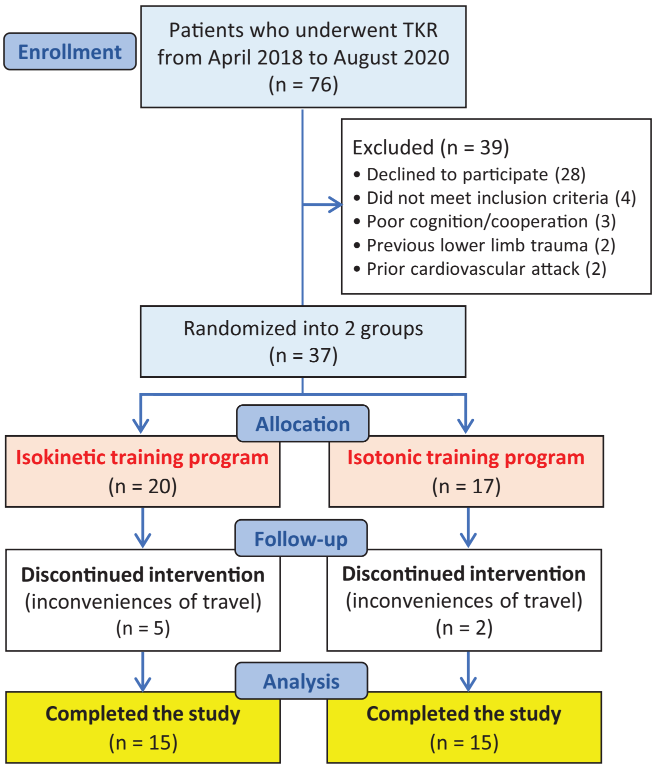

Figure 2. The flowchart of this study. TKR, total knee replacement.

Figure 3. Exercise training (isokinetic or isotonic modes) using an isokinetic dynamometer.

or isotonic training group by the orthopaedic surgeon who performed TKR using a random-numbers table. The tester was blinded to their allocations. A well-trained therapist continued the training programs within the assigned groups. Among the 20 patients receiving isokinetic training, 5 dropped out because of inconveniences caused by travel, and 2 of the 17 patients in the isotonic group dropped out for the same reason. Ultimately, 30 patients (15 patients in each group) completed the training programs.

To determine the sample size of our study, we referred to a study by Huang et al,[18] who used improvement on the TUG test to measure outcomes after isokinetic training on patients with knee OA. In their study, the improvement of the isokinetic group was 10.2 ± 9.7 m/s, and that of the control group was 2.2 ± 7.7 m/s, with an effect size of 0.936. With the setting of $\alpha = 0.05$ and power $(1 - \beta) = 0.8$, it was determined that there should be at least 30 participants to achieve sufficient statistical power for our study after calculating the changes in TUG test results (ambulation speed) between groups. Analysis was conducted using G*Power 3.1.9.7 (Heinrich-Heine-Universität).[13]

Radiographic Evaluation

The preoperative lower limb alignment, hip-knee-ankle (HKA) angle, was defined as the angle between the mechanical axes of the femur and the tibia. The HKA angle in both groups was measured using a full-length, lower limb radiograph.

Training Protocols

The participants were randomized into either the isokinetic or isotonic training group. The isokinetic or isotonic mode of exercise training was then performed according to their assigned groups using an isokinetic dynamometer (Biodex Multi-Joint System 3; Biodex Medical) (Figure 3). The training program was followed 3 times per week, for a total of 4 weeks. In addition to the strengthening exercises, other rehabilitation programs, such as trunk balance training, lower limb coordination training, and ambulation training, were also implemented within the 2 groups during the 4-week training period. The training programs or tests could be stopped at any time if the patients felt discomfort.

For the isokinetic group, each participant performed 3 sets of 5 repetitions each of knee concentric flexion/extension exercises, along with 5 repetitions of knee eccentric flexion/extension exercise training at 60 deg/s using the isokinetic dynamometer. During the isokinetic training, participants were permitted to follow the monitor of the isokinetic dynamometer to check their real-time performance during torque exertion as a visual biofeedback. During this time, the assistant would encourage the patient to push the lever arm as hard as possible. This training program was followed 3 times per week, for a total of 4 weeks.

For the isotonic training group, the dynamometer was adjusted to the isotonic mode, with resistance set at 50% of the peak torque while the knee was in 90° of flexion. Each participant performed 10 repetitions of knee flexion/extension per set, over a total of 3 sets. The training program was also performed 3 times per week, for a total of 4 weeks.

Outcome Measurements

The primary outcome was the time needed to complete the TUG test, and the secondary outcomes were peak torque at knee extension and flexion, the 36-item Short Form Health Survey (SF-36), and the Western Ontario and McMaster Universities Arthritis Index (WOMAC). Participants underwent all assessments both before the strength training program and 4 weeks after; all testing was conducted by the same assistant, who was blinded to the study group allocation. All outcome results were analyzed by a single physician (Y.Y.C.), who was also blinded to the patient's allocation.

The TUG test is an objective assessment of lower limb and locomotion function.[26] It measures the total time needed for a patient to stand up from a chair, walk 3 m, turn around, return to the chair, and sit down. The patient can use any walking aid he or she may need, but no physical assistance from others is allowed during the test. Results from the TUG test have been shown to be associated with future falls in older people,[20] and excellent test-retest reliability has been shown in patients with TKR.[33]

For the secondary outcomes, peak torque during knee extension and flexion was examined at angular velocities of 60 and 120 deg/s using an isokinetic dynamometer. Participants were allowed to warm up and familiarize themselves with the testing machine by performing 5 repetitions of both knee flexion and extension for 2 sets. After 5 minutes of rest, the participants performed the formal test, consisting of 5 consecutive sets of maximal knee flexion and extension at both 60 and 120 deg/s, with a 5-minute rest interval. Peak torque was defined as the maximal value reached from any test during the 5 exertion episodes.

The SF-36 is a commonly used questionnaire to evaluate both physical and mental health status as well as quality of life.[32] It consists of 36 questions categorized into 8 subdomains: physical functioning, role limitations due to physical health, pain, general health condition, vitality, social functioning, role limitations due to emotional problems, and emotional well-being. The scores of the first 4 subdomains were averaged and labeled as the physical domain score, while those of the latter 4 subdomains were averaged to become the mental domain score. The total SF-36 score was the average of the physical and mental domain scores. Higher scores indicated better outcomes.

The WOMAC was used to evaluate the participants' physical function, pain, and stiffness status.[3] The index consists of 24 questions, graded from 0 to 4, with patients experiencing more severe knee symptoms getting a higher WOMAC index score.

Statistical Analysis

We used Predictive Analytics SoftWare (PASW Version 18.0) for statistical analysis in our study. The Kolmogorov-Smirnov test was performed at the beginning of the study to examine the degree of normal distribution. Because the outcome measurements were not normally distributed in our study, nonparametric tests were used to analyze our data. The chi-square and Mann-Whitney *U* tests were utilized to determine the differences in basic characteristics between the isokinetic and isotonic groups. The Wilcoxon signed-rank test was then used to examine the degree of improvement after 4 weeks of either isokinetic or isotonic strength training. Finally, the Mann-Whitney *U* test was performed to determine if there was a significant difference in the degree of improvement between the 2 groups. $P < .05$ was considered statistically significant.

RESULTS

The average age of the 30 study participants was 67.6 ± 9.2 years (range, 46-84 years). There were 8 men and 22 women, with 14 patients receiving TKR on the right side and 16 on the left side. There were no significant differences in the basic characteristics of the isokinetic and isotonic groups (Table 1).

Table 2 displays the outcome measures of both groups before strength training. There were no significant differences between the 2 groups regarding most of the outcome measures. Only 2 parameters revealed significant group differences: the general health subdomain of the SF-36 ($P = .043$) and the physical function domain of the WOMAC ($P = .045$).

After 4 weeks of isokinetic training, significant improvements were noted in all peak torque values compared with pretraining: 17.9 ± 11.4 to 31.5 ± 15.7 N·m for flexion at 60 deg/s, 19.5 ± 14.4 to 34.1 ± 15.8 N·m for extension at 60 deg/s, 16.6 ± 9.4 to 25.8 ± 13.1 N·m for flexion at 120 deg/s, and 12.9 ± 9.0 to 21.8 ± 11.0 N·m for extension at 120 deg/s ($P = .002$ for all). Overall, the SF-36 score improved from 41.5 ± 9.9 to 55.1 ± 16.6 ($P < .009$). However, 5 subdomains within the SF-36 were not significantly improved: physical function, general health, vitality, social function, and emotional well-being. Results on the WOMAC and TUG test indicated significant improvement, from 36.0 ± 9.6 to 22.2 ± 9.9 ($P = .001$) and from 11.8 ± 3.5 to 9.1 ± 2.7 seconds ($P = .002$), respectively. The results are shown in Table 3.

In contrast to the isokinetic group, patients receiving isotonic training did not show significant improvement on any parameter of peak torque. The SP-36 overall, physical domain, and mental domain scores progressed significantly, from 47.3 ± 16.0 to 60.9 ± 15.3 ($P = .016$), 42.5 ± 14.2 to 53.9 ± 16.9 ($P = .021$) and 52.1 ± 21.6 to 68.0 ± 18.0 ($P = .026$), respectively. The WOMAC and TUG test indicated significant improvement, from 30.0 ± 11.2 to 15.6 ± 11.4 ($P = .001$) and 9.7 ± 3.2 to 8.6 ± 2.9 seconds ($P = .041$), respectively. These results are displayed in Table 4.

Nevertheless, the time needed in performing the TUG test, the score of the 3 domains of the WOMAC index, and the total score of the WOMAC index all improved significantly in both

TABLE 1
Baseline Characteristics of the Study Participants[a]

Characteristics	Isokinetic Group (n = 15)	Isotonic Group (n = 15)	*P*
Age, y	66.73 ± 10.39	68.4 ± 8.09	.678
≤70	9	8	.713
>70	6	7	
Sex			
Male	2	6	.099
Female	13	9	
Side of TKR			
Right	5	9	.143
Left	10	6	
Body mass index, kg/m^2	28.94 ± 3.42	27.23 ± 4.41	.33
HKA angle, deg	7.09 ± 10.02	8.94 ± 5.53	.983
Extension deficit of knees, deg	4.20 ± 3.14	4.27 ± 3.75	.966

[a]Data are reported as mean ± SD or No. of patients. HKA, hip-knee-ankle; TKR, total knee replacement.

TABLE 2
Outcome Measures Between the Isokinetic and Isotonic Groups Before Training[a]

Outcome Measure	Isokinetic Group	Isotonic Group	*P*
Peak torque, N·m			
Knee extension at 60 deg/s	17.9 ± 11.4	12.9 ± 8.60	.215
Knee flexion at 60 deg/s	19.5 ± 14.4	15.0 ± 9.40	.491
Knee extension at 120 deg/s	16.6 ± 9.4	11.5 ± 6.80	.135
Knee flexion at 120 deg/s	12.9 ± 9.0	10.5 ± 5.20	.491
SF-36	41.5 ± 9.9	47.3 ± 16.0	.383
Physical domain	38.2 ± 14.7	42.5 ± 14.2	.581
Physical functioning	38.2 ± 14.7	39.6 ± 21.2	.963
Physical role limitations	5.4 ± 14.5	10.7 ± 23.4	.582
Pain	51.1 ± 17.6	53.4 ± 19.9	.744
General health	52.5 ± 18.5	66.4 ± 19.3	**.043**
Mental domain	42.5 ± 9.4	52.1 ± 21.6	.312
Vitality	46.4 ± 15.4	58.2 ± 19.7	.062
Social functioning	58.1 ± 18.9	57.1 ± 22.3	.850
Emotional role limitations	11.9 ± 28.1	33.3 ± 39.2	.113
Emotional well-being	53.7 ± 11.8	64.6 ± 22.0	.117
WOMAC	36.0 ± 9.6	30.0 ± 11.2	.084
Pain	7.7 ± 4.3	6.2 ± 4.1	.150
Stiffness	4.0 ± 1.4	3.3 ± 1.4	.179
Physical function	24.3 ± 6.2	19.1 ± 7.4	**.045**
TUG test, s	11.8 ± 3.5	9.7 ± 3.2	.060

[a]Data are expressed as mean ± SD. Boldface *P* values indicate a statistically significant difference between groups ($P < .05$, Mann-Whitney *U* test). SF-36, 36-item Short Form Health Survey; TUG, Timed Up and Go; WOMAC, Western Ontario and McMaster Universities Arthritis Index.

TABLE 3
Outcome Measures Before and After the Isokinetic Strength Training Program[a]

Outcome Measure	Before Training	After Training	*P*
Peak torque, N·m			
Knee extension at 60 deg/s	17.9 ± 11.4	31.5 ± 15.7	**.002**
Knee flexion at 60 deg/s	19.5 ± 14.4	34.1 ± 15.8	**.002**
Knee extension at 120 deg/s	16.6 ± 9.4	25.8 ± 13.1	**.002**
Knee flexion at 120 deg/s	12.9 ± 9.0	21.8 ± 11.0	**.002**
SF-36	41.5 ± 9.9	55.1 ± 16.6	**.009**
Physical domain	38.2 ± 14.7	49.7 ± 18.5	**.035**
Physical functioning	41.8 ± 27.4	51.8 ± 27.3	.108
Physical role limitations	5.4 ± 14.5	23.2 ± 36.0	**.041**
Pain	51.1 ± 17.6	63.5 ± 16.4	**.028**
General health	52.5 ± 18.5	60.1 ± 19.4	.271
Mental domain	42.5 ± 9.4	60.2 ± 18.0	**.009**
Vitality	46.4 ± 15.4	55.0 ± 20.8	.058
Social functioning	58.1 ± 18.9	67.9 ± 18.8	.080
Emotional role limitations	11.9 ± 28.1	59.5 ± 45.6	**.020**
Emotional well-being	53.7 ± 11.8	58.3 ± 18.3	.262
WOMAC	36.0 ± 9.6	22.2 ± 9.9	**.001**
Pain	7.7 ± 4.3	5.2 ± 3.1	**.025**
Stiffness	4.0 ± 1.4	2.3 ± 1.5	**.013**
Physical function	24.3 ± 6.2	14.7 ± 7.2	**.001**
TUG test, s	11.8 ± 3.5	9.1 ± 2.7	**.002**

[a]Data are expressed as mean ± SD. Boldface *P* values indicate a statistically significant difference between groups ($P < .05$, Wilcoxon signed-rank test). SF-36, 36-item Short Form Health Survey; TUG, Timed Up and Go; WOMAC, Western Ontario and McMaster Universities Arthritis Index.

groups. Furthermore, the degree of improvement in all the outcome measures did not reveal a significant difference between the groups, as shown in Table 5.

DISCUSSION

The results of this study revealed that although the participants of both strength training groups improved significantly in strength, WOMAC index, and TUG test, the differences

TABLE 4
Outcome Measures Before and After the Isotonic Strength Training Program[a]

Outcome Measure	Before Training	After Training	P
Peak torque, N·m			
Knee extension at 60 deg/s	12.9 ± 8.6	21.2 ± 12.1	**.008**
Knee flexion at 60 deg/s	15.0 ± 9.4	21.1 ± 8.2	.065
Knee extension at 120 deg/s	11.5 ± 6.8	15.7 ± 7.1	**.016**
Knee flexion at 120 deg/s	10.5 ± 5.2	14.3 ± 5.5	**.013**
SF-36	47.3 ± 16.0	60.9 ± 15.3	**.016**
Physical domain	42.5 ± 14.2	53.9 ± 16.9	**.021**
Physical functioning	39.6 ± 21.2	60.0 ± 23.3	**.003**
Physical role limitations	10.7 ± 23.4	23.2 ± 38.6	.263
Pain	53.4 ± 19.9	74.3 ± 14.9	**.002**
General health	66.4 ± 19.3	64.6 ± 17.7	.728
Mental domain	52.1 ± 21.6	68.0 ± 18.0	**.026**
Vitality	58.2 ± 19.7	61.1 ± 20.2	.430
Social functioning	57.1 ± 22.3	71.8 ± 17.5	**.020**
Emotional role limitations	33.3 ± 39.2	66.7 ± 43.4	.111
Emotional well-being	64.6 ± 22.0	71.5 ± 17.2	**.073**
WOMAC	30.0 ± 11.2	15.6 ± 11.4	**.001**
Pain	6.2 ± 4.1	4.1 ± 3.8	**.012**
Stiffness	3.3 ± 1.4	1.9 ± 1.2	**.009**
Physical function	19.1 ± 7.4	9.6 ± 7.6	**.001**
TUG test, s	9.7 ± 3.2	8.6 ± 2.9	**.041**

[a]Data are expressed as mean ± SD. Boldface P values indicate a statistically significant difference between groups ($P < .05$, Wilcoxon signed-rank test). SF-36, 36-item Short Form Health Survey; TUG, Timed Up and Go; WOMAC, Western Ontario and McMaster Universities Arthritis Index.

between isokinetic and isotonic training did not reach statistical significance. Thus, our hypothesis that isokinetic training would result in superior outcomes compared with isotonic training for patients who underwent TKR in the early stage of recovery was not supported. However, in contrast to the isotonic training, the isokinetic training group showed improvements in more items of torque measurement. Furthermore, the time taken in the TUG test also more improved in the isokinetic group, albeit not significantly.

It has been shown that the isokinetic strength of thigh muscles is closely related to functional performance in patients with knee OA.[16] Therefore, through isokinetic training of knee flexion and extension, functional activities of the knees can also be improved as expected, including rising from a chair, standing, walking, and stair climbing and descending.[14] In our study, we adopted the TUG test as our primary outcome measure, which is a composite measurement of several functions of the knees, including standing up, walking, turning around, and sitting down. Our results revealed significantly improved TUG test results after isokinetic training, with similar results also being observed in past literature.[2,15] Although the patients in our isotonic group also showed a significant improvement, the average amount of improvement still did not reach the minimal detectable change (2.27 seconds) for patients with TKR as recommended by previous literature.[33] In contrast, the average improvement in time needed for completing the TUG test in our isokinetic group was −2.7 ± 2.3 seconds, which exceeded the threshold of the minimal detectable change.[33] Therefore, in this study, we demonstrated that for patients receiving TKR, isokinetic training was capable of achieving genuine functional improvement, based on the results of the TUG test.

In our study, all the peak torque measurements improved significantly in the isokinetic group but not in the isotonic group. In the latter group, improvement of peak torque during knee flexion at 60 deg/s did not achieve statistical significance. Similar results were observed in our previous work studying subacute stroke patients.[6] Another report studying patients with knee OA has also revealed significant improvement in knee flexion peak torque with isokinetic training.[4] Neither aerobic training nor isometric training was associated with the same level of improvement. The reason behind this finding may be related to the familiarization that patients in the isokinetic group had with the peak torque tests during their training period. Another explanation perhaps lies in the principle of specificity,[8] which originally indicates the specificity between the adaptation of body fitness and type of training undertaken. This principle can also be applied in the field of isokinetic training, which has been evidenced in past literature.[24]

We adapted 2 subjective questionnaires in order to evaluate the health status and physical function of our participants. From the results of our study, different subdomains within the SF-36 improved significantly between the isokinetic and isotonic groups. The parameters that improved significantly in both groups are seen in the pain subdomain, the physical domain, the mental domain, and the total SF-36 scores. Additionally, the WOMAC index and the pain domain within it also experienced significant improvements in both groups. Similar results can be found in past literature. Both Eyigor et al[12] and Tüzün et al[31] compared the results between isokinetic and isotonic training in patients with knee OA, and the pain subdomain within the SF-36 and WOMAC index improved in both groups. The Maurer et al[22] study also revealed a superior reduction in pain in the isokinetic exercise training group when compared with patients receiving education only. Through strength training, whether in the isokinetic or isotonic mode, knee joint function of the replaced knee joint can be improved.

Limitations

There are some limitations in our study. First, we did not monitor the patients' daily physical activities or at-home rehabilitation, which may have interfered with the results. This limitation was considered from the onset of our study, but we could only try to mitigate it by persuading our participants to follow the same home educational programs to the best of their abilities. Second, the 4-week training program was relatively short, with the end evaluation being completed only 2 months after TKR, and only short-term results were collected. Third, the relatively small sample size in the present study may have resulted in some differences in baseline data and pretraining TUG test between

TABLE 5
Improvement of Outcome After 4-Week Strength Training Program[a]

Outcome Measure	Isokinetic Group	Isotonic Group	P
Change in peak torque, N·m			
Knee extension at 60 deg/s	13.7 ± 11.0	8.3 ± 8.5	.251
Knee flexion at 60 deg/s	14.6 ± 10.9	6.1 ± 9.5	.066
Knee extension at 120 deg/s	9.3 ± 9.7	4.2 ± 4.8	.175
Knee flexion at 120 deg/s	8.9 ± 8.1	3.8 ± 4.5	.059
Change in SF-36	9.8 ± 17.8	39.3 ± 13.6	.544
Physical domain	11.4 ± 18.8	11.4 ± 15.7	.836
Physical functioning	10.0 ± 30.1	20.4 ± 19.1	.392
Physical role limitations	17.9 ± 30.1	12.5 ± 37.7	.609
Pain	12.4 ± 17.8	20.9 ± 19.1	.285
General health	7.6 ± 18.8	–1.8 ± 21.9	.258
Mental domain	17.6 ± 20.1	15.9 ± 23.7	>.999
Vitality	8.6 ± 14.5	2.9 ± 12.4	.172
Social functioning	9.8 ± 17.8	14.7 ± 19.3	.544
Emotional role limitations	47.6 ± 53.5	33.3 ± 66.7	.760
Emotional well-being	4.6 ± 15.2	6.8 ± 12.1	>.999
Change in WOMAC	–13.8 ± 8.4	–14.4 ± 9.6	.872
Pain	–2.5 ± 3.4	–2.1 ± 2.5	.58
Stiffness	–1.7 ± 2.1	–1.4 ± 1.4	.64
Physical function	–9.6 ± 5.9	–9.5 ± 8.6	.982
Change in TUG test, s	–2.7 ± 2.3	–1.1 ± 2.1	.066

[a]Data are expressed as mean ± SD. SF-36, 36-item Short Form Health Survey; TUG, Timed Up and Go; WOMAC, Western Ontario and McMaster Universities Arthritis Index.

the groups and in some comparisons being underpowered. A larger prospective, randomized controlled study with longer training and follow-up periods is needed in order to elucidate the long-term effects of the different training programs.

CONCLUSION

The findings of the current study indicated that both isokinetic and isotonic training during the early postoperative stage was beneficial for patients who had received TKR. Although isokinetic training resulted in improvements in more items of knee flexion tests and gait function, as evaluated by the TUG test, the extent of improvement did not significantly differ between the 2 groups. Therefore, both modes of short-term strengthening exercises can be recommended for patients undergoing TKR.

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