A Comparison of Various Therapeutic Exercises on the Functional Status of Patients With Knee Osteoarthritis

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Objective: **To investigate the therapeutic effects of different muscle-strengthening exercises on the functional status of patients with knee osteoarthritis (OA).**

Methods: **One hundred thirty-two patients with bilateral knee OA (Altman Grade II) were sequentially divided into 4 random groups (GI to GIV). The patients in group I received isokinetic muscle-strengthening exercise, group II received isotonic muscle-strengthening exercise, group III received isometric muscle-strengthening exercise, and group IV acted as controls. The changes of muscle power of leg flexion and extension were measured with a Kinetic Communicator dynamometer, and patients' functional status was evaluated by visual analogue scale, ambulation speed, and Lequesne index before and after treatment, and at the follow-up 1 year later.**

Results: **The results showed that the patients with OA in each treated group had significant improvement in pain reduction, disability reduction, and in walking speed after treatment and at follow-up when compared with their initial status. Isotonic exercise had the greatest effect on pain reduction after treatment, and fewer participants discontinued the treatment because of exercise knee pain. Isokinetic exercise caused the greatest increase of walking speed and decrease of disability after treatment and at follow-up. The greatest muscle-strength gain in 60°/second angular velocity peak torques was found in the isokinetic and isotonic exercise groups. A significant muscle-strength gain in 180°/second angular velocity peak torques was found only in the isokinetic group after treatment.**

Conclusion and Relevance: **Isotonic exercise is suggested for initial strengthening in patients with OA with exercise knee pain, and isokinetic exercise is suggested for improving joint stability or walking endurance at a later time.**

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INDEX WORDS: Osteoarthritis; exercise; isokinetic; isotonic; isometric.

OSTEOARTHRITIS (OA) is the most common joint disorder in a large number of people older than 65 years (1). Knee OA is more commonly associated with disability than OA of any other joint. Prevalence increases with age, and radiographic abnormalities are present in more than 30% of persons older than 65 years, with approximately 40% of these persons being symptomatic (2). Many treatment programs have been developed, including medication with nonsteroidal anti-inflammatory drugs, physical modalities, and therapeutic exercises.

OA is characterized by a noninflammatory deterioration of the articular cartilage with reactive new bone formation at the joint's surface and margins. Whether this new bone formation originates from the cartilage or from the subchondral bone is still uncertain. Many authors (1-4) have considered that the primary lesion of OA is in the

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articular cartilage, in which the earliest change is diminution of mucopolysaccharide chondroitin sulphate relative to the collagen in the matrix. This depletes the ground substance and unmasks the collagen. Normally, the matrix dissipates stresses hydrostatically. However, when the collagen is unmasked, its fibers are subjected to excessive flexural and torsional stresses, leading to their rupture. This produces the characteristic lesions of early OA.

Much like bone, the health of cartilage depends on the mechanical loading it experiences. Cartilage is an avascular tissue, and the chondrocytes within it depend on diffusion and convection for nutrition. The cyclic loading induced by everyday activities produces deformations, pressure gradients, and fluid flows within the tissues that enhance this process. Laboratory and animal investigations have shown that mechanical stress has a direct effect on the synthetic and catabolic activities of chondrocytes (5-7). Moderate to strenuous articular loading, such as that associated with regular distance running, seems to have no adverse affects on the health of normally congruent joints. However, high-impact joint loading, through either a single traumatic event or through repetitive events of less severity, may also lead to joint degeneration (8-9). On the other hand, too little loading can be equally detrimental, and disuse has been shown to have adverse, but reversible, effects on cartilage health (10-11). However, normal loads can accelerate degeneration in deformed, unconstrained, or damaged joints because of instability of the arthritic joint and uneven loading force (12). Therefore, increasing the stability of an arthritic joint helps prevent further deterioration.

Therapeutic exercise in OA may prevent accelerated degeneration caused by disuse without causing further degeneration and pain as a consequence of joint deformity or incongruence. Several recent longitudinal studies conclude that carefully controlled exercise programs designed primarily to address OA of the knee are beneficial (13-15). Among the benefits reported were increased joint mobility, increased strength, and enhanced activity performance. However, compliance is an issue, and those studies with high compliance produced better results. Patients' compliance depends on many elements, including consistent education, encouragement, and follow-up. However, injury and complications as a direct consequence of inappropriate exercise (14), such as knee pain during exercise or weakness of leg muscles, are major factors resulting in poor compliance. Therefore, we studied the therapeutic effects and compliance of different exercises for patients with knee OA. Patients with moderate knee OA were selected, and therapeutic exercises, including isokinetic, isotonic, and isometric exercise, were applied to patients in different groups. The therapeutic effects of different exercises were evaluated by changes in the visual analogue scale (VAS) (16), ambulation speed (AS), Lequesne index (LI) (17) and peak torques of knee flexion and extension, and compliance in each group was analyzed.

METHOD

Subjects

On hundred thirty-two patients with moderate bilateral knee OA (Altman grade II; Table 1) (18) were selected by clinicians from outpatients attending the department of rehabilitation. Patients with respiratory or cardiac dysfunction, or combined ankle or hip pain, were excluded from this study. Patients were randomly assigned into 4 groups (GI-GIV) by a secure system of sequentially numbered I-IV opaque sealed envelopes. The doctor who assigned the patients was blinded to the treatment the patient received. The patients in group I (33 patients) received isokinetic muscle-strengthening exercise, group II (33 patients) received isotonic muscle-strengthening exercise, group III (33 patients) received isometric muscle-strengthening exercise, and group IV (33 patients) acted as controls. Patients in groups I, II, and III exercised 3 times weekly for 8 weeks. The patients in all groups also received 20 minutes of hot packs and passive range motion exercise by an electric stationary bike (20 cycles per minute) for 5 minutes to both knees before muscle strengthening exercise. The muscle power of arthritic knee in extension and flexion was measured with an isokinetic dynamometer (Kin-Com; Chattanooga Corp, Chattanooga, TN) (19), and the functional status of patients was evaluated by VAS pain scale, AS, and LI. Evaluations were performed before and after treatment, and at follow-up 1 year after completing treatment.

Measurement of Pain Severity

The severity of knee pain was evaluated by the VAS after patients were in a weight-bearing pos-

Table 1: The Criteria of Stages of Knee OA

Stage	Knee Pain	Radiographic Osteophytes	Age (yr)	Morning Stiffness	Crepitus	Bony Enlargement on Physical Examination
I	✓	✓	<40	—	—	—
II	✓	✓	>40	<30 min	✓	—
III	✓	✓	>40	>30 min	✓	—
IV	✓	✓	>40	>30 min	✓	✓

Modified from Altman (18).
—, findings absent.

ture (walking or standing) for 5 minutes. The instrument consisted of horizontal or vertical lines 10-cm long with anchor points of 0 (no pain) and 10 (pain as bad as it could possibly be).

Measurement of Ambulation Activity

Ambulation activity was evaluated by walking speed. The time needed to complete a predetermined distance (50 m) on a treadmill as comfortably and quickly as possible was recorded. The distance of 50 m was preset on the treadmill, and an alarm sounded when the distance was completed. The walking time was recorded with a stopwatch by the same physiatrist.

Measurement of Disability

Disability of patients with knee OA was evaluated with LI (17) as shown in Table 2. The questionnaire included 11 questions about knee discomfort, endurance of ambulation, and difficulties in daily life. A maximum score of 26 indicates the greatest degree of dysfunction and a score of 1 to 3 indicates mild dysfunction. A score of less than 7 points indicates acceptable functional status.

Measurement of Isokinetic Peak Torque of Knee Flexion and Extension

For evaluating the maximal voluntary force capacity, the peak torque of the arthritic knee was measured by using the method modified by Snow et al (20) in the following conditions: extension concentric (Ex/Con) (knee extension with quadriceps contraction), extension eccentric (Ex/Ecc) (knee flexion with quadriceps contraction), flexion concentric (Flex/Con) (knee extension with biceps femoralis contraction) and flexion eccentric (Flex/Ecc) (knee flexion with biceps femoralis contraction). The subject was seated, leaning against a backrest inclined at 16° from the vertical and with the seat inclined 6° from horizontal. The axis of the knee was aligned with the axis of the Kin-Com (Kin-Com 505, Chattanooga, TN) exercise arm. The accuracy of alignment was checked by allowing the subject to extend the leg while pushing against the shin pad that was positioned over the lower third of the leg. If the pad did not move up or down the leg over the range of motion to be tested, the knee was considered to be aligned with the axis of the exercise arm. The gravity-compensated torque values were corrected with the exercise arm positioned 15° from horizontal.

The Kin/Com exercise arm was used to set the test range of motion. The angle at which knee flexor muscle shortening began (start angle) was set at 20° from horizontal, and the angle at which muscle lengthening began (return angle) was set at 85° from horizontal. To calculate torque, the distance between the point of application of the generated force and the axis of rotation of the exercise arm was measured by using the scale on the arm itself and keyed into the computer. Each subject used the same radius for all tests. Exercise-arm velocity was set to 60°/second and 180°/second, respectively, for the previously mentioned isokinetic peak torques measurement.

Isokinetic Exercise

Isokinetic exercise is a mode of speed-constant exercise. The velocity of joint motion is constant, excluding acceleration to and deceleration from the designated speed, and the force is dependent on how hard the individual pushes against the load cell.

After evaluating pain and range of motion in each arthritic joint, measuring blood pressure and heart rate, and stretching the quadriceps and ham-

Table 2: Lequesne Functional Index for Knee OA

	Points
Pain	
Nocturnal pain	
Only on movement or in certain attitudes	1
Even without moving	2
Morning stiffness or pain after getting up	
Less than 15 min	1
15 min or more	2
Standing for 30 minutes results in more knee pain	1
When walking, does the pain occur	
Only after certain distance	1
Or from beginning and does it increase	2
Pain or discomfort when getting up from a seat	1
Maximum distance walked	
More than 1 km, but limited	1
About 1 km (about 15 min)	2
From 500 to 900 m (about 8 to 15 min)	3
From 300 to 500 m	4
From 100 to 300 m	5
Less than 100 m	6
With 1 walking stick or crutch	1
With 2 walking sticks or crutches	2
Some difficulties in daily life	
Can you ascend a flight of stairs?	0-2
Can you go down a flight of stairs?	0-2
Can you arrange something on a low shelf while squatting or being on your knee?	0-2
Can you walk on uneven ground?	0-2
Are you suffering from shooting pains and/or sudden lack of support in the involved limb?	
Sometimes	1
Often	2

Answer rating: 0, easily; 1 (or 0.5 or 1.5), with difficulty; 2, impossible.
The disability may be graded as follows: more than 14 points, extremely severe; 11–13 points, very severe; 8–10 points, severe; 4–7 points, moderate; 1–3 points, mild disability.

strings after the application of hot packs, the patient underwent a 5-minute warm-up exercise on a stationary bike set without resistance. The isokinetic muscle-strengthening exercise program was performed 3 times a week for 8 weeks (24 sessions) on each knee. Sixty percent of the average peak torque was selected as the initial dose of isokinetic exercise, and an increasing dose program was used in the initial first to fifth sessions (1 set to 5 sets), and a dose of 6 sets was applied from sixth to the twenty-fourth sessions. Each set consists of 5 repetitions of concentric and eccentric (Con/Ecc) contraction in angular velocity 30°/second and 120°/second for extensors, and 5 repetitions of eccentric and concentric (Ecc/Con) contraction in angular velocity 30°/second and 120°/second for flexors. The start and stop angles for extension exercise were 40° and 70° degrees, and the start and stop angles for flexion exercise were 70° and 40° degrees. Patients were allowed 5 seconds of rest between sets, 10 seconds of rest between different modes of training, and 10 minutes of rest between right and left knee training.

Isotonic Exercise

Isotonic exercise is a mode of speed-variable exercise. The tension the muscle generates in response to a window of force is limited in both the concentric and eccentric directions. The amount of force generated also varies depending on the position of the limb and its range of motion. During isotonic exercise, the speed at which a weight is moved is variable, dependent on patient effort, and is displayed as a velocity trace on the Kin-Com monitor screen. Through the use of a velocity trace and positional markers or zones, the patient gains not only strength but also progressive training of neuromuscular motor control.

The same protocol was used as in the isokinetic exercise. The isotonic muscle strengthening exercise program consisted of 5 repetitions of Con/Ecc at the maximum velocity that the lever arm could achieve during the forward or backward motion, from start to stop angle.

Isometric Exercise

Isometric exercise is a mode of speed constant exercise. The patient contracts the muscle at various isometric hold angles in the range of motion, as preset. The same protocol of was used as in the isokinetic exercise. The speed of passive forward or backward motion was set at 30°/second.

Home Exercise Program

After completing the treatment, patients in the isokinetic and isotonic exercise groups received a home exercise program consisting of 15 minutes of stationary-bike exercise. Patients in the isometric group performed 5 seconds of isometric contraction of the quadriceps and biceps in full knee extension with 30 repetitions daily until follow-up 1 year later.

Compliance

Compliance was determined by the number of participants who had completed the treatment course divided by the number of participants initially. The major causes of noncompliance, and when the exercise program was discontinued, also were analyzed.

Statistical Analysis

Paired *t* test was used to study the changes of VAS, LI, AS values, and peak torques in each group after treatment and at follow-up 1 year later. One-way analysis of variance with the Tukey test was used to compare the different values of VAS, LI, AS, and peak torques among the 3 treated groups, and the Dunnett test was used to compared the difference between the treated groups and the control group at zero time, after treatment, and 1 year later. A statistically significant difference was defined as $P < .05$. Pearson correlation analysis was used to study the correlation between exercise-induced knee pain, leg muscle weakness, and the time until treatment discontinuation for patients who abandoned the protocol.

RESULTS

Subjects

The ages of the 132 patients ranged from 45 to 77 years (mean, 62 ± 4.5) with a female to male ratio of 93:39. The duration of knee pain ranged from 4 months to 9 years.

CHANGES IN KNEE PAIN

The changes in average scores of knee pain for each subgroup are shown in Table 3. There were 8 patients who stopped the therapeutic exercises because of intolerable pain during exercise (4 subjects in the isokinetic group, 2 in the isotonic group, and 2 in the isometric group). Contact with 10 subjects was lost in the follow-up period (1 subject in the isokinetic group, 2 in isotonic group, 1 in the isometric group, and 6 in the control

Table 3: The VAS Score of Knee Pain in Each Group Before and After Treatment

	I (Isokinetic)	II (Isotonic)	III (Isometric)	IV (Control)
Before	4.8 ± 1.4 (66)	4.6 ± 1.7 (66)	4.7 ± 1.4 (66)	4.6 ± 1.3 (66)
After	3.1 ± 1.2 (58)*†	2.6 ± 0.7 (62)*†‡	3.6 ± 0.6 (62)*	4.4 ± 0.4 (66)
Follow-up	2.5 ± 1.8 (56)*†	2.0 ± 1.4 (58)*†‡	3.2 ± 1.6 (60)*†	6.1 ± 1.3 (54)*

Values shown as mean ± SD. The number of knees in each group is shown in parentheses.
*Significant difference of VAS score after treatment or follow-up in each group ($P < .05$).
†Significant difference of VAS in each group compared with control group ($P < .05$).
‡Significant difference compared with other treated groups ($P < .05$).

Table 4: The AS (M/Min) of Patients in Each Group Before and After Treatment

	I (Isokinetic)	II (Isotonic)	III (Isometric)	IV (Control)
Before	69 ± 6 (33)	67 ± 7 (33)	68 ± 5 (33)	68 ± 5 (33)
After	87 ± 3 (29)*†	85 ± 4 (31)*†	78 ± 5 (31)*‡	70 ± 3 (33)
Follow-up	94 ± 7 (28)*†‡	85 ± 8 (29)*†	79 ± 7 (30)*†	65 ± 5 (27)

Values shown as mean ± SD. The number of patients in each group is shown in parentheses.
*Significant difference of AS after treatment ($P < .05$).
†Significant difference of AS compared with control group ($P < .05$).
‡Significant difference compared with other treated groups ($P < .05$).

group). Pain scores among groups I through IV were similar initially. However, pain scores decreased significantly in all treated groups after treatment and at follow-up, whereas it increased in the control group. Patients in the isotonic group showed the greatest degree of pain reduction compared with the isotonic and isometric groups, both after treatment and in the follow-up period.

Changes in AS

There were no marked differences of initial average AS between the treated and control groups. The mean changes in AS in each group are shown in Table 4. The average AS increased significantly only in the isokinetic and isotonic groups after treatment, but increased in all treated groups at follow-up when compared with the control group. Patients in the isokinetic group showed the most improvement, and the isometric group showed the least improvement in AS, after treatment and at follow-up.

Changes in LI

Initially, there were no significant LI differences among the treated and control groups. The changes in mean LI values in each patient group are shown in Table 5. The average LI scores decreased significantly in all treated groups after treatment and at the 1-year follow-up. Patients in the isometric group had the least reduction of LI scores after treatment, and patients in the isokinetic group had the greatest reduction of disability in the follow-up period.

Changes in Muscle Power

The changes in mean peak torques of knee flexion and extension in concentric and eccentric contraction in all patient groups are shown in Tables 6 (60°/second) and 7 (180°/second). The average peak torque of 60°/second in Ex/Con, Ex/Ecc, Flex/Ecc, and Flex/Con increased significantly in the isokinetic and isotonic groups, both after treatment and in the follow-up period. Patients in the isometric group showed the least improvement of peak torques after treatment. However, there was a significant improvement of muscle peak torques in the isometric group compared with the control group at follow-up. This shows that, in short term training, isokinetic and isotonic muscle strengthening exercises are more effective than isometric exercise. Table 7 shows that only patients in the isokinetic group had im-

Table 5: The Mean LI of Patients in Each Group Before and After Treatment

	I (Isokinetic)	II (Isotonic)	III (Isometric)	IV (Control)
Before	6.9 ± 1.4 (33)	7.1 ± 1.2 (33)	6.8 ± 2.2 (33)	7.2 ± 1.5 (33)
After	4.8 ± 0.7 (29)* †	5.3 ± 1.3 (31)*†	5.6 ± 0.7 (31)*†‡	6.9 ± 1.1 (33)
Follow-up	3.1 ± 1.6 (28)*†‡	4.0 ± 1.4 (29)*†	4.8 ± 1.5 (30)*†	7.6 ± 1.5 (27)

Values shown as mean ± SD. The number of patients in each group is shown in parentheses.
*Significant difference of LI in each group after treatment and at follow-up ($P < .05$).
†Significant difference of LI in each group compared with control ($P < .05$).
‡Significant difference compared with other treated groups ($P < .05$).

Table 6: The Mean Peak Torque of Knee Flexion and Extension in Concentric and Eccentric Contraction at 60°/second in Each Group Before and After Treatment

	I (Isokinetic)	II (Isotonic)	III (Isometric)	IV (Control)
60° (Ex/Con)				
Before	233 (66)	240 (66)	236 (66)	241 (66)
After	294 (58)*†	290 (62)*†	255 (62)‡	240 (66)
Follow-up	324 (56)*†	322 (58)*†	278 (60)*†‡	221 (54)
60° (Ex/Ecc)				
Before	434 (66)	444 (66)	425 (66)	438 (66)
After	576 (58)*†	605 (62)*†	455 (62)‡	440 (66)
Follow-up	613 (56)*†	636 (58)*†	488 (60)†‡	417 (54)
60° (Flex/Ecc)				
Before	331 (66)	343 (66)	330 (66)	339 (66)
After	388 (58)*†	400 (62)*†	333 (62)‡	330 (66)
Follow-up	381 (56)*†	396 (58)*†	345 (60)†‡	300 (54)*
60° (Flex/Con)				
Before	270 (66)	274 (66)	276 (66)	276 (66)
After	340 (58)*†‡	307 (62)*†	273 (62)	255 (66)
Follow-up	353 (56)*†‡	319 (58)*†	270 (60)†	224 (54)*

The number of knees in each group is shown in parentheses.
*Significant difference of peak torque in each group after treatment or follow-up ($P < .05$).
†Significant difference of peak torque in each group compared with control ($P < .05$).
‡Significant difference compared with other treated groups ($P < .05$).

Table 7: The Mean Peak Torque of Knee Flexion and Extension in Concentric and Eccentric Contraction at 180°/second in Each Group Before and After Treatment

	I (Isokinetic)	II (Isotonic)	III (Isometric)	IV (Control)
180° (Ex/Con)				
Before	178 (66)	181 (66)	177 (66)	181 (66)
After	237 (58)*†‡	195 (62)	197 (62)	179 (66)
Follow-up	228 (56)*†‡	206 (58)*†	215 (60)*†	172 (54)
180° (Ex/Ecc)				
Before	488 (66)	477 (66)	479 (66)	483 (66)
After	649 (58)*†‡	511 (62)†	471 (62)	471 (66)
Follow-up	715 (56)*†‡	541 (60)*†	476 (60)†	452 (54)*
180° (Flex/Con)				
Before	188 (66)	181 (66)	183 (66)	179 (66)
After	271 (58)*†‡	192 (62)	207 (62)	182 (66)
Follow-up	294 (56)*†‡	213 (58)*†	227 (60)*†	163 (54)*
180° (Flex/Ecc)				
Before	288 (66)	293 (66)	295 (66)	290 (66)
After	370 (58)*†‡	316 (62)†	291 (62)	282 (66)
Follow-up	443 (56)*†‡	333 (58)*†	319 (60)†	258 (54)*

The number of knees in each group is shown in parentheses.
*Significant difference of peak torque in each group after treatment or follow-up ($P < .05$).
†Significant difference of peak torque in each group compared with control ($P < .05$).
‡Significant difference compared with other treated groups ($P < .05$).

provement in peak torque of 180°/second in all contraction modes (Ex/Con, Ex/Ecc, Flex/Con, and Flex/Ecc) after treatment and at follow-up, which correlates with joint (20) stability.

Compliance

For completed patients, compliance in the isokinetic group was 0.88 (29 of 33) and was 0.93 (31 of 33) in the isotonic and isometric groups. Patients withdrew from the treatment because of intolerable exercise-induced knee pain and leg muscle weakness. The correlation of knee pain and the duration of treatment was $r = -0.63$, and the correlation of leg muscle weakness and duration of treatment was $r = -0.21$. There was greater treatment compliance in the isotonic and isometric exercise groups, and exercise-induced knee pain was the major factor causing discontinuation of treatment.

DISCUSSION

Pain and functional disability are the most common symptoms of patients with OA. Because curative therapy is not available, treatment is aimed primarily at the alleviation of these symptoms and the prevention of further joint deterioration. Knee pain and disability in patients with knee OA are associated with cartilage and bone degeneration (articular level); with muscular weakness and limitation of joint motion (kinesiologic level); and with anxiety, obsession with symptoms, and possibly depression (psychologic level). Drugs, physical modalities, and the role of exercise in the treatment of OA of the knee have been reviewed by others (21-30). Three randomized controlled trials in patients with knee OA showed that strengthening of the quadriceps musculature with either isometric or isotonic-resistive exercise was associated with significant improvement in quadriceps strength, reduction of knee pain, and improved function (22,27,30). Furthermore, a well-controlled trial with an 8-week isokinetic muscle-strengthening exercise program improved the functional status of patients with OA of knee joints (26). Therapeutic exercise has a major influence on kinesiology. An appropriate exercise mode should be selected in accordance with the patient's condition, and differences in the therapeutic effects of various strengthening exercises should be identified.

In our study, 8 weeks of isokinetic or isotonic strengthening improved walking speed, similar to findings reported by Fisher et al (31). Patients in the isometric group showed some improvement of walking speed after treatment, but results were not significant. However, walking speed improvement persisted in each group when compared with those initially and with the control group in the follow-up period. Thus, the 3 kinds of strengthening exercises were all effective in improving ambulation for patients with moderate knee OA, although isometric exercises were less beneficial.

In each treated group, our patients with knee OA showed a significant decrease in disability index after treatment, which decreased progressively at follow-up. However, the reduction of disability in the isokinetic group was significantly greater than that in the isotonic or isometric groups, which may be caused by the improvement of knee stability through more strengthening of type II (fast twitch) muscle fibers during isokinetic exercise (32).

Findings with regard to increased muscle strength were similar to those reported by Schike et al (26) and Fisher et al (31), who used isokinetic and isometric/isotonic strength training for patients with OA. Our study shows that muscle strength in leg extension (concentric or eccentric at 60°/second) increased more in the isokinetic and isotonic groups after treatment and at follow-up than in the isometric or control groups. However, the percentage of muscle strength gain in Ex/Con and Ex/Ecc were greater than Flex/Ecc and Flex/Con, suggesting that the increase of muscle power in the quadriceps was more than for the biceps with isokinetic or isotonic exercise. Improvement of muscle power for Ex/Con, Ex/Ecc, Flex/Con, and Flex/Ecc at 180°/second after treatment was noted only in the isokinetic exercise group. Significant improvement of high angular velocity peak torque through isokinetic exercise was noted, which enhances support and mobility of the knee. However, there was significant improvement in the peak torques in each contraction mode in the isotonic and isometric groups at follow-up, which suggests that regular long-term isotonic or isometric exercises at home were helpful. In addition, the significant increase of muscle strength in leg flexion or extension in the treated groups, when compared with the control group at follow-up, indicated that therapeutic exercises prevented deterioration of muscle power.

In the present study, patients with similar severity knee OA received isokinetic, isotonic, or isometric strengthening exercises. More subjects in the isokinetic group discontinued treatment than those in the isotonic and isometric groups, suggesting that isokinetic exercises induce more knee pain. However, those patients who completed the isokinetic exercises had greater pain reduction and improvement of disability, walking speed, and leg-muscle power. Thus, patients with acute knee pain should not isokinetic exercises initially; instead, they should have isotonic exercises initially, followed by isokinetic exercises later, to improve joint stability and walking endurance.

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