Home Stretching Exercise is Effective for Improving Knee Range of Motion and Gait in Patients with Knee Osteoarthritis

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Abstract. [Purpose] The purpose of this study was to assess the effects of home-based knee stretching exercises on knee range of motion (ROM) and gait speed in patients with knee osteoarthritis awaiting total knee arthroplasty. [Subjects] Thirty-six patients with severe knee osteoarthritis were randomly allocated to stretching (n=17) and control (n=19) groups. [Method] The subjects in the stretching group were instructed to perform home-based knee stretching exercises once a day for about 80 days, whereas the subjects in the control group were told to maintain their current level of physical activity. Outcomes assessed percentage changes in the total range of knee ROM in the supine position (S-ROM), pain, gait speed and knee ROM during gait (G-ROM). [Results] The stretching group showed significantly greater improvement in S-ROM, gait speed and G-ROM than the control group (control vs stretching; S-ROM, 0.4 ± 8.6% vs 9.5 ± 16.2%; gait speed, 1.6 ± 11.4% vs 11.6 ± 10.7%; G-ROM, 0.6 ± 15.2% vs 14.2 ± 14.6%; p<0.05 for all). Pain was significantly decreased in the stretching group compared to the control group (median values: –15.6% and 6.5%, p<0.01).

Key words: Osteoarthritis, Stretching, Home exercise

INTRODUCTION

Knee osteoarthritis (OA) is associated with numerous symptoms such as deformity, pain, muscle weakness and limited range of motion (ROM). These symptoms cause difficulty in performing activities of daily living (ADL), including walking. At present, OA is not curable and the goal of management is to maintain or improve function and quality of life.

Exercise therapy for knee OA has small-to-moderate beneficial effects on pain and disability1). Moreover, land-based exercise was shown to reduce pain and improve physical function for knee OA3). It is widely accepted that regular exercise, such as muscle exercise and walking, is beneficial for the management of pain and improvement of physical function in patients with knee OA3-4). Although home-based exercises have advantages over clinic-or hospital-based exercises because they are inexpensive and easy to perform, there are concerns about long-term implementation of home-exercise regimens. In a long-term study conducted by Deyle et al.5), the effects of a home-exercise program that
included ROM, stretching and strengthening exercises on lower extremity function were almost equal to those of supervised exercise even after 1 year. Other studies\textsuperscript{6–10} have consistently shown that a home-based exercise regimen is beneficial for strength, pain, gait speed and self-efficacy. In these studies, however, the exercises were mainly comprised of muscle-strengthening exercises. Hence, the effects of stretching alone are not well known.

Home exercises, including muscle stretching, ROM and strength training, have been reported to cause an improvement in stiffness and in the Western Ontario and McMaster Universities Osteoarthritis Index pain subscale\textsuperscript{11}. Similarly, Rogind et al.\textsuperscript{12} reported that a combination of clinic-based exercises (strengthening, stretching and balance) and 3 months of home-based exercises (strengthening and stretching) reduced pain and improved gait speed. These two studies indicated that these exercises improved both impairments (e.g. strength and ROM) and activities (e.g. gait speed).

As a part of the traditional Japanese lifestyle, which includes kneeling on tatami mats, bilateral deep knee flexion is frequently required. Therefore, it is important to maintain or improve knee ROM in patients with knee OA. Stretching is one type of exercise performed to maintain or improve ROM and has been shown to improve ROM in healthy elderly people\textsuperscript{13}. However, little is known about the effect of the stretching exercises on static and dynamic knee ROM in knee OA patients, despite the fact that most of these patients have limited ROM. Restriction of activity is imposed by lack of knee flexion angle\textsuperscript{14}, and knee flexion angle is associated with disability (e.g. walking, sitting down in a chair, reclining on a bed and bending over to pick up a weight from the floor) in knee OA patients, whereas extension angle is not\textsuperscript{15}.

We hypothesised that exercise regimens that included only knee flexion stretching would improve ROM and gait speed. The present study was designed to determine whether home-based stretching exercise was effective for improving ROM and gait. Generally, it is considered that stretching means muscle stretching, but factors of knee contracture are not only muscle but also capsule, ligament and skin. In this study, we defined the objects of stretching exercise as muscles, myofascia, capsule, ligament and skin.

**METHODS**

**Patients**

Thirty-six patients with severe knee OA established on radiographs were recruited from an outpatient clinic of a large rehabilitation hospital (Table 1). Subjects having unilateral or bilateral OA and planning to undergo total knee arthroplasty (TKA) were included in this study. Patients who could not follow instructions and lie prone, and who had self-reported severe cardio respiratory disease, neurological disease, or lower limb disorders other than knee OA were excluded from the study. Participants were explained the purpose of the study and consented to participation; they were randomly allocated to stretching (17 women with 33 affected joints; mean ± SD age=72.3 ± 5.2 years; BMI=26.6 ± 3.0; duration from the onset of pain=9.8 ± 7.4 years; FTA=187.9 ± 4.9°) and control groups (19 women with 34 affected joints; mean ± SD age=74.4 ± 6.4 years; BMI=25.8 ± 2.4; duration from the onset of pain=9.3 ± 7.9 years; FTA=187.3 ± 5.6°) (Table 2).

The stretching group was instructed to perform home-based stretching exercises every day and to record it daily on a calendar until admission for surgery. They performed two exercises daily: 1) knee flexion assisted by hand while sitting on the floor and 2) knee flexion assisted by hand (or by the opposite leg if difficult to reach with the hand) while the subject was in a prone position (Fig. 1). Participants had to keep the knee flexed as much as possible for 30 seconds and complete a minimum of 10 such repetitions at least once a day. The subjects in the control group were instructed to maintain their current level of physical activity.

### Table 1. Patient characteristics at registration (N=36)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Mean ± SD</th>
</tr>
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<tbody>
<tr>
<td>Male / Female (n)</td>
<td>0 / 36</td>
</tr>
<tr>
<td>Joints (n)</td>
<td>bilateral OA =31, unilateral OA =5</td>
</tr>
<tr>
<td>Age (y)</td>
<td>73.3 ± 5.8</td>
</tr>
<tr>
<td>BMI (kg / m²)</td>
<td>26.2 ± 3.0</td>
</tr>
<tr>
<td>Duration from the onset of pain (y)</td>
<td>9.8 ± 7.4</td>
</tr>
<tr>
<td>FTA (°)</td>
<td>187.3 ± 5.2</td>
</tr>
</tbody>
</table>

Note. Values are means ± standard deviations (SD) unless
Outcome measures

We evaluated the participants at the time when they were registered for a TKA operation and just after admission to hospital for the operation. Measurements included the total range of knee ROM in the supine position (S-ROM), pain, gait speed and knee ROM from maximum flexion to extension during gait (G-ROM). For the measurement of gait speed and G-ROM, the participants were asked to walk along a 10-m line three times. S-ROM was measured from maximum extension to flexion with a goniometer by a physiotherapist blinded to the participants. Pain experienced during gait was quantitatively evaluated using a 100-mm visual analogue scale. Gait speed was calculated from the step duration and length determined from force plate data; we used the mean of three such values for analysis.

G-ROM of the knee was measured three times, and the mean of these measurements was used in the analysis. We used a three-dimensional optical motion capture system with six cameras (Mac3D system; Motion Analysis Co., CA) and two force plates (1200 mm × 600 mm; Kistler Japan Co., Tokyo, Japan) with a sampling rate of 60 Hz. Markers were placed at a point on the lower 2/3rd part of the line drawn from the anterior superior iliac spine to the greater trochanter and at the knee and ankle joints.

Analysis

For baseline comparison, the mean age, BMI, duration from the onset of pain, FTA, S-ROM, gait speed and G-ROM at the time of registration for a TKA were compared between the groups using Student’s t-test after confirmation of a normal
distribution. Kellgren-Lawrence grade and the severity of pain were compared between the groups using Wilcoxon’s rank-sum test. In addition, we compared S-ROM, pain, gait speed, G-ROM between registration and admission by paired t-test or Wilcoxon’s signed-rank test.

We calculated the percentage changes in S-ROM, gait speed, pain and G-ROM from the time of registration to admission as outcomes using the following formula:

$$%\text{change} = \left( \frac{\text{admission} - \text{registration}}{\text{registration}} \right) \times 100$$

These changes were compared between the groups by using Student’s t-test and Wilcoxon’s rank-sum test.

In this study, participants had to wait about 3 months until admission because of hospital circumstances. In addition, participants didn’t need to visit hospital until admission, so that we couldn’t regulate the intervention term. We assessed the dose effects of the number of days for which the participants had performed stretching exercises and the percentage change in S-ROM, pain, gait speed and G-ROM using Spearman’s correlation analysis. We used JMP IN 5.1 (SAS Institute Japan, Tokyo, Japan) for statistical analysis, and a significance level of p=0.05.

### RESULTS

At baseline comparison, there were no significant differences in any measurement between the groups (age, p=0.30; BMI, p=0.46; duration from the onset of pain, p=0.57; FTA, p=0.65; Kellgren-Lawrence grade, p=0.22; S-ROM, p=0.98; pain, p=0.09; gait speed, p=0.80; G-ROM, p=0.46).

There was no significant difference in duration from registration to admission between the control (82.3 ± 34.5 days; range: 25–146 days) and stretching group (80.7 ± 32.2 days; range: 30–142 days). The percentage of days for which the participants performed the exercises during the study period was 93.1 ± 4.3% in the stretching group.

In the comparison of S-ROM, pain, gait speed between at the time of registration and admission, significant differences were obtained in the stretching group (p<0.05 for all, paired t-test or Wilcoxon signed-rank test).

<table>
<thead>
<tr>
<th></th>
<th>Control Registration*</th>
<th>Admission</th>
<th>Change (%)†</th>
<th>Stretching Registration*</th>
<th>Admission</th>
<th>Change (%)‡</th>
<th>p-value§</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-ROM (°)</td>
<td>109.9 ± 23.5</td>
<td>109.1 ± 20.4</td>
<td>0.4 ± 8.6</td>
<td>110.0 ± 25.6</td>
<td>117.6 ± 20.2</td>
<td>9.5 ± 16.2</td>
<td>0.007</td>
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<tr>
<td>(mean ± SD)</td>
<td></td>
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<tr>
<td>Pain (mm)</td>
<td>45.5</td>
<td>49.5</td>
<td>6.5</td>
<td>60.0</td>
<td>43.5</td>
<td>–15.6</td>
<td>0.002</td>
</tr>
<tr>
<td>(median, interquartile range)</td>
<td>(21.0 to 67.3)</td>
<td>(39.5 to 62.8)</td>
<td>(–20.0 to 42.0)</td>
<td>(41.5 to 75.5)</td>
<td>(36.0 to 64.8)</td>
<td>(–27.8 to –4.9)</td>
<td></td>
</tr>
<tr>
<td>Gait speed (m / min)</td>
<td>32.4 ± 12.9</td>
<td>32.1 ± 11.4</td>
<td>1.6 ± 11.4</td>
<td>33.2 ± 7.3</td>
<td>36.9 ± 8.2</td>
<td>11.6 ± 10.7</td>
<td>0.01</td>
</tr>
<tr>
<td>(mean ± SD)</td>
<td>39.6 ± 13.3</td>
<td>39.4 ± 12.6</td>
<td>0.6 ± 15.2</td>
<td>37.4 ± 10.5</td>
<td>42.1 ± 11.7</td>
<td>14.2 ± 14.6</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Note. Values are means ± standard deviations (SD) or median and interquartile range.

Abbreviations: S-ROM, knee ROM in the supine position; G-ROM, knee ROM during gait

*No significant difference between groups at registration (Student’s t-test or Wilcoxon’s rank-sum test).

†Percentage changes from registration to admission.

‡Comparison of percentage changes between groups (Student’s t-test or Wilcoxon’s rank-sum test).

§Significant difference between registration and admission (p<0.05 for all, paired t-test or Wilcoxon’s signed-rank test).
the number of days and the percentage change in S-ROM, pain, gait speed and G-ROM (p=0.44, 0.99, 0.94, 0.83, respectively).

**DISCUSSION**

The effectiveness of regular exercise in the management of pain and improvement of physical function has been established in patients with knee OA. In the present study, the stretching group showed significantly greater improvement in S-ROM than the control group and the mean percentage change was about 9%. This could be partly attributed to performing knee flexion exercises once a day. Of interest was the finding by Szabo et al. who reported that the flexion ROM in Muslim patients with knee OA, whose religious tradition involves frequent deep flexion of the knee, similar to the Japanese tradition, was better than that of non-Muslim patients, who did not have such traditions. Moreover, they mentioned that the restriction of knee movement might be prevented by regular exercise.

Pain decreased by about 15% from the time of registration to admission in the stretching group. Minor et al. reported that the pain subscale of the arthritis impact measurement scale was improved by ROM exercise, isometric training and relaxation exercises in patients with rheumatoid arthritis and osteoarthritis. In addition, another study showed that pain scores improved compared with baseline in the stretching training group as compared with controls. Our findings agree with those of these others.

Fredericson and Yoon reported that tight quadriceps muscles lead to high patellofemoral stresses. Although the mechanisms of pain improvement are not yet known, we speculate that improvement in soft tissue flexibility may have led to a reduction in knee pain in the stretching group.

Our results indicate an improvement of 11.6% in gait speed from the time of registration to admission, whereas Minor et al. reported no change in 50-foot walking time in patients with rheumatoid arthritis and OA who performed ROM exercises. This discrepancy may be due to the differences in sample populations between the two studies; our study included patients with severe knee OA (as indicated by a low gait speed) awaiting surgery, whereas the patients in the study of Minor et al. were recruited from the community.

Lee et al. reported that maximal knee flexion angle during gait of normal elderly people aged 65.4 ± 6.2 years was 57.1 ± 7.7° and minimal knee flexion was 4.6 ± 4.9°. Similar to our unpublished data, G-ROM in 11 normal old people aged 66.3 ± 4.0 years was 59.1 ± 3.2°. In this study, G-ROM was improved about 14%, and was about 42° at the time of admission in the stretching group. However, we regarded this as insufficient for normal gait. We postulate that pain improvement led to an improvement of gait speed, and improvement of G-ROM seemed to result from improvement of S-ROM and pain.

Generally, a home-based exercise regimen is prescribed to patients as a part of the rehabilitation program to maintain their functions, and improve their impairments and ADL. However, whether therapist interventions are more effective than home-based exercise regimens in the long term is debatable. The advantage of home exercises is that patients can perform them at any time and at low cost. However, disadvantages include a possible lack of continuity and incorrect performance of the maneuvers because of lack of supervision. In previous studies, researchers regularly contacted their participants by telephone or home visits to ensure that the prescribed exercises were being performed. However, we did not contact the participants during the course of the present study. Nevertheless, the mean compliance rate based on the self-reported calendar was unexpectedly high (93%). The limited period of waiting time for surgery (i.e. about 3 months) may have contributed to the participants' motivation to perform the exercises. Henry et al. reported that a simple, as opposed to a complex, home-based exercise regimen was essential to ensure the continuity of exercise and improvement in physical function. In the present study, the participants were prescribed a simple exercise regimen consisting of only two exercises, and the patients were given a self-report calendar at the time of registration, which may also have contributed to the high compliance rate.

Because the period of home-based stretching exercises ranged from 30 to 140 days, we assessed the dose effects on S-ROM, pain, gait speed and G-ROM using correlation analysis. No significant relationships were observed. Harvey et al. reported that a minimum of 3 weeks is required to improve ROM by stretching. This might partly account for our result that there was no dose effect
on S-ROM. However, we could not account for the lack of a significant correlation between the period of exercise and the improvement in pain, gait speed and G-ROM.

In the present study, the home-based stretching exercise regimen was effective even in patients with severe knee OA awaiting TKA. Knee flexibility after TKA is dependent on the preoperative range of flexion\(^ {27,28}\), and a preoperative improvement in S-ROM may provide better results after surgery. Moreover, simple preoperative home-based stretching exercises are easy to perform and are beneficial for knee OA if the compliance with the exercise regimen is good.

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REFERENCES


