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# The effect of exercise on hip muscle strength, gait speed and cadence in patients with total hip arthroplasty: a randomized controlled study

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**Objective**: To evaluate the effect of home versus in-hospital exercise (under supervision) programmes on hip strength, gait speed and cadence in patients with total hip arthroplasty at least one year after operation.
**Setting**: Physical therapy and rehabilitation department.
**Subjects**: Twenty-six patients who had had a total hip arthroplasty operation 12–24 months prior to the study were enrolled.
**Interventions**: The patients were randomized into three groups: group 1 patients were assigned a home exercise programme, group 2 patients exercised under physiotherapist supervision in hospital, and group 3 served as the control group, with no specific intervention. The study duration was six weeks.
**Main measures**: Maximum isometric abduction torque of operated hip muscle, gait speed and cadence were measured before and after the study.
**Results**: Maximum isometric abduction torques of the hip abductor muscles improved in groups 1 and 2, but not in group 3 ($30 \pm 12$ to $38 \pm 11$ ft.lb in group 1, $18 \pm 10$ to $30 \pm 9.8$ ft.lb in group 2). Gait speed improved from $67.8 \pm 23$ to $74.35 \pm 24$ m/min in group 1, from $48.53 \pm 4$ to $56.7 \pm 5$ m/min in group 2 and from $58.01 \pm 12$ to $59.8 \pm 14$ m/min in group 3. Cadence also improved, from $97.7 \pm 18$ to $111 \pm 17$ steps/min in group 1, from $90.75 \pm 6$ to $104.75 \pm 7$ steps/min in group 2, and from $87 \pm 16$ to $88.22 \pm 16$ steps/min in group 3. When the three groups were compared, group 2 showed the best improvement ($P = 0.006$) only in maximum isometric abduction torque.
**Conclusion**: Our findings suggest that both home and supervised exercise programmes are effective one year after total hip arthroplasty. Home exercise programmes with close follow-up could be recommended.

## Introduction

Patients with total hip arthroplasty for hip osteoarthritis have mild-to-moderate long-term impairments and disabilities postoperatively. These patients usually complain of problems in the conduct of their daily living activities. The disabilities primarily include pain, muscle weakness of hip abductors, contracture of hip joint and gait disorders[1,2] as well as weakness of hip extensors[3] and flexors.[4]

Exercise is an important part of preventive and rehabilitative programmes to ameliorate disability from various surgical procedures of

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hip arthroplasty. Walking speed, cadence and the strength of hip muscles are important in the disability of these patients. Exercise programmes prescribed to enhance functional performance of patients after surgery are required. Although home exercise programmes are recommended in the early phase after the operation, these patients may still have functional impairments causing disability even after one year.

Trudelle-Jackson *et al.*[5] assessed the outcomes of total hip arthroplasty by comparing range of motion, muscle strength and postural stability in the surgical hip with those of the uninvolved hip one year post surgery. They emphasized the importance of a rehabilitation programme in the late phase after total hip arthroplasty and advised weight-bearing and postural stability exercises.

Frost *et al.*[4] compared the differences in isometric strength of the patients who underwent unilateral total hip arthroplasty five months prior to their evaluation and a population of community-dwelling older adults without total hip arthroplasty. They found lower peak torque of hip flexors compared with the control group. They recommended additional physical therapy after total hip arthroplasty. It has also been reported that in addition to the exercise programme itself, patient compliance to these home programmes is also important.[1,6]

Strength deficits in the hip muscles following total hip arthroplasty are still a problem and relatively few studies have evaluated this subject. To our knowledge, there has been no study showing the superiority of home versus supervised in-hospital exercise programmes.

The purposes of this investigation were: (1) to assess the effect of rehabilitation on the strength deficits one year after total hip arthroplasty; (2) to investigate the effectiveness of home versus supervised in-hospital exercise programmes in improving the strength, walking speed and cadence of patients one year after total hip arthroplasty for hip osteoarthritis.

## Materials and methods

We reviewed the medical records of 80 patients who had had total hip arthroplasty for hip osteoarthritis in the Orthopedics and Traumatology Clinic of our hospital within the previous two years. A duration of 12–24 months had passed since time of operation. Twenty-six patients were enrolled in the study. A flowchart illustrating patient selection is presented in Figure 1. Informed consent was provided by all patients.

Demographic data including age, gender, and body weight and height were collected. The 26 patients were randomly assigned to one of three groups by self-selecting an unmarked envelope containing a letter indicating the treatment group. Unmarked envelopes were used with a letter filled at random, using a list of numbers provided by a random number generator.

Gait speed (the distance in metres walked in 1 minute) and cadence (the number of steps walked in 1 minute) were calculated.

The maximum isometric abduction torque of the hip joints was measured bilaterally using the Cybex II(a) isokinetic system (Cybex International Inc., Ronkonkoma, New York, USA)[7]. During the measurement, patients were lying on their side with their lower leg stabilized by two belts in the abdominal and thigh regions. The upper leg was tied with a belt to the dynamometer of the machine at 0° of abduction. Following a training session, the patient was asked to apply maximum resistance to abduction in this position. The measurement was repeated three times and the mean value was calculated.

Group 1 patients were recommended to follow a home exercise programme consisting of range of motion, isometric and eccentric contractile hip exercises bilaterally.[1] Isometric muscle strengthening exercises were performed under low resistance of 10–30% of maximum isometric muscle torque (ft.lb). An experienced physiotherapist explained the exercises in a practice session. The patients were asked to perform these exercises twice a day for six weeks. These patients were contacted once a week and queried regarding any problems encountered during this period. Appropriate modifications were applied to the exercises (either decreasing the number of repetitions or omitting the exercise for a few days due to pain or fatigue).

Group 2 patients were prescribed exercise in hospital under supervision for six weeks.

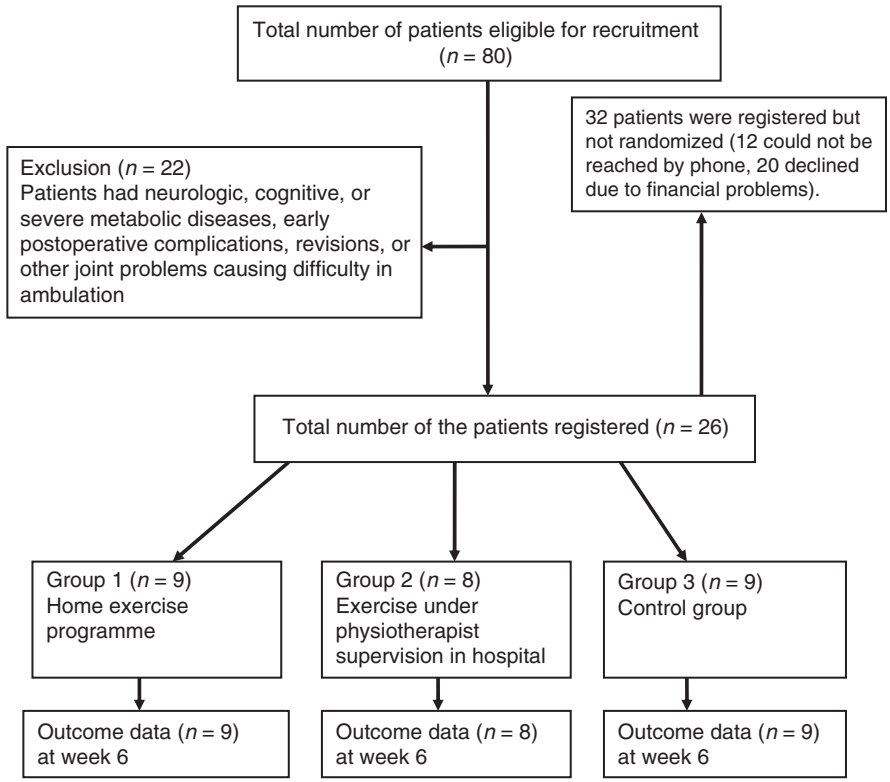


**Figure 1** Flow diagram for randomized subject assignment in this study.

The same exercise procedure as in the first group was applied to these patients, with the only difference being direct physiotherapist supervision during the exercise session.

Group 3 patients were assigned only walking. At the end of the study, the home programme was also recommended to the patients in the control group. We defined a practice ratio (%) of the home programme as the percentage of practice days to the total days of the exercise period in groups 1 and 2. At the end of the six weeks, maximum isometric hip abduction torques, gait speed and cadence were measured in all groups. Our primary outcome measure was maximum isometric hip abduction torques. The outcome variables were examined by the same physiatrists who were blinded to the patient's group affiliation.

### Statistical analyses

In comparative analysis of the distribution of continuous variables, Mann–Whitney *U*-test and Kruskal–Wallis test were used to compare and contrast two and three groups simultaneously. For comparison of the variables between initial and last findings within groups, Wilcoxon signed ranks test was used. Level of statistical significance was accepted as 0.05 throughout the analyses. All analyses were conducted using SPSS for Windows, version 11.0.

## Results

The characteristics of patients in each group are shown in Table 1. Improvements in the maximum

**Table 1** Demographic data of patients according to group

| | Group 1 | Group 2 | Group 3 | *P*-value |
|---|---|---|---|---|
| Age (years) (mean ± SD) | 45.44 ± 8.70 | 57.75 ± 7.45 | 52.55 ± 10.32 | 0.033 |
| Gender (female/male) | 7/2 | 6/2 | 5/4 | 0.54 |
| Weight (kg) (mean ± SD) | 77.55 ± 4.74 | 73.25 ± 9.11 | 72.44 ± 12.61 | 0.25 |
| Height (m) (mean ± SD) | 162.11 ± 6.75 | 158.75 ± 7.70 | 162.78 ± 9.17 | 0.57 |
| Age of prosthesis (months) (mean ± SD) | 17.00 ± 6.16 | 19.00 ± 8.05 | 16.55 ± 8.51 | 0.67 |
| Side of prosthesis (L/R) | 5/4 | 4/4 | 4/5 | – |
| Exercise ratio (%) | 82.01 | 82.22 | – | 0.92 |

**Table 2** Improvements in maximum isometric abduction torque, gait speed and cadence after the rehabilitation period according to groups

| | Group 1 (mean ± SD) | | | Group 2 (mean ± SD) | | | Group 3 (mean ± SD) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Initial | Last | *P*-value | Initial | Last | *P*-value | Initial | Last | *P*-value |
| Maximum isometric abduction torque (ft.lb) | 30 ± 12 | 38 ± 11 | 0.018 | 18 ± 10 | 30 ± 9.8 | 0.012 | 18 ± 10 | 19 ± 8 | 0.200 |
| Gait speed (m/min) | 67.8 ± 23 | 74.35 ± 24 | 0.021 | 48.53 ± 4 | 56.7 ± 5 | 0.012 | 58.01 ± 12 | 59.8 ± 14 | 0.110 |
| Cadence (step/min) | 97.7 ± 18 | 111 ± 17 | 0.011 | 90.75 ± 6 | 104.75 ± 7 | 0.012 | 87 ± 16 | 88.22 ± 16 | 0.119 |

isometric abduction torque, gait speed and cadence after the rehabilitation period in groups 1, 2 and 3 are shown in Table 2.

When maximum isometric abduction torque was compared among the three groups, group 2 showed the best improvement ($P = 0.006$). When gait speed was compared among the three groups, there was a statistically significant difference in improvement in groups 1 and 2 relative to group 3 ($P = 0.046$), but no significant difference between groups 1 and 2 ($P > 0.05$). When cadence was compared among the three groups, there was a statistically significant difference in improvement in groups 1 and 2 relative to group 3 ($P = 0.006$), but no significant difference between groups 1 and 2 ($P > 0.05$).

The practice ratio of the home programme was 82.01% in group 1 and 82.2% in group 2 ($P > 0.05$). The reasons for non-compliance in group 2 were pain, hypotension and fatigue, etc.

## Discussion

This study revealed that both home and in-hospital supervised exercise programmes were beneficial even one year after operation in total hip arthroplasty patients. Therefore, patients should be encouraged to exercise for the long term after the operation. Moreover, the patients who exercised in-hospital under supervision showed a more marked improvement in maximum isometric torque of the hip abductor muscles than the patients who exercised at home. However, the small sample of the study group and the shortness of the rehabilitation period are the limitations of our study in demonstrating the longer term benefits of the exercise programme.

Total hip arthroplasty is a valuable surgical procedure for patients with osteoarthritis of the hip. It has been shown that patients often have disability one year post surgery.[5] The main problems related to disability are contracture of the hip, loss of strength in the hip abductor and flexor/extensor muscles, pain, walking problems and impairments in daily living activities. These problems may in turn lead to complications such as loosening of the prosthesis and joint instability.[1,8–10] Home programmes including muscle-strengthening exercises are important not only in the discharge period but also in

the long term.[4] These programmes generally consist of range of motion, isometric and isotonic exercises mainly for hip abductors, and eccentric contractile exercises.[1,2,11,12]

The present study showed significant improvement in the strength of hip abductor muscles one year after total hip arthroplasty in both home and in-hospital supervised exercise groups, but especially in the latter. Sashika *et al.*[1] found that a home exercise programme involving range of motion and low-resistance strengthening exercises for hip muscles significantly improved strengthening of these muscles 6–48 months after total hip arthroplasty. Burton and Imrie[2] showed that progressive ambulation accomplished improvement in strength of hip abductors physiologically. Hodge *et al.*[11] reported that low-resistance isometric exercise for hip abductors was adequate for total hip arthroplasty patients. Considering the gradual decline in hip muscle strength in the first years after total hip arthroplasty, an exercise programme should remain a key component in the daily lives of these patients.

We assessed that gait speed and cadence improved significantly in both home and in-hospital supervised exercise groups. This can be attributed to the improved hip muscle strength. We expected walking speed and cadence to be better in the supervised exercise patients, reflecting a greater hip muscle strength in this group. We assume that if the follow-up period had been longer the effect of increased maximum abduction torque would have had positive effects on cadence and gait speed. Sashika *et al.*[1] showed an improvement in walking speed of 7.1% after a six-week daily home exercise programme. In another study, an increase in walking speed on level ground and grass surfaces and improvement in functional scores were determined.[2] Another limitation of our study is that functional score was not evaluated, but we believe that muscle weakness of hips and concomitant insufficient walking speed could cause restrictions in daily living activities.

The most important factor affecting the efficacy of any home exercise programme is compliance. We had a good compliance rate of 82% in both groups. In previous studies, the compliance rates varied between 50 and 70%.[1,2] Ice[13] stated that patient compliance to the exercise programme significantly influenced the exercise effects. The compliance rate in Sashika's study was approximately 70%.[1] Jan *et al.*[6] demonstrated in their study significant improvement in the muscle strength of bilateral hip muscles in the high-compliance exercise group. Our results show that the compliance level plays an important role in the efficacy of both home and supervised exercise programmes. The reason for the high compliance rate observed in the home exercise programme might be related to interaction via the weekly telephone contact.

**Clinical messages**

- Both home and supervised exercise programmes are effective late after total hip arthroplasty.
- Home exercise programmes with close follow-up can be recommended.

In conclusion, our findings suggest that both home and supervised exercise programmes are effective even one year after total hip arthroplasty. Although supervised exercise programmes seem to be more effective, considering the probability of the cost effectiveness, home exercise programmes with close follow-up could be recommended.

## References

1 Sashika H, Matsuba Y, Watanabe Y. Home program of physical therapy: effect on disabilities of patients with total hip arthroplasty. *Arch Phys Med Rehabil* 1996; **77**: 273–77.

2 Burton DS, Imrie SH. Total hip arthroplasty and postoperative rehabilitation. *Phys Ther* 1973; **53**: 132–40.

3 Bean JF, Leveille SG, Kiely DK *et al.* A comparison of leg power and leg strength within the InCHIANTI study: which influences mobility more? *J Gerontol A Biol Sci Med Sci* 2003; **58**: 728–33.

4 Frost KL, Bertocci GE, Wassinger CA *et al.* Isometric performance following total hip arthroplasty and rehabilitation. *J Rehabil Res Dev* 2006; **43**: 435–44.

5 Trudelle- Jackson E, Emerson R, Smith S *et al.* Outcomes of total hip arthroplasty: a study of

patients one year postsurgery. *J Orthop Sports Phys Ther* 2002; **32**: 260–67.
6 Jan MH, Hung JY, Lin J *et al*. Effects of a home program on strength, walking speed, and function after total hip replacement. *Arch Phys Med Rehabil* 2004; **85**: 1943–51.
7 Frontera WR, Hughes VA, Dallal GE *et al*. Reliability of isokinetic muscle strength testing in 45- to 78-year-old men and women. *Arch Phys Med Rehabil* 1993; **74**: 1181–85.
8 Holman PR, Tyer HD. Porous coated anatomic non-cemented total hip arthroplasty. *Aust N Z J Surg* 1992; **62**: 56–59.
9 Borja F, Latta LL, Stinchfield FE *et al*. Abductor muscle performance in total hip arthroplasty with and without trochanteric osteotomy. Radiographic and mechanical analyses. *Clin Orthop Relat Res* 1985; **197**: 181–90.
10 Victor CR. Rehabilitation after hip replacement: a one-year follow up. *Int J Rehabil Res* 1987; **10**(suppl 5): 162–67.
11 Hodge WA, Carlson KL, Fijan RS *et al*. Contact pressures from an instrumented hip endoprosthesis. *J Bone Joint Surg Am* 1989; **71**: 1378–86.
12 Johnsson R, Melander A, Onnerfalt R. Physiotherapy after total hip replacement for primary arthrosis. *Scand J Rehabil Med* 1988; **20**: 43–45.
13 Ice R. Long term compliance. *Phys Ther* 1985; **65**: 1832–39.