Patients 10 years after total hip arthroplasty have the deficits in functional performance, physical activity, and high fall rate compared to healthy adults

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ABSTRACT. Background: Long-term results in muscle strength, physical activity (PA), and functional improvement after total hip arthroplasty (THA) have not been studied. The purpose of this study was to evaluate the deficits in functional performance, PA, and high fall rate in patient 10 years after THA compared to healthy adults. Methods: The subjects were 58 patients who underwent primary THA for unilateral hip osteoarthritis 10 years, and 46 healthy adults. Hip abductor strength, balance function (single-leg stance time), Maximal Walking Speed (MWS), fall rate, and PA (IPAQ short ver.) were evaluated. The unpaired t-test and $\chi^2$ test were used to assess differences between the groups. Statistical significance was set at p value <0.05. Results: Compared to healthy adults, THA patients had 9.5% less hip abductor muscle strength on the operated side, 42.1% shorter single-leg stance time on the operated side, 14.8% slower MWS, 2.0 times less High-PA group, and 2.8 times higher fall rate (p<0.05). Conclusion: This study showed that hip abductor muscle strength, gait speed, balance function, and PA were significantly lower in patients 10 years after THA than in healthy adults. Additionally, the fall rate was significantly higher in patients 10 years post-THA than in healthy adults.

Key words: total hip arthroplasty, muscle strength, physical activity, fall

Total hip arthroplasty (THA) is an effective treatment to reduce pain and improve functional performance, physical activity (PA), and quality of life for patients with end-stage osteoarthritis (OA) of the hip1). The ≥10 years survival rate after artificial joint implant is reported to be 98-100% with cementless stem improvements and introduction of cross-linked polyethylene in recent years 2-3). This is promising in terms of extending the time until revision arthroplasty from what was previously considered reasonable. At the same time, while reports on long-term outcomes following THA include some on clinical outcomes based on hip joint functional assessment scales and other scales, they are few in number.

The present study revealed that THA patients, 4-5 months after surgery, hip abductor muscle strength was about 55% that of healthy adults4). Shih et al. 5) compared leg muscle strength in patients one year after THA and healthy adults, and they reported that the leg muscle strength in THA patients was about 84-89% in men and 79-81% in women. In addition, Rasch et al. 6) reported that hip abductor muscle strength in patients two years after THA was about 90% that of healthy adults. From these reports, it is thought that, although functional performance centered on leg muscle strength in THA patients approaches that of healthy adults over time, the remaining difference in functional performance is about 10% lower in THA patients even two years after surgery. Also, the deficit in leg muscle strength and balance function was related to a fall7). Therefore, the fall rate of THA patients with a deficit in functional performance centered on leg muscle strength might be higher than that of healthy adults, but there were few re-
ports about the fall rate of patients a long time after THA.

Regarding PA after THA, Wagenmakers et al. \(^9\) examined PA after THA by comparing PA in THA patients with that in healthy adults, and they reported that no significant difference was seen in the PA of THA patients compared with healthy adults. Since PA is correlated with leg muscle strength and walking ability\(^{\text{10,11}}\), it is conjectured that functional performance of patients a long time after THA would approach that of healthy adults, but there are no reports on functional performance, PA, and fall rate in patients a long time after THA compared with healthy adults.

The purpose of this study was to evaluate the deficits in functional performance, PA, and high fall rate in patient 10 years after THA compared to healthy adults.

**Materials and Methods**

**Experimental design**

This was a cross-sectional, controlled study.

**Subjects**

The subjects were 167 unilateral OA patients who underwent their first THA at the authors’ hospital between October 2004 and May 2006. The inclusion criteria were that the individual had undergone his or her first THA for unilateral OA, was 60 years or older at the time of the 10 years examination, had undergone the mini antero-lateral operative procedure\(^{\text{12}}\), had no serious medical or orthopedic disease, and consented to participate in this study. Preoperative upward shift of the femoral head was assessed with the Crowe classification using frontal radiographs of the hip joint. The interteardrop line connecting the bilateral teardrops was taken as the reference line. The ratio between the distance from the reference line to the superior margin of the femoral head on the healthy side and the distance from the reference line to the head-neck junction of the femoral head on the operated side were then obtained, and the proportion with upward shift compared with the healthy side was obtained\(^{\text{13}}\).

The healthy group consisted of 52 people participating in local health classes between March 2015 and July 2016. Inclusion criteria were age 60-80, no serious medical or orthopedic diseases, and consent to participate in this study.

**Ethical considerations**

Written, informed consent was obtained from all subjects. This study was approved by the Tokushukai ethics committee (Approval Number TGE 00502-115).

**Outcome measures**

**Hip abductor muscle strength**

Hip abductor muscle strength was measured in the supine position using a hand-held dynamometer (HHD) (MicroFET2, Hoggan Health Industries, Salt Lake City, UT, USA). The HHD was attached to a special fixator, and measurements were made three times at a position 2.5 cm proximal from the lateral malleolus of the ankle. The maximum value was used. The torque to body weight ratio of abductor muscle strength (Nm/kg) was calculated from the body weight and spina-malleolar distance\(^{\text{14}}\).

**Single-limb stance time**

Single-limb stance time was measured with subjects in a standing posture with both hands on the hips, starting at the time when one foot was lifted from the floor from the standing position. The evaluation was stopped when 1) the support leg shifted from the floor, 2) the lifted leg touched the floor, 3) the lifted leg came in contact with the support leg, or 4) 60 seconds was reached. Measurements were done twice, and the longest time was used in the analysis.

**Maximal walking speed (MWS)**

MWS was measured along a straight distance of 10 m with 2-m runways set at both ends. The subjects were told to “walk as fast as you can.” Measurements were done twice, and the fastest time was used in the analysis.

**Fall rate**

The fall rate was surveyed by asking participants if they had fallen in the past year. Falls were defined as “a person falling onto the same level or a lower level on their own, with no external force from another person, loss of consciousness, paralysis from a sudden attack such as stroke, or an epileptic seizure”\(^{\text{15}}\).

**Physical activity (PA)**

For PA, subjects were asked the mean number of days and hours of PA in one week, using the International Physical Activity Questionnaire (IPAQ)\(^{\text{16}}\). High-intensity exercise was taken as 8 metabolic equivalents (Mets), physical activity at moderate intensity was taken as 4 Mets, and walking was taken as 3.3 Mets. The obtained activity intensity was converted to the respiratory quotient (RQ), and the amount of calories consumed in activity per week was calculated from the RQ and body weight (Table 1). In addition, based on the report of Brach et al.\(^{\text{17}}\), people were classified as high activity or low activity, with those who burned $\geq$1,000 kcal in activity per week considered high activity and those who burned <1,000 kcal considered low activity.

**Protocol**

In the postoperative protocol, full weight-bearing was allowed on the day of surgery, walking with a walker was started on the day after surgery, and walking with a cane was started on the second day after surgery. Patients were allowed to leave the hospital when they could walk with a cane and climb and descend stairs. The number of postoperative days in hospital was 7-12. Subjects had regular examinations at 2 months, 6 months, and 1 year after leaving the hospital, and once a year after that. Exercise and lifestyle guidance matched to the state of recovery were given.

**Statistical analysis**
Dificits in patients after THA

The statistical analysis was done using unpaired t-tests and χ² tests. The Statistical Package for Social Sciences Version 24 (SPSS, IBM Inc., Chicago, IL, USA) was used. The level of significance was taken to be 5%.

**Results**

Patient selection in the THA group is shown in Fig. 1. After excluding 85 people who did not come for a regular examination, 10 who had an orthopedic disease postoperatively, 3 who died, and 11 with missing values, 58 patients were included in the analysis. There were no patients who developed infections or who required revision arthroplasty.

Femoral prostheses used included the VerSys HA/TCP fiber metal stem (Taper stem: 12, Midcoat stem 19)(Zimmer Biomet, Warsaw, IN, USA) in 31 patients, the Alloclassic stem (Zimmer Biomet) in 14 patients, the VerSys Heritage stem (Zimmer Biomet) in 8 patients, the DCM-J stem (Zimmer Biomet) in 3 patients, the VerSys Beaded full coat (Zimmer Biomet) in 1 patient, and the APS Natural-Hip stem (Zimmer Biomet) in 1 patient. Femoral head diameter was 26 mm in 39 patients, 28 mm in 17 patients, and 32 mm in 2 patients.

In the healthy group, 2 patients aged 80 years or older and 4 patients with serious orthopedic diseases were excluded, and 46 people were included as subjects.

The basic data for the two groups are shown in Table 2. No significant differences were seen in any of the parameters.

Compared to healthy adults, THA patients had 9.5%...
The results showed that functional performance and PA of patients after THA were significantly lower than those of healthy adults even 10 years postoperatively. And, the fall rate was also found to be significantly higher in THA patients than in the healthy adults.

First, the leg muscle strength of patients with hip OA and 1 year after THA is lower than that of healthy adults, with a reported difference of about 17-20% \(^5\), \(^6\). Rasch et al. also reported that hip abductor muscle strength on the affected side in THA patients 2 years after surgery was significantly lower than that of healthy adults, with a difference of about 10% \(^6\). Hip abductor muscle strength on the affected side of the THA patients in this study was significantly lower than those of healthy adults even 10 years postoperatively. And, the fall rate was also found to be significantly higher in THA patients than in the healthy adults.

Discussion

There have been few reports on functional performance and PA in patients a long time after THA. Thus, this study was the first study to evaluate functional performance, PA, and high fall rate in patients 10 years after THA. The results showed that functional performance and PA of patients after THA were significantly lower than those of

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**Table 2.** IPAQ (short) scoring guidelines and PA classification criteria.

| 1. Physical Activity Scoring |
|-----------------------------|
| Vigorous PA score = 8x (days with vigorous activities) x (daily minutes of vigorous activity) |
| Moderate PA score = 4x (days with moderate activities) x (daily minutes of moderate activity) |
| Walking PA score = 3.3x (days with walking activities) x (daily minutes of walking activity) |
| Total PA score = Vigorous PA score + Moderate PA score + Walking PA score |
| *All PA scores are expressed as METs·min·week |

| 2. Method for consumed calories per week (kcal/week) = Total PA score (METs·min-days) x 3.5 (ml/kg/min) x 0.05 (kcal/ml) x weight (kg) |

| 3. Physical activity classification criteria |
|--------------------------------------------|
| High-PA group: ≥1000 kcal/week |
| Low-PA group: <1000 kcal/week |

IPAQ (short): The International Physical Activity Questionnaire, short version
PA: Physical activity
METs: Metabolic Equivalents

| Table 3. Comparison of functional outcomes, physical activity and fall rate of THA group and control group. |
|---------------------------------------------------------------|
| | THA group (n=58) | Control group (n=46) | p Value |
|---------------------------------------------------------------|
| Hip abductor muscle strength, Nm/kg |
| operated side | 0.95±0.22 | 1.05±0.24 | .024* |
| unaffected side | 0.98±0.27 | 1.05±0.24 | .121* |
| Single-limb stance time, sec |
| operated side | 31.67±23.58 | 54.65±12.07 | <.0001* |
| unaffected side | 43.93±21.32 | 54.65±12.07 | <.0001* |
| MWS, m/sec |
| 1.68±0.24 | 1.97±0.30 | <.0001* |
| Fall rate, % (n) |
| 31.0 (18) | 10.9 (5) | .022* |
| IPAQ |
| High-PA group, % (n) | 34.4 (20) | 69.6 (32) | .004* |
| Low-PA group, % (n) | 65.5 (38) | 30.4 (14) | |

Values are presented as mean ± standard deviation
MWS: Maximal Walking Speed
IPAQ: The International Physical Activity Questionnaire, short version
Note: *t-test *χ²-test

less hip abductor muscle strength on the operated side, 42.1% shorter single-leg stance time on the operated side, 14.8% slower MWS, 2.0 times less High-PA group, and 2.8 times higher fall rate (p < 0.05)(Table 3).
looseness. This is thought to have resulted in significantly lower exercise involving intense activity to prevent wear and tear. A systematic review of PA in patients 6-12 months after THA found that there were still significant deficits in functional performance such as hip abductor muscle strength, these results considered the difference in muscular strength, these results were about 85% that of healthy adults. Judd et al. reported that the MWS of patients 9.0-61.2 months after THA was about 83% that of healthy adults. Previously, Vissers et al. reported that, while the MWS of THA patients improved to about 80% that of healthy adults at 6-8 months postoperatively, there was no subsequent improvement, and they did not reach the same level as healthy adults. It has also been reported that the MWS of patients 1.0-61.2 months after THA was about 83% that of healthy adults. Similarly to the difference in muscular strength, these results considered that the balance and the walking ability decline remained before and 6-12 months after THA. These findings suggest that there were still significant deficits in functional performance in patients, even after 10 years THA, compared to healthy adults.

Third, the fall rate in the THA group (31.0%) was 2.8 times higher than the fall rate in the healthy group (10.9%). Previously, a fall rate of 36% was reported in patients 2.0-7.8 years after THA. The fall rate of 31.0% in the THA group in the present study and the fall rates of THA patients in previous studies were found to be similar. Additionally, it is reported that the cause of the fall of the elderly occurs due to muscle weakness, decreased balance ability, and walking ability. Particularly, hip abductor muscle strength is highly correlated with lateral stability and trunk control during body-weight transfer from the operative to the non-operative side. Also, this study showed functional performance such as hip abductor muscle strength was significantly lower than that of the healthy adults. Therefore, fall rate of the THA patients was significantly higher than that of the healthy adults.

Finally, the THA group in this study had a significantly smaller proportion of people with high PA than the healthy group. High-intensity PA after THA is a cause of wear and looseness in artificial joints, and the possibility of the need for revision arthroplasty at an early stage has been reported. Because of this, patients have been instructed to limit exercise involving intense activity to prevent wear and looseness. This is thought to have resulted in significantly lower levels of high activity than in healthy adults. A previous systematic review of PA in patients 6-12 months after THA reported that the PA of THA patients was lower than that of healthy adults. The results of this study, similar to previous studies, also showed that the PA of THA patients was lower than that of the healthy group.

The limitations of this study are, first, that it cannot be considered an investigation of the age-related changes in both groups, because it was a cross-sectional study. The second limitation is that confounding factors affecting functional performance and PA after THA were not investigated. From previous studies, it was reported that pain remained in about 7-23% of patients more than 3 years after THA, and that pain after THA affects the functional performance parameters of muscle strength and walking ability and PA. The decrease in leg muscle strength and walking ability is also reported to be a factor in falls, while falls are reported to cause decreases in subsequent functional performance and PA. In addition to hip joint function, PA is also reported to be correlated with age, body mass index, social factors such as work, and psychological factors such as self-efficacy. In the future, it will be necessary to conduct a longitudinal study to compare the THA patients and healthy adults, Confounding factors should also be solved, and to examine what kind of exercise is effective for the patients.

Conclusion

This study showed that hip abductor muscle strength, gait speed, balance function, and PA were significantly lower in patients 10 years after THA than in healthy adults. Additionally, the fall rate was significantly higher in patients 10 years post-THA than in healthy adults.

Conflict of Interest: There are no conflict of interest.

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