J. Phys. Ther. Sci.
24: 561–565, 2012

Relationship between Physical Activity Level and Hip Joint Pain in Adult Women with Chiari Pelvic Osteotomy

Yoshiharu Nagai, PT[1)], Tetsuo Maeda, PT, PhD[2)], Ryoji Kiyama, PT, PhD[2)], Akihiko Oowatashi, PT[2)], Hideo Kaneko, PT, PhD[1)], Kensuke Matsuda, PT[1)], Masami Nakahara, PT[1)], Hiroyuki Tahara, PT, PhD[1)], Kazunori Yone, MD, PhD[2)], Akio Inoue, MD, PhD[3)]

[1)] *Department of Physical Therapy, Fukuoka School of Rehabilitation Sciences, International University of Health and Welfare: 137-1 Enokizu, Okawa city, Fukuoka 831-8501, Japan. E-mail: ykstnagai@iuhw.ac.jp*
[2)] *School of Health Sciences, Faculty of Medicine, Kagoshima University*
[3)] *Department of Orthopedic Surgery, Yanagawa Rehabilitation Hospital*

Abstract. [Purpose] The purpose of this study was to establish the criteria for postoperative physical activity levels that do not overload the hip joint. We examined the relationship between physical activity levels and hip joint pain in hip osteoarthritis patients. [Subjects] Subjects were 52 females who had osteoarthritis of the hip joint and underwent Chiari pelvic osteotomy. [Methods] Levels of physical activity were evaluated using an activity recorder to measure number of steps as well as duration of activity according to exercise intensity. By using the Harris Hip Score, patients with 40 or more points were classified as the no-pain group, and those with 30 or less points as the pain group. [Results] The number of steps was significantly greater in the pain group than in the no-pain group 10562 ± 2731 steps/day versus 7411 ± 1746 steps/day. The threshold value for the number of steps based on the receiver operating characteristic (ROC) curve was 8981 steps/day, sensitivity was 0.75, and specificity was 0.79. [Conclusion] On the basis of our results, we suggest that walking more than 9000 steps/day is an excessive level of postoperative physical activity that aggravates hip joint pain.
Key words: Physical activity, Hip osteoarthritis, Hip joint pain

(This article was submitted Dec. 21, 2011, and was accepted Feb. 18, 2012)

INTRODUCTION

In Japan, most cases of hip joint osteoarthritis (OA) are secondary disorders resulting from congenital dislocation of the hip or acetabular dysplasia, and there is a higher prevalence in females than in males (0–2.0% in males and 2.0–7.5% in females) [1, 2)]. The incidence of primary OA is extremely low at less than 0.65% overall[3)], but the risk of occurrence is deemed high in occupations where heavy objects weighing 25 kg or more are carried each day[4)]. In Europe and North America, the risk is also high for individuals with a body mass index (BMI) of >25 kg/m^2 and in athletic running, and high-level sports is also reported as a risk factor for the occurrence of primary OA[5, 6)]. Hard exercise is cited as a risk factor for disease progression and has been correlated to loosening of artificial joints[7)]. Large amounts and high intensities of daily physical activity may also lead to joint degeneration, but as yet there has been no clarification of either the actual levels of physical activity or routine levels of physical activity believed to place stress on the hip joints.

As a surgical treatment for secondary OA, we have performed Chiari pelvic osteotomy with femoral valgus osteotomy, a joint preserving surgery[8)], instead of total hip arthroplasty. To prevent progression of OA following surgery, adequate postoperative physical therapy[9)] and appropriate advice regarding daily physical activity should be provided.

The purpose of this study was to clarify the appropriate postoperative physical activity levels, which do not overload the hip joint, by examining the relationship between physical activity level and hip joint pain in hip OA patients.

SUBJECTS AND METHODS

The subjects were 52 females who had unilateral OA of the hip joint and underwent Chiari pelvic osteotomy with femoral valgus osteotomy. The subjects having painful hip joints were classified according to the Kellgren and Lawrence (K/L) osteoarthritis classification, and all subjects were categorized as Grade 3 or 4. Their mean age was 53.1 ± 4.3 (mean ± SD) years, their mean postoperative period was 43.9 ± 18.1 months (minimum postoperative period, 12 months), and their mean BMI was 21.6 ± 2.8 kg/m^2. Subjects with neurological disease or joint disease in addition to that of the hip joints were excluded from this study. This study was approved by the Kagoshima University Ethical Review Board. Informed consent was received from all the subjects.

Physical activity levels were evaluated using an activity recorder (Lifecorder EX; Suzuken Co., Ltd; Nagoya, Japan; 72.5 × 41.5 × 27.5 mm, 60 g), which recorded the number of steps and duration of activity according to exercise intensity. Lifecorder EX contains a built-in accelerometer and can distinguish 10 levels of exercise intensity based on the magnitude of acceleration of movement at 4-s intervals. Levels 1–3 (low intensity activity: LA) measured by this instrument are 1.8–3.6 METs, levels 4–6 (moderate intensity activity: MA) are 3.6–5.2 METs, and levels 7–9 (high intensity activity: HA) are 6.1–9.0 METs[10]. It is reported that Lifecorder EX is a reliable instrument for this type of measurement[11, 12].

The Lifecorder EX was attached to the spina iliaca anterior superior of each subject for 3 days between Monday and Friday, excluding times of sleep and bathing, and was collected by mail. Recorded data were downloaded to a computer, and the number of steps and the average value of activity time and time ratio (LA%, MA%, HA%=(active time / total active time)× 100) according to exercise intensity were calculated. Data from portions of the day when daytime activity was not recorded for 3 or more hours were excluded.

The radiographs acquired at the time of follow-up showed that there was no contact of the subchondral bone of the acetabulum with the femoral head in the hip joint spaces. The acetabular head index (AHI) and Sharp angle were measured based on the hip joint antero-posterior radiograph acquired at the time of follow-up. Femoral head morphology was evaluated by calculating the roundness index13), with an index of 50 representing a perfectly spherical head, and progressively larger indices representing increasingly stronger coxa plana. The head roundness index was calculated as follows. The baseline joining the left and right tear drops was moved upward in parallel fashion until the baseline touched the superior aspect of the head. From this point of contact, a line was drawn perpendicular to the baseline, and the distance from the intersection with the baseline to the interior edge of the head was divided by the transverse diameter of the head and expressed as a percentage (Fig. 1).

Pain was evaluated using the pain index of the Harris Hip Score[14], in which a score of 44 describes pain as "none, or ignorable it," 40 as "slight, occasional, no compromise in activity," 30 as "mild pain, no effect on average activities, rare moderate pain with unusual activity, may take aspirin," 20 as "moderate pain, tolerable but makes concessions to pain, some limitations of ordinary activity or work may require occasional pain medication stronger than aspirin," 10 as "marked pain, serious limitation of activities," and 0 as "totally disabled, crippled, pain in bed, bedridden." Thus, higher scores represent less pain. The definition of the pain group is a score of ≤ 30 with duration of the same pain for a week before the examination day. Subjects were given a thorough explanation of the evaluation criteria, and completed a survey form during the 3 days they wore the Lifecorder EX. The form and recorder were returned by postal mail. Subjects with a score of ≥ 40 were assigned

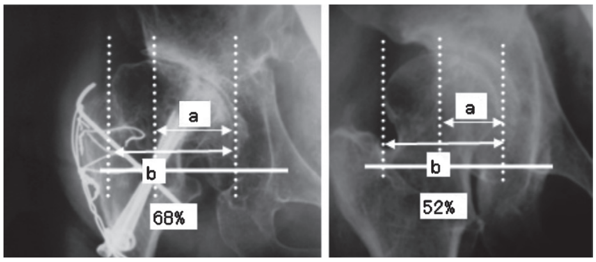

Fig. 1. The roundness index was calculated as the ratio of the distances from the medial border to the top of the femoral head and the medial border to the lateral border of the femoral head. (a/b×100%).

to the no-pain group, and those with a score of ≤ 30 were assigned to the pain group, and physical activity levels were calculated for each group. Information about employment status (unemployed or employed) exercise habit, and physical activity connected with employment was obtained by interview.

Measured values of the no-pain group and the pain group were analyzed using Student's *t*-test and the Mann–Whitney test. The receiver operating characteristic (ROC) curve was used to determine threshold values for optimal classifications of significant values in the no-pain and pain groups, and the area under the curve (AUC) was calculated. SPSS ver. 14.0 J was used for all statistical analyses. A P-value less than 5% was considered significant.

RESULTS

There were no significant differences between the groups in age, postoperative period, or BMI. Significant differences were not observed in the Sharp angle, AHI, or roundness index, which were evaluated using radiographs (Table 1).

On the pain index of the Harris Hip Score, 23 patients had a score of 44 and 7 had a score of 40 in the no-pain group, while 18 had a score of 30, 4 had a score of 20 and no patients had a score of 20 to 0 in the pain group. In the no-pain group, 5 patients were employed in a sitting occupation and the rest were housewives with no exercise habit. In the pain group, 7 were employed in a sitting occupation, 3 in standing/walking occupations, and the rest were 8 housewives with exercise habit and 4 without exercise habit.

The number of steps per day was 7411 ± 1746 in the no-pain group and 10562 ± 2731 in the pain group, revealing a significant difference ($p<0.01$). Based on the time ratio and according to exercise intensity, a significant difference between the 2 groups was not observed for LA%, MA%, and HA%. However, LA duration and MA duration were significantly higher in the pain group, 89.5 ± 26.0 min, than in the no-pain group, 23.2 ± 11.2 min, demonstrating significantly longer physical activity than the pain group ($p<0.01$). There was no significant difference in HA duration, during which exercise intensity was high (Table 2).

ROC curves were then determined for the 3 values representing significant intergroup differences: number of steps,

Table 1. Patient characteristics

	Total sample (n=52) Mean (SD)	no-pain group (n=30) Mean (SD)	pain group (n=22) Mean (SD)
Age (years)	53.1 (4.3)	52.7 (4.3)	51.0 (3.8)
Time from surgery (months)	43.9 (18.1)	46.0 (19.1)	41.0 (13.9)
Body Mass Index (kg/m^2)	21.6 (2.8)	21.3 (2.9)	21.7 (1.3)
Sharp angle°	40.6 (3.4)	40.8 (3.6)	40.1 (3.3)
AHI (%)	83.1 (11.4)	82.6 (11.7)	84.3 (11.4)
Femoral head sphericity index (%)	59.3 (7.1)	59.0 (7.6)	60.2 (5.6)

LA duration, and MA duration. In the best-fit regression models of the ROC curve, (LA duration AUC 0.77 ($p<0.05$), and MA duration AUC0.72 ($p<0.05$)), the number of steps exhibited the highest AUC 0.84 ($p<0.01$), and a threshold value of 8981 steps/day. True positivity (i.e., sensitivity) above the threshold value for the pain group was 75%, and true negativity (i.e., specificity) below the threshold value for the no-pain group was 79% (Fig. 2).

DISCUSSION

Most studies which have examined physical activity duration in Japan have focused on the maintenance and improvement of health resulting from a lifestyle-related disease[15], and no reports are available concerning the relationship between physical activity level and hip joint pain in patients with OA of the hip joint. A report on the relationship between age and physical activity level states that the number of steps per day was 7762 ± 3301steps at an age of 52.6 ± 6.3 years, 7257 ± 2623 steps at an age of 65.0 ± 5.0 years, and 5003 ± 3182 steps at an age of 78.0 ± 8 years [16]. By using a pedometer, Tudor-Locke et al.[17, 18] classified the amounts of physical activities into 5 levels as follows: limited activity (2500–4999 steps/day), low active (5000–7499 steps/day), somewhat active (7500–9999 steps/day), active (10000–12499 steps/day), and highly active (>12500 steps/day). At 7411 ± 1746 steps/day, the number

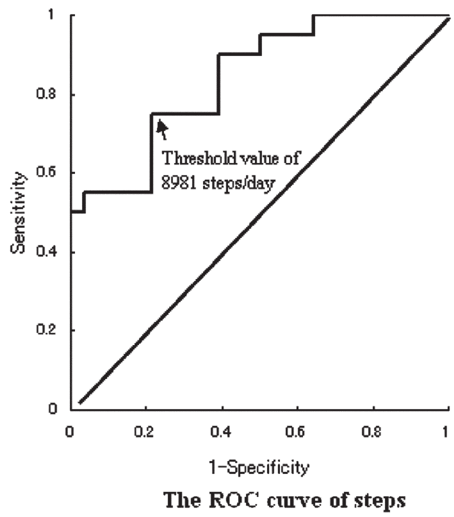

Fig. 2. A threshold value of 8981 steps/day. True positivity above the threshold value for the pain group was 75%, and true negativity below the threshold value for the no-pain group was 79%. The asymptotic significance level was 0.0001.

Table 2. Physical activity of the no-pain and pain groups

Ambulation Measure	Total sample (n=52) Mean (SD)	no-pain group (n=30) Mean (SD)	pain group (n=22) Mean (SD)
Steps/day	8724 (2689)	7411 (1746)	10562 (2731)*
Time by exercise intensity			
LA duration (min/day)	77.2 (23.6)	67.4 (16.1)	89.5 (26.0)*
MA duration (min/day)	17.9 (10.1)	14.1 (8.1)	23.2 (11.2)*
HA duration (min/day)	1.4 (1.7)	1.0 (1.6)	1.8 (1.7)
Total (min/day)	96.4 (29.3)	82.5 (20.4)	115.9 (29.1)*
Time ratio by exercise intensity			
LA %	80.6 (9.8)	82.3 (8.1)	78.3 (9.2)
MA %	18.0 (9.4)	16.4 (8.1)	20.2 (8.8)
HA %	1.4 (1.3)	1.3 (2.2)	1.6 (1.4)

*$p<0.01$.

of steps in the no-pain group was "low active" according to the Tudor–Locke classification, and this number was the same for healthy individuals of the same age. In the pain group, however, the daily number of steps was 10562 ± 2731, which is considered to be the "active" level, and the number was larger than that of healthy individuals of the same age. Data sampling was usually performed over 3 days. Measurement should be done over a period of at least 1 week, including the weekend, during which subjects tend to be less active, to obtain reliable measurements of physical activity[19]. It should thus be noted that, since the present data were obtained over 3 days during which the subjects were relatively active, the data might not directly reflect the overall physical activity and the actual activity might have been lower.

The present results show high physical activity in the pain group. According to Hirata et al. [20], a large proportion of individuals with deteriorating joints were individuals who were not working, and these individuals took 5105 ± 1438 steps/day. Also, a large proportion of individuals with good joints were individuals who were working, and these individuals were employed in jobs that involved standing / walking occupation and they took 8518 ± 2250 steps. In the present study, individuals with deteriorating joints had lower levels of physical activity, but individuals with good joints had increased levels of physical activity since they had no such pain preoperatively.

We observed significant differences between the no-pain group and the pain group in LA duration, MA duration, and number of steps. In a best-fit regression model for the ROC curve for these 3 factors, number of steps had the highest AUC (0.84), with a threshold value of 8981 steps/day, a sensitivity of 0.75, and a specificity of 0.79.

According to a study by Lane et al.[21] of 745 postmenopausal white females aged ≥ 65, 23.6% of the subjects with hip joint pain underwent total hip arthroplasty (THA), but only 2.7% of those without hip joint pain had THA. A 6 year follow-up study of 1904 K/L Grade I or higher patients aged ≥55 years also radiographically showed progression of OA of the hip joint in 13.1% of cases, of which 35.8% of cases underwent THA[22]. Prognostic factors for major OA progression were reported as having an odds ratio of 24.3 when K/L Grade II or greater hip joint pain was present; thus, hip joint pain is a risk factor for OA progression. It was reported that the 15 year implant survival rate in THA is 72% in young patients (age, 24–55 years; mean, 44 years) and 86.3% in elderly patients (age, 56–82 years; mean, 65 years), and that young age may be a risk factor for loosening or system failure of THA because young patients have high activity levels in daily life[23, 24]. In the present study, in the pain group, an increase in the number of steps was associated with regular physical activity due to employment or exercise habit. It's impossible to limit the number of the steps in employment, however, we should give information and try to prevent aggravation of hip joint pain.

In the present study, the amounts of postoperative daily physical activities in hip joint OA patients who had underdone Chiari pelvic osteotomy were determined. Based on our results, we suggest a threshold value of approximately 9000 steps/day is an excessive level of postoperative physical activity that aggravates hip joint pain.

As cross-sectional research, our study is limited to proposing that joint pain caused by an increased level of physical activity may cause progression of joint disease; however, we also see potential merit in the suggestion that current levels of physical activity in OA as well as the relationship between physical activity level and hip joint pain may serve as indices for excessive levels of physical activity. Patient education is required about appropriate levels of physical activity. We plan to conduct a tracking study to investigate the relationship between pain and progression of degenerative hip joint change.

REFERENCES

1) Yoshimura N, Campbell L, Hashimoto T, et al.: Acetabular dysplasia and hip osteoarthritis in Britain and Japan. Br J Rheumatol, 1998, 37: 1193–1197. [Medline]
2) Inoue K, Wicart P, Kawasaki T, et al.: Prevalence of hip osteoarthritis and acetabular dysplasia in french and japanese adults. Rheumatology, 2000, 39: 745–748. [Medline]
3) Nakamura S, Ninomiya S, Nakamura T: Primary osteoarthritis of the hip joint in Japan. Clin Orthop Relat Res, 1989, 241: 190–196. [Medline]
4) Yoshimura N, Sasaki S, Iwasaki K, et al.: Occupational lifting is associated with hip osteoarthritis: a Japanese case-control study. J Rheumatol, 2000, 27: 434–440. [Medline]
5) Lievense AM, Bierma-Zeinstra SM, Verhagen AP, et al.: Influence of obesity on the development of osteoarthritis of the hip: a systematic review. Rheumatology, 2002, 41: 1155–1162. [Medline]
6) Lievense AM, Bierma-Zeinstra SM, Verhagen AP, et al.: Influence of sporting activities on the development of osteoarthritis of the hip: a systematic review. Arthritis Rheum, 2003, 49: 228–236. [Medline]
7) Weller IM, Kunz M: Physical activity and pain following total hip arthroplasty. Physiotherapy, 2007, 93: 23–29.
8) Koyama K, Higuchi F, Inoue A: Modified Chiari osteotomy for arthrosis after Perthes' disease. 14 hips followed for 2–12 years. Acta Orthop Scand, 1998, 69: 129–132. [Medline]
9) Nagai Y, Ueda N, Nogami S, et al.: Objective Guideline for Exercise Therapy after Chiari pelvis osteotomy operation. Rigakuryouhougaku, 2003, 30: 362–370 (in Japanese).
10) Kumahara H, Schutz Y, Ayabe Y, et al.: The use of uniaxial acceleromrtry for the assessment of physical-activity-related energy expenditure: a validation study against whole-body indirect calorimetry. Br J Nutr, 2004, 91: 235–243.
11) Schneider PL, Crouter SE, Bassett DR: Pedometer measures of free-living physical activity: comparison of 13 models. Med Sci Sports Exerc, 2004, 36: 331–335. [Medline]
12) Crouter SE, Schneider PL, Karabulut M, et al.: Validity of 10 electronic pedometers for measuring steps, distance, and energy cost. Med Sci Sports Exerc, 2003, 35: 1455–1460. [Medline]
13) Okano K, Enomoto H, Osaki M, et al.: Outcome of rotational acetabular osteotomy for early hip osteoarthritis secondary to dysplasia elated to femoral head shape: 49 hips followed for 10–17 years. Acta Orthop, 2008, 79: 12–17. [Medline]
14) Söderman P, Malchau H: Is the Harris hip score system useful to study the outcome of total hip replacement? Clin Orthop Relat Res, 2001, 384: 189–197. [Medline]
15) Ohkawara K, Tanaka S, Miyachi M, et al.: A dose-response relation between aerobic exercise and visceral fat reduction: systematic review of clinical trials. Int J Obes, 2007, 31: 1786–1797.
16) Bohannon RW: Number of pedometer-assessed steps taken per day by adults: a descriptive meta-analysis. Phys Ther, 2007, 87: 1642–1650. [Medline]
17) Tudor-Locke C, Hatano Y, Pangrazi RP, et al.: Revisiting "how many steps are enough?" Med Sci Sports Exerc, 2008, 40: S537–S543. [Medline]
18) Tudor-Locke C, Jonson WD, Katzmarzyk PT: Accelerometer-determined step per day in US adults. Med Sci Sports Exerc, 2009, 41: 1384–1391. [Medline]
19) Matthews CE, Ainsworth BE, Thompson RW, et al.: Sources of variance

in daily physical activity levels as measured by an accelemeter. Med Sci Sports Exerc, 2002, 34: 1376–1381. [Medline]
20) Hirata S, Ono R, Yamada M, et al.: Ambulatory physical activity, disease severity, and employment status in adult women with osteoarthritis of the hip. J Rheumatol, 2006, 33: 939–945. [Medline]
21) Lane NE, Nevitt MC, Hochberg MC, et al.: Progression of radiographic hip osteoarthritis over eight years in a community sample of elderly white women. Arthritis Rheum, 2004, 50: 1477–1486. [Medline]
22) Reijman M, Hazes JM, Pols HA, et al.: Role of radiography in predicting progression of osteoarthritis of the hip: prospective cohort study. BMJ, 2005, 330: 1183. [Medline]
23) Hartofilakidis G, Karachalios T, Karachalios G: The 20-year outcome of the charnley arthroplasty in younger and older patients. Clin Orthop Relat Res, 2005, 177–182. [Medline]
24) Chougle A, Hemmady MV, Hodgkinson JP: Long-term survival of the acetabular component after total hip arthroplasty with cement in patients with developmental dysplasia of the hip. J Bone Joint Surg Am, 2006, 88: 71–79. [Medline]