INTRODUCTION

Hip osteoarthritis (OA) is a common condition worldwide, particularly in older individuals. Radiographic deterioration over time is common, although the rate varies from person to person. The pain associated with hip OA usually limits function, so therapy for hip OA has two major objectives: to relieve pain and to preserve hip functions.

From a general literature review, interventions for hip OA use surgery in 74% of cases, pharmaceuticals in 19%, and non-pharmaceuticals in 7%. For total hip arthroplasty (THA), the latest second-generation non-cemented stems with a proximal circumferential porous or hydroxyapatite (HA) coating are considered to be suitable for young OA patients, but polyethylene wear, liner problems, and osteolysis around THAs are major problems with modern non-cemented acetabular components. Pharmacologic therapy is effective in reducing pain and improving function of the hip but has side effects.

As a conservative therapy for hip OA, we developed the WISH-type hip brace. Suitable candidates for this therapy are patients that experience relief from hip pain during weight-bearing gait by applying manual pressure on the greater trochanter. We have previously described the positive effects of the brace on the hip function of patients with hip OA. The relief of pain in the stance phase by use of the brace equipment results in strong steps in the early stance phase, as demonstrated by force-plate analyses. Another direct effect of this brace is significant improvement of posture. Furthermore, the average time to complete the Timed Up and Go test (TUG) was significantly shorter in patients with the brace, especially during the turning phase.

 OBJECTIVES: The WISH-type S-form hip brace (WISH brace) has significantly improved hip function and functional mobility in patients with hip osteoarthritis (OA). However, most patients later undergo surgery. The main purpose of this study was to evaluate how long the orthosis can be effectively used by patients with hip OA, and to reveal the associated prognostic factors. METHODS: This prospective study examined the survival curve of the equipment by using surgery as an endpoint and investigated how the duration of use affects patients. Harris Hip Score, muscle strength, and the Timed Up and Go test (TUG) were evaluated as prognostic factors. RESULTS: By drawing the survival curves of 26 patients, approximately one third were expected to be still using the brace after 7 years. A rapid decrease in use was observed at around 1 year. A significant difference between patients with and without bracing at 1 year was found for the TUG result with the unaffected leg inside (ULI) at the start of bracing. A cut-off value of 9.5 s for the TUG with ULI significantly differentiated patients with and without bracing at 1 year, suggesting a possible predictor of brace survivorship in the early phase. CONCLUSIONS: The TUG with ULI with a cut-off value of 9.5 s, or at most 10 s, may be a possible predictor of persistence of brace use in the early phase.
This improvement of functional mobility may be related to augmentation of the hip-abduction muscle strength, acquired by daily walking exercise. Although both direct and indirect positive changes have been observed in response to the WISH-type brace, some patients underwent surgery in the follow-up course of this orthosis therapy. The purpose of this brace is not to replace surgical management forever, but rather to delay the need for it.

The main purpose of this study was to evaluate how long the orthosis offers benefit to patients with hip osteoarthritis. Using surgery as an endpoint, we investigated how the brace affected the subjects’ overall long-term survival and the shape of the survival curve.

MATERIALS AND METHODS

Subjects

Patients with symptoms of unilateral OA of the hip were referred to the outpatient clinic of our institution. Hip OA was defined according to the clinical criteria of the American College of Rheumatology. Patients in whom the hip pain induced by weight bearing during gait was notably reduced by manual pressure on the greater trochanter were recruited for this investigation. Subjects were excluded if they were on a waiting list for hip replacement, had previously undergone hip replacement, or used a WISH brace for both hips. The radiological grade of OA was estimated according to the grading system proposed by Crowe et al., and patients with radiological grade III or IV were excluded. In addition, the Kellgren and Lawrence grade (K/L grade) and lateral center edge angle (LCE angle) were evaluated.

Fifty-one patients accepted this orthosis therapy with WISH-type hip brace during the clinical trial period from October 2006 to September 2015. The TUG was performed by 26 patients from August 2007 to April 2013, and these participants were analyzed until September 2015. Age, height, weight, medical history, complications, and drug therapy were recorded for each patient.

This study was conducted after approval by the Gunma University Hospital Clinical Research Review Board (Approval No. 515). Written informed consent for the study was obtained from each participant.

Hip Brace

The WISH-type hip brace (PO Support, Takasaki, Gunma, Japan) was manufactured based on the design concept of the Wakayama Medical College. We improved the brace to make it lighter and more compact, and named this version the WISH-type. The resultant hip brace weighed around 0.9 kg, and the lateral prominence caused by the lateral bar was reduced. As previously reported, the brace consists of a pelvic portion, an S-form portion, and a lateral bar connecting them. The pelvic portion of the hip brace holds it in the correct position. The greater trochanter pad serves as a fulcrum and pushes the great trochanter inward when the affected limb is abducted or bears weight. The lateral bar has two joints, allowing flexion, extension, and abduction of the affected hip.

Exercise Therapy

Patients fitted with the WISH brace were required to walk for at least 30 min every day to strengthen muscles around the hip joint required for gait. Weight exercises for strengthening hip muscles were suggested as home exercise. The performance of gait exercise in water was also recommended.

Hip Function Assessments

Hip function was evaluated using the Harris Hip Score (HHS) as the primary outcome measure. The HHS consists of four variables: pain, functional capacity, range of motion, and deformity. The maximum score is 100, and scores below 70 reflect poor function (poor category).

Timed Up and Go Test

The TUG measures, in seconds, the time taken by an individual to stand up from a standard armchair (approximate seat height of 46 cm), walk a distance of 3 m, turn, walk back to the chair, and sit down again. The subjects wore their regular footwear. When performing the TUG, subjects were given verbal instructions to stand up from the chair, walk 3 m as quickly as possible, pass around a cone on the floor, walk back, and sit down. Each subject performed the TUG separately with right and left turns. When a patient walked and rounded the cone with the equipped leg inside (ELI), the TUG with spin turn was evaluated. Conversely, when the test was performed with the unequipped leg inside (ULI), the TUG with step turn was evaluated. A stopwatch was used to time the performance.

Muscle Strength Assessment around the Hip

Muscle strength testing was performed as described previously. Muscle strength testing was performed with the patient lying on an examination table according to the method described by Thorborg et al. using the Power track II Commander Hand Held Dynamometer (HHD) (ITECK Medical, Midvale, UT, USA). The HHD was calibrated on
RESULTS

Patient Characteristics and Follow-up

A total of 26 patients (1 male, 25 females) were recruited (Table 1). The patients ranged in age from 29 to 74 years, and the average age was 53.7 years (SD, 10.7 years). All patients had osteoarthritis secondary to acetabular dysplasia. Twelve patients had right-side involvement and 14 had left-sided involvement. The radiological grade was determined according to Crowe et al. Seventeen patients were assessed as grade I and 9 patients were grade II. For K/L grade, 2 patients were grade II, 8 patients were grade III, and 16 patients were grade IV. The LCE angle was 2.2 ± 1.1 degrees. Medical history and complications included lumbar spinal canal stenosis in 3 patients, lumbar disk herniation in 2 patients, spine osteoarthritis in 5 patients, osteoporosis in 1 patient, cervical spondylosis in 2 patients, and lumbar spondylosis in 1 patient. Drug therapy included the use of NSAIDs in 19 patients, prostaglandin E1 in 9 patients, and muscle relaxant in 5 patients. Of the 26 patients, 13 received THA and 1 received rotational acetabular osteotomy (RAO). The average time to surgery was 26.9 (SD 19.4) months.

Examination of Survivorship Curve

Figure 1 shows the survivorship curve of the 26 patients, using surgical intervention as an endpoint of the survival of the brace equipment. A relatively rapid decrease in the curve is seen at around 12 months. Interestingly, one third of patients were expected to use the brace for 7 years.

Differences in Initial Physical Functions between Over-1Y Group and Interrupted Group

Because the survival curve showed a rapid decrease at around 1 year, we examined which of the parameters evaluated at the starting point affected the persistence of the brace over 1 year. Comparing the Over-1Y group (n=20) and the Interrupted group (n=6), there were no significant differences in HHS (56.9±8.3 vs 57.8±9, P=0.83), age (53.6±10.6 vs 54±12.1 years, P=0.93), height (156.4±5.4 vs 152.3±5.7 cm, P=0.12), weight (54.4±8.2 vs 56±4.4 kg, P=0.53), body mass index (BMI; 22.2±3.0 vs 24.3±2.9 kg/m², P=0.15), or muscle strength (Table 2). However, the TUG result with ULI in the Over-1Y group (7.94 ± 1.27 s) was significantly faster than that for the Interrupted group (9.37 ± 1.65 s) (Fig. 2A), whereas the TUG result with ELI showed no significant difference between the two groups (8.19 ± 1.76 vs 9.12 ± 1.37 s, P=0.25) (Fig. 2B).
Change in HHS in Over-1Y Group and Interrupted Group during the First Year

In the Over-1Y group, the mean HHS score significantly improved from $56.9 \pm 8.3$ to $82.2 \pm 11.0$ ($P<0.01$) at 1 year. In the Interrupted group, no significant improvement of HHS was observed before surgery (from $65.7 \pm 13.8$ to $57.8 \pm 8.97$; $P=0.365$).

Cut-off Value for TUG with ULI

Focusing on the TUG with ULI, we postulated a walking speed threshold of 9.5 s and divided the cohort into two groups: 9.5 s or slower (slower group) and faster than 9.5 s (faster group). As shown in Fig. 3, the survival rate decreased gradually in the faster group. In contrast, the survival rate in the slower group decreased rapidly over 12 months, although the log rank test did not indicate a significant difference ($P=0.08$). However, Fisher’s exact test with a cut-off value of 9.5 s showed a significant difference between the two groups ($P<0.034$), suggesting that 9.5 s for TUG with ULI may be a predictor of persistence of brace use in the short term.

DISCUSSION

The survivorship curve for persistence of the WISH-type hip brace use showed a relatively rapid decrease around 12

Table 1. Patient characteristics

| Patient number | Age (years) | Height (cm) | Weight (kg) | BMI (kg/m²) | Radiological gradea | Follow-up timeb (months) | Operation | HHS Start | HHS 1 yearb |
|----------------|-------------|-------------|-------------|--------------|----------------------|--------------------------|-----------|-----------|-------------|
| 1              | 48          | 150         | 51.6        | 22.9         | I                    | 47                       | THA       | 49.7      | 75.7        |
| 2              | 41          | 162         | 64          | 24.4         | II                   | 56                       | THA       | 46        | 88          |
| 3              | 59          | 167         | 58          | 20.8         | I                    | 62                       | THA       | 55        | 94          |
| 4              | 70          | 155         | 63          | 26.2         | I                    | 85                       | -         | 51        | 90          |
| 5              | 52          | 154         | 50          | 21.1         | II                   | 78                       | -         | 60.8      | 75.7        |
| 6              | 59          | 157         | 42          | 17           | II                   | 62                       | -         | 48.7      | 66          |
| 7              | 50          | 153         | 44.5        | 19           | I                    | 62                       | -         | 47        | 95          |
| 8              | 59          | 148         | 46.5        | 21.2         | I                    | 30                       | THA       | 56        | 76          |
| 9              | 50          | 150         | 46          | 20.4         | II                   | 56                       | -         | 63        | 82.7        |
| 10             | 49          | 153         | 65          | 27.8         | II                   | 35                       | THA       | 50        | 95.7        |
| 11             | 38          | 158         | 58          | 23.2         | II                   | 39                       | THA       | 47.7      | 94          |
| 12             | 54          | 156         | 72          | 29.6         | I                    | 45                       | -         | 65.7      | 69          |
| 13             | 51          | 167         | 58          | 20.8         | I                    | 37                       | THA       | 66        | 60          |
| 14             | 57          | 163.5       | 65          | 24.3         | I                    | 43                       | -         | 61        | 81          |
| 15             | 65          | 152         | 49          | 21.2         | I                    | 16                       | THA       | 59        | 93          |
| 16             | 52          | 154         | 48          | 20.2         | I                    | 41                       | -         | 55.7      | 91.7        |
| 17             | 50          | 161.5       | 52          | 19.9         | II                   | 39                       | -         | 76        | 78          |
| 18             | 64          | 155         | 54.5        | 22.7         | I                    | 35                       | -         | 62.7      | 76          |
| 19             | 29          | 155         | 50          | 20.8         | I                    | 32                       | -         | 49.7      | 93          |
| 20             | 74          | 157         | 50          | 20.3         | I                    | 29                       | -         | 68        | 69.7        |
| 21             | 66          | 143         | 57          | 27.9         | I                    | 12                       | THA       | 62.7      | 60c         |
| 22             | 43          | 153         | 55          | 23.5         | II                   | 7                        | THA       | 60        | 79c         |
| 23             | 65          | 152.5       | 60          | 25.8         | I                    | 7                        | THA       | 66        | 53.3c       |
| 24             | 58          | 149         | 56          | 25.2         | II                   | 11                       | THA       | 53.3      | 85c         |
| 25             | 36          | 158         | 48          | 19.2         | I                    | 9                        | RAO       | 63        | 51c         |
| 26             | 56          | 158         | 60          | 24           | I                    | 8                        | THA       | 41.7      | 65.7c       |
| Average        | 53.7        | 155.4       | 54.7        | 22.7         |                       | 37.8                     |           | 57.1      | 82.2        |
| SD             | 10.7        | 5.6         | 7.4         | 3.1          |                       | 22                       |           | 8.3       | 11          |

a Radiological grade was evaluated according to Crowe et al.\(^{13}\)
b Time after starting brace use.
c Measurement taken just prior to operation.
months, although continuous use by one third of patients was expected to be seen for 7 years. The patients in the Over-1Y group showed shorter times for the TUG with ULI at entry. Interestingly, HHS was significantly improved after 1 year in the Over-1Y group, whereas this improvement was not observed in the Interrupted group. Using a walking speed threshold of 9.5 s for the TUG with ULI, the drop in the survivorship over 12 months was much less pronounced in the faster group. Fisher’s exact test with a cut-off value of 9.5 s showed a significant difference between the fast and slow groups.

There are few studies describing the effects and limitations of hip braces for hip OA. In addition, there are few known scientific analyses on the persistence of bracing in hip OA patients. Although a review article about the hip brace was published recently, the role of the brace was focused on post-operative support after THA. We have scientifically and biomechanically investigated the WISH-type hip brace preoperatively. Another hip brace based on a new concept has also been reported. To our best knowledge, the present report is the first analysis of the persistence of hip bracing (i.e., the longevity of the brace until surgery). It is noteworthy that one third of the patients were expected to use the hip brace continuously for more than 7 years. Although the purpose of hip bracing is not to permanently replace surgical management, it has the potential to help patients avoid invasive surgery such as THA up until natural death without suffering the effects of hip disability in the interim.

The survivorship curve for persistence of the brace depicted a relatively rapid decrease at around 12 months, indicating the existence of patients in whom the effect of the brace was small or was lost within 1 year. This was confirmed by the hip functional scores that showed less improvement in HHS in the Interrupted group at 1 year, whereas the HHS

![Survivorship curve for all patients. Mo, months.](image)

**Fig. 1.** Survivorship curve for all patients. Mo, months.

**Table 2.** Comparison of average muscle strength between Over-1Y group and Interrupted group

| Muscle measure | Affected (Nm/kg) | Unaffected (Nm/kg) |
|----------------|------------------|-------------------|
|                | Over-1Y group    | Interrupted group | P value | Over-1Y group    | Interrupted group | P value |
|                | Average | SD    | Average | SD    | Average | SD    | Average | SD    | Average | SD    |
| FLEX           | 0.49    | 0.21  | 0.37    | 0.08  | 0.28    | 0.78  | 0.22    | 0.5    | 0.16    | 0.07  |
| ABD            | 0.38    | 0.14  | 0.42    | 0.1   | 0.73    | 0.53  | 0.16    | 0.46   | 0.09    | 0.5   |
| ADD            | 0.37    | 0.13  | 0.4     | 0.17  | 0.75    | 0.42  | 0.14    | 0.41   | 0.12    | 0.95  |
| K-EXT          | 0.45    | 0.19  | 0.47    | 0.04  | 0.88    | 0.75  | 0.2     | 0.63   | 0.1     | 0.21  |
in the Over-1Y group improved significantly. There was a significant difference in the TUG result with ULI between these groups. The improvement in the TUG result through use of the WISH-type hip brace was significant with ULI but not for ELI for the patients with unilateral hip OA. When a patient walked and rounded the cone with ULI, the TUG with step turn was evaluated for the affected limb. In the stepping strategy, hip abductor muscles in the stance leg control the duration of swing of the opposite leg. During turning with ULI, the affected hip joint rotates externally with abduction.

A short-term longitudinal study revealed that the inherent hip abduction muscle strength was improved by the WISH
brace to the same degree as the unaffected limb. Taken together, initial functional mobility evaluated from the TUG with ULI, which is mainly related to the abduction muscle strength, may be a predictor for the persistence of brace equipment use in the early phase, although the abductor muscle strength itself was not a direct predictor in the present study.

Fisher’s exact test with a cut-off value of 9.5 s showed a significant difference between the faster and slower groups. In addition, these two groups showed different Kaplan–Meier survival curves. Podsiadlo and Richardson reported that TUG results of less than 10 s could be used to identify freely independent individuals. Arnold and Faulkner reported a higher likelihood of frequent near-falls if TUG scores in older adults with hip osteoarthritis were over 10 s or if they were over the age of 75. Furthermore, Shumway-Cook et al. found that a TUG result of over 14 s in older adults indicates the risk of a fall. In the present study, the mean age of the participants was 53.7±10.7 years, which was lower than the subjects evaluated by Shumway-Cook et al. Taken together, 9.5 s, or 10 s at most, may be an appropriate cut-off value for the TUG, which is completed by walking as quickly as possible, when predicting the persistence of brace use in the early phase.

In summary, the survivorship curve of the equipment, using surgical intervention as an endpoint, revealed that one third of patients were expected to continue to use the brace for 7 years. Patients using bracing continuously for longer than 1 year were associated with significantly shorter times in the TUG using ULI at entry. When the walking speed threshold was taken as 9.5 s for the TUG with ULI, the survival rate decreased rapidly in the slower group over 12 months but decreased gradually in the faster group. Although this difference was not significant, Fisher’s exact test with a cut-off value of 9.5 s showed a significant difference between the two groups. This result suggests that a cut-off value of 9.5 s (or 10 s at most) for the TUG with ULI may be a predictor of persistence of brace use in the early phase.

No significant difference was observed in function scores or muscle strengths around the evaluated hip except for functional mobility. Given that muscle strength is related to functional mobility, more predictors of muscle strength should be extracted in further studies with larger numbers of subjects. One obvious limitation of the current study was the low number of subjects. In addition, we did not perform imaging evaluation before and after brace therapy intervention. However, we consider that the evaluation of joint space width in patients with OA of the hip is very important. Therefore, the use of imaging evaluations before and after brace therapy intervention is recommended for prosthesis prescription. This issue should be examined separately in future detailed studies.

CONCLUSION

The use of hip braces offers the possibility of avoiding invasive surgeries, such as THA, but must be carefully monitored over long periods of time. This outcome would be the ultimate and unexpected benefit of hip brace use for patients with hip OA.

ACKNOWLEDGMENTS

This work was supported in part by a Grant-in-Aid for Young Scientists JP18K17710 (E.S.) from the Japan Society for the Promotion of Science.

CONFLICTS OF INTEREST

The authors report no conflicts of interest.

REFERENCES

1. Bennell K: Physiotherapy management of hip osteoarthritis. J Physiother 2013;59:145–157. https://doi.org/10.1016/S1836-9553(13)70179-6, PMID:23896330
2. Lane NE: Clinical practice. Osteoarthritis of the hip. N Engl J Med 2007;357:1413–1421. https://doi.org/10.1056/NEJMcp0711112, PMID:17914042
3. Zhang W, Doherty M, Arden N, Bannwarth B, Bijlsma J, Gunther KP, Hauselmann HJ, Herrero-Beaumont G, Jordan K, Kaklamani P, Leeb B, Lequesne M, Lohmander S, Mazieres B, Martin-Mola E, Pavelka K, Pendleton A, Punzi L, Swoboda B, Varatojo R, Verbruggen G, Zimmermann-Gorska I, Dougados M, EULAR Standing Committee for International Clinical Studies Including Therapeutics (ESCISIT): EULAR evidence based recommendations for the management of hip osteoarthritis: report of a task force of the EULAR Standing Committee for International Clinical Studies Including Therapeutics (ESCISIT). Ann Rheum Dis 2005;64:669–681. https://doi.org/10.1136/ard.2004.028886, PMID:15471891
4. Eskelinen A, Remes V, Helenius I, Pulkkinen P, Nevalainen J, Paavolainen P: Uncemented total hip arthroplasty for primary osteoarthritis in young patients: a mid- to long-term follow-up study from the Finnish Arthroplasty Register. Acta Orthop 2006;77:57–70. https://doi.org/10.1080/17453670610045704, PMID:16534703

5. Sato T, Yamaji T, Inose H, Sekino Y, Uchida S, Usuda S, Takagishi K, Shirakura K, Watanabe H: Effect of a modified S-form hip brace, WISH type, for patients with painful osteoarthritis of the hip: a role in daily walking as a hip muscle exercise. Rheumatol Int 2008;28:419–428. https://doi.org/10.1007/s00296-007-0455-x, PMID:17899093

6. Sato T, Yamaji T, Inose H, Sato E, Yoshikawa A, Usuda S, Watanabe H: Extended application of WISH type S-form hip brace for patients with bilateral painful hip osteoarthritis: report of two cases. Prosthet Orthot Int 2009;33:173–178. https://doi.org/10.1080/03093640902829162, PMID:19365721

7. Yamaji T, Usuda S, Sato E, Yamaji T, Sekino Y, Watanabe H: Biomechanical analysis of gait in patients with painful osteoarthritis of the hip treated with WISH-type hip brace. J Orthop Sci 2009;14:423–430. https://doi.org/10.1007/s00776-009-1343-x, PMID:19662477

8. Sato E, Yamaji T, Sato T, Hasegawa M, Shirakura K, Yanagawa T, Watanabe H: Effect of the WISH-type hip brace on postural control in patients with osteoarthritis of the hip: evaluation using the cross test. Kita Kanto Med J 2016;66:103–110. https://doi.org/10.2974/kmj.66.103

9. Sato E, Yamaji T, Watanabe H: Effect of the WISH-type hip brace on functional mobility in patients with osteoarthritis of the hip: evaluation using the Timed Up & Go test. Prosthet Orthot Int 2012;36:25–32. https://doi.org/10.1177/0309364611427765, PMID:22095957

10. Sato E, Yamaji T, Watanabe H: Effects of the WISH-type S-form hip brace on muscle strength in patients with osteoarthritis of the hip: a short-term longitudinal study. Prog Rehabil Med 2019;4:20190015. https://doi.org/10.2490/prm.20190015, PMID:32789262

11. Watanabe H, Sato E, Yamaji T, Chigira Y: WISH-type hip brace for patients with osteoarthritis of the hip. Phys Med Rehabil Disabil 2021;7:1–4. https://doi.org/10.24966/PMRD-8670/100064

12. Altman R, Alarcón G, Appelrouth D, Bloch D, Borenstein D, Brandt K, Brown C, Cooke TD, Daniel W, Feldman D, Greenwald R, Hochberg M, Howell D, Ike R, Kapila P, Kaplan D, Koopman W, Marino C, McDonald E, McShane DJ, Medsger T, Michel B, Murphy WA, Osial T, Ramsey-Goldman R, Rothschild B, Wolfe F: The American College of Rheumatology criteria for the classification and reporting of osteoarthritis of the hip. Arthritis Rheum 1991;34:505–514. https://doi.org/10.1002/art.1780340502, PMID:2025304

13. Crowe MJ, Mani VJ, Ranawat CS: Total hip replacement in congenital dislocation and dysplasia of the hip. J Bone Joint Surg Am 1979;61:15–23. https://doi.org/10.2106/00004623-197961010-00004, PMID:365863

14. Kawamura T: Development of the S-form hip brace of Wakayama Medical College type for osteoarthritis of the hip [in Japanese]. Nippon Seikeigeka Gakkai Zasshi 1983;57:1665–1679. PMID:6676387

15. Harris WH: Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. J Bone Joint Surg Am 1969;51:737–755. https://doi.org/10.2106/00004623-196951040-00012, PMID:5783851

16. Podsadlo D, Richardson S: The timed “Up & Go”: a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc 1991;39:142–148. https://doi.org/10.1111/j.1532-5415.1991.tb01616.x, PMID:1991946

17. Shumway-Cook A, Brauer S, Woollacott M: Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. Phys Ther 2000;80:896–903. https://doi.org/10.1093/ptj/80.9.896, PMID:10960937

18. Thorborg K, Petersen J, Magnusson SP, Hölmich P: Clinical assessment of hip strength using a hand-held dynamometer is reliable. Scand J Med Sci Sports 2010;20:493–501. https://doi.org/10.1111/j.1600-0838.2009.00958.x, PMID:19558384

19. Sisto SA, Dyson-Hudson T: Dynamometry testing in spinal cord injury. J Rehabil Res Dev 2007;44:123–136. https://doi.org/10.1682/JRRD.2005.11.0172, PMID:17551866

20. Kaplan EL, Meier P: Nonparametric estimation from incomplete observations. J Am Stat Assoc 1958;53:457–481. https://doi.org/10.1080/01621459.1958.10501452
21. Mantel N: Evaluation of survival data and two new rank order statistics arising in its consideration. Cancer Chemother Rep 1966;50:163–170. PMID:5910392
22. Bennell KL, Hall M, Hinman RS: Osteoarthritis year in review 2015: rehabilitation and outcomes. Osteoarthritis Cartilage 2016;24:58–70. https://doi.org/10.1016/j.joca.2015.07.028, PMID:26707993
23. Kemker BP, Kankaria R, Patel N, Golladay G: Hip and knee bracing: categorization, treatment algorithm, and systematic review. J Am Acad Orthop Surg Glob Res Rev 2021;5:e20.00181–12. https://doi.org/10.5435/JAAOSGlobal-D-20-00181, PMID:34096901
24. Nérot A, Nicholls M: Clinical study on the unloading effect of hip bracing on gait in patients with hip osteoarthritis. Prosthet Orthot Int 2017;41:127–133. https://doi.org/10.1177/0309364616640873, PMID:27117011
25. Hase K, Stein RB: Turning strategies during human walking. J Neurophysiol 1999;81:2914–2922. https://doi.org/10.1152/jn.1999.81.6.2914, PMID:10368408
26. Arnold CM, Faulkner RA: The history of falls and the association of the timed up and go test to falls and near-falls in order adults with hip osteoarthritis. BMC Geriatr 2007;7:17. https://doi.org/10.1186/1471-2318-7-17, PMID:17610735