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Influence of hip joint dysfunction on motor disorders in Japanese patients with osteoarthritis of the hip: Assessment of the JHEQ and GLFS-25 scores and hip muscle strength

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ABSTRACT

Background: Motor disorders are caused by orthopedic problems that are mainly related to aging. These disorders can lead to a decline of physical activity and impairment of ADL. When evaluating a patient's motor function after treatment, it is necessary to determine whether or not the level of function is age-appropriate. To investigate the influence of hip joint dysfunction on motor disorders, we determined the JHEQ and GLFS-25 scores and performed muscle strength testing in female patients with hip osteoarthritis.
Methods: The subjects were 108 women who had received THA, 56 women scheduled for THA, and 64 women on conservative treatment. The JHEQ score (evaluation scale for hip joint function) and GLFS-25 score (evaluation scale for ADL) were determined and muscle strength testing was conducted at a routine outpatient visit.
Results: A strong correlation was found between the total JHEQ score and the GLFS-25 score ($r = -0.837$). Patients after THA and patients with successful conservative treatment aged 60–79 years showed similar motor function to healthy persons of the same age. There was a significant difference of straight leg raising and abduction strength (both $p < 0.01$) between patients in GLFS-25 levels 1–3 and patients in GLFS-25 levels 4–7.
Conclusion: While hip joint dysfunction has a strong influence on overall motor function, the patients after THA and patients with successful conservative treatment showed similar motor function to healthy persons of the same age. And patients with hip osteoarthritis must preserve or increase SLR strength to maintain adequate motor function.

1. Introduction

With aging of the population in many countries, the number of elderly persons is increasing worldwide and so is the number of people with declining physical function. It has been estimated that 20–30% of older persons have functional limitations and impairment of activities of daily living (ADL), and the prevalence of such impairment increases with age (Fried, Ferrucci, Darer, Williamson, & Anderson, 2004). Motor dysfunction is one of the reasons for declining physical activity and impairment of ADL. Low back pain and knee joint pain are frequent causes of motor dysfunction, and hip joint disease also makes an important contribution. While the extent to which hip joint dysfunction affects physical activity and ADL is unknown, comparing ADL and hip joint functional scores before and after treatment of hip disease might provide evidence about the influence of hip joint dysfunction on overall motor function.

Because the frequency and symptoms of motor dysfunction tend to increase with aging, the fact that motor function changes with age needs to be taken into consideration, so it is necessary to evaluate whether or not motor function is age-appropriate when assessing patients. Similarly, when making comparisons between before and after treatment, it seems important to consider whether the outcome is age-appropriate or not.

In Japan, hip joint function is often evaluated by using the Japanese Orthopaedic Association Hip Disease Evaluation Questionnaire (JHEQ), because it reflects the Asian lifestyle. The 25-question Geriatric Locomotive Function Scale (GLFS-25) was also established by the Japanese Orthopaedic Association, as a simple tool for determining the presence and severity of motor disorders based on questions related to daily life. The GLFS-25 has the advantage of available data on age-

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specific mean scores. It is well known that lower limb muscle strength, especially extensor muscle strength, has a considerable influence on daily activities, and recovery of lower limb strength is closely related to postoperative improvement of ADL after THA.

In this study, we used the JHEQ and GLFS-25 scores to evaluate the influence of hip joint dysfunction on overall motor dysfunction in patients with osteoarthritis of the hip (including those on conservative treatment, scheduled for THA, and post-THA), and to determine whether patients were able to achieve age-appropriate motor function after improvement of hip joint function. We also performed muscle strength testing to investigate whether muscle strength was related to the JHEQ and GLFS-25 scores.

2. Patients and methods

2.1. Subjects

The 228 subjects included 108 women who had received THA (Post-THA group), 56 women scheduled for THA (Pre-THA group), and 64 women on conservative treatment (Conservative group).

The underlying disease was osteoarthritis of the hip in all 228 patients and they underwent regular assessment at our outpatient clinic from April 2016 to March 2017. The following patients were excluded from this study: patients with loosening of the prosthesis, patient who had revision THA, and patients with collagen diseases. In addition, to clarify the effects of THA, patients with moderate to severe osteoarthritis of the contralateral hip joint (≥ grade 3 according to the Kellgren and Lawrence classification) were excluded from the Post-THA group. All patients were able to answer the JHEQ and GLFS-25 questionnaires without assistance. In the Post-THA group, the mean age was 71.5 years (range: 54 to 86 years) and the mean postoperative period was 7.9 years (range: 3 to 29 years). The mean age of the Pre-THA group was 64.9 years (range: 43 to 91 years) and that of the Conservative group was 63.4 years (range: 40 to 90 years). In the Conservative group, patients had moderate to severe osteoarthritis of the affected hip joint and did not want surgical treatment. The mean duration of the follow-up period from initial to last visit was 10.5 years (range: 3 to 26 years). These patients were recommended to perform exercise at home (isometric hip muscle exercises) and to walk as much as they could during daily life without causing pain. There were no restrictions on sports that had no adverse effects on the hip joint, such as swimming, light strength training, Tai Chi, cycling, aquatic aerobics, and yoga. The details of the home exercise program are described below.

Among the Post-THA group, the contralateral hip joint was normal and mild OA (≤ grade 2 assessed according to the Kellgren and Lawrence classification) in 55 patients and had already received THA in 53 patients. In the Pre-THA group, the contralateral hip was classified as normal and mild OA in 29 patients, while it showed moderate to severe OA in 13 patients and had already received THA in 14 patients. In the Conservative group, the contralateral hip was classified as normal and mild OA in 49 patients and showed moderate to severe OA in 15 patients (Table 1).

2.2. Measurement

The three evaluations (JHEQ score, GLFS-25 score, and muscle strength testing) were conducted at a routine outpatient clinic visit, with the JHEQ score and muscle strength being recorded as the lowest value obtained on each of the right and left sides.

This research has been approved by the IRB of the authors' affiliated institutions.

2.3. JHEQ (Japanese Orthopaedic Association Hip Disease Evaluation Questionnaire)

The JHEQ was developed by Japanese Orthopaedic Association to evaluate the state of hip joints for patients living Asian lifestyle (Matsumoto et al., 2012). In the Asian lifestyle, it is often necessary to flex the knees and hips fully, such as when using an Asian-style toilet, when sitting on the floor/getting up from the floor, and when sitting with the legs folded under the thighs. Some of the JHEQ items evaluate actions that require deep flexion and assess patient QOL from a multidimensional perspective. The JHEQ has three subscales [pain (28 points), movement (28 points), and mental health (28 points)], with higher scores indicating better performance for each subscale. In each of the subscales, questions are answered by choosing from 5 options (0, strongly agree; 1, agree; 2, uncertain; 3, disagree; 4, strongly disagree). Each item has a score from 0 to 4 points and the maximum total score is 84 points, with the left and right hips being assessed separately.

2.4. GLFS-25 (The 25-question Geriatric Locomotive Function Scale)

Japanese Orthopaedic Association developed he 25-question Geriatric Locomotive Function Scale (GLFS-25), that is a self-completed questionnaire for evaluation of motor dysfunction (locomotive syndrome) among the elderly (Seichi et al., 2012). The GLFS-25 includes 4 questions regarding pain, 16 questions about ADL, 3 questions on social functioning, and 2 questions regarding mental health during the past month. Each item is graded on a five-point scale from no impairment (0 point) to severe impairment (4 points), and the total score is calculated as the sum of the scores for the individual items (range: 0–100). This score provides quantitative evaluation of the difficulty in performing daily activities because of disability related to motor (locomotor) function. The age-specific mean GLFS-25 score is 4.7–6.8 in the 40 s, 5.8–7.6 in the 50 s, 6.6–9.7 in the 60 s, and 7.1–12.8 in the 70 s. If the GLFS-25 score is ≧16, limitations on walking and going out can be expected. According to the classification of Iwaya, Doi, Seichi, Ogata, and Akai (2017), the GLFS-25 score was stratified into the following seven levels: < 6 = level 1; 7–15 = level 2; 16–22 = level 3; 23–32 = level 4; 33–40 = level 5; 41–49 = level 6; and ≥ 50 = level 7. Impairment of ADL becomes greater as the GLFS-25 score increases. Elderly persons with no obvious motor disorders fit into GLFS-25 levels 1–3, while those with increasingly severe motor disorders are assigned to GLFS-25 levels 4–7.

2.5. Home exercise program (isometric hip muscle exercises)

One set of straight leg-raising (SLR) and hip abduction exercises

Table 1
Patients demographics.

Group	Number of patients	Mean age (range)	contralateral hip		
			Normal / Mild OA	Moderate to severe OA	Already received THA
Post-THA	108	71.5 (54-86)	55	0	53
Pre-THA	56	64.9 (43-91)	29	13	14
Conservative	64	63.4 (40-90)	49	15	0
Total	228	67.6 (40-91)	133	28	67

(each exercise was repeated 20 times) was performed twice a day, in the morning and evening. SLR exercise involved lying on the back, raising the affected lower limb until the ankle was 10 cm above the surface, holding that position for 5 s, and then slowly lowering the limb. Hip abduction exercise was performed by lying on the unaffected side, slowly moving the affected lower limb sideways in the horizontal plane, holding that position for 5 s, and then slowly returning the limb.

2.6. Muscle strength test

The maximum voluntary bilateral hip flexion strength (straight leg raising: SLR) and abduction strength were measured with a hand-held dynamometer (Isoforce GT-300, OG Giken Co. Ltd., Okayama, Japan) during isometric contraction for 3 s against manual resistance, as reported previously (Harris, 1969). The subject rested in the supine position with the hip and knee in the neutral position for flexion/extension and the hip in the neutral position for abduction/adduction. The sensor of the dynamometer was placed at the proximal border of the patella when assessing hip flexion. Thus, the "lever arm" for calculating hip flexion (SLR) torque was the distance from the proximal border of the border of the patella to the anterior superior iliac spine. Similarly, the sensor was placed 5 cm proximal to the proximal border of the lateral malleolus when assessing hip abduction, and the lever arm for calculating hip abduction torque was the distance from this point to the anterior superior iliac. Torque was calculated as force multiplied by the lever arm and was expressed per body weight (Nm/kg).

2.7. Statistical analysis

The significance of differences in mean muscle strength between GLFS-25 levels 1–3 and GLFS-25 levels 4–7 was evaluated with the unpaired *t*-test for normally distributed data. Statistical analysis was performed with StatView Ver. 5.0 software for Macintosh (SAS Institute Inc., North Carolina) and $p < 0.05$ was considered to indicate statistical significance.

3. Results

The mean JHEQ total score and mean GLFS-25 score was respectively 60.0 (range: 17–84) and 14.0 (range: 0–53) in the Post-THA group, 17.0 (range: 0–49) and 56.4 (range: 8–97) in the Pre-THA group, and 47.5 (range: 13–84) and 17.1 (range: 0–46) in the Conservative group. Table 2 shows the percentage of patients assigned to each level of the GLFS-25 score in each group. The percentage of patients in GLFS-25 levels 1–3 vs. GLFS-25 levels 4–7 was 81% vs. 19% in the Post-THA group, 7% vs. 93% in the Pre-THA group, and 72% vs. 28% in the Conservative group. The JHEQ total score of patients in each GFLS-25 score level according to the classification (levels 1–7) of Iwaya et al. (2017) was as follows: level 1 = 71.8 (n = 44), level 2 = 58.3 (n = 61), level 3 = 46.4 (n = 24), level 4 = 36.5 (n = 24), level 5 = 22.4 (n = 14), level 6 = 28.8 (n = 10), and level 7 = 13.7 (n = 38). Thus, the JHEQ score decreased as the classification increased from level 1 to 7, except for level 6. Fig. 1 shows the relation between the JHEQ total score and the GFLS-25 score in all 228 subjects. There was a strong negative correlation between the JHEQ total score and the GLFS-25 score (r = - 0.837), since the JHEQ score increases as hip function improves while the GLFS-25 score decreases as motor function improves.

Table 2
The percentage of patients assigned to each level of the GLFS-25 score in each group.

Group	Level						
	1	2	3	4	5	6	7
Post-THA	32.4	37	11.1	11.1	2.7	3.7	1.9
Pre-THA	0	3.6	3.6	5.4	16.1	7.1	64.3
Conservative	15.6	34.4	21.9	18.9	6.3	3.1	0

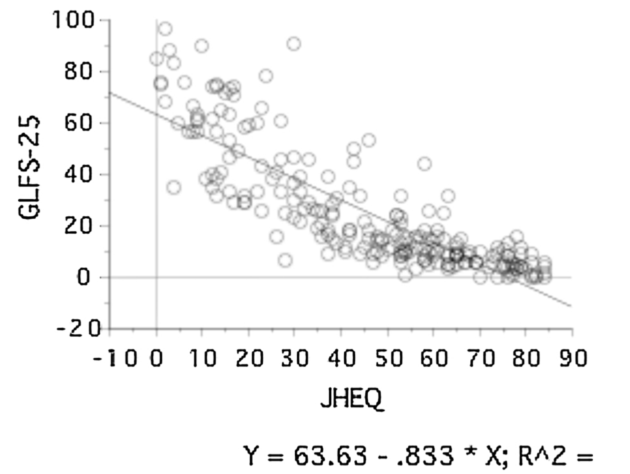

Fig. 1. The relation between the JHEQ total score and the GFLS-25 score in all 228 subjects.

Concerning the influence of age, the mean GLFS-25 scores of patients aged 50–59 years from the Post-THA group, Pre-THA group, and Conservative group were 22.7, 52.5, and 22.1, respectively. In addition, the mean GLFS-25 scores of patients aged 60–69 years from the Post-THA group and Pre-THA group were 8.3 and 51.1, respectively. (There were no patients aged 60–69 years in the Conservative group). Similarly, the mean GLFS-25 scores of patients aged 70–79 years from the Post-THA group, Pre-THA group, and Conservative group were 15.5, 59.2, and 15.0, respectively.

Regarding the relationship between the GLFS-25 classification and muscle strength, patients from the Post-THA group classified into GLFS-25 levels 1–3 or levels 4–7 ha d a mean SLR strength of 0.82 Nm/kg and 0.67 Nm/kg, respectively. In addition, the mean SLR strength of patients from the Pre-THA group classified into GLFS-25 levels 1–3 or levels 4–7 was 0.63 Nm/kg and 0.57 Nm/kg, respectively, while the corresponding values in the Conservative group were 0.76 Nm/kg vs. 0.60 Nm/kg. There was a significance difference in SLR strength between GLFS-25 levels 1–3 and GLFS-25 levels 4–7 in the Post-THA group ($p < 0.01$) and in the Conservative group ($p < 0.05$) (Fig. 2). On the other hand, the mean abduction strength of patients from the Post-THA group classified into GLFS-25 levels 1–3 or GLFS-25 levels 4–7 was 1.52 Nm/kg and 1.40 Nm/kg, respectively, while it was 1.19 Nm/kg vs. 1.15 Nm/kg in the Pre-THA group and 1.34 Nm/kg vs. 1.24 Nm/kg in the Conservative group. There was no significance difference

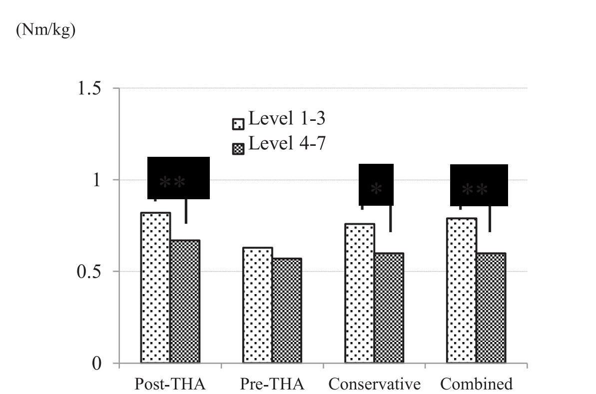

Fig. 2. The mean SLR strength in each group. There was a significance deference between GLFS-25 levels 1–3 and 4–7 in the Post-THA group (**: $p < 0.01$), Conservative group (*: $p < 0.05$), and the three groups combined (**: $p < 0.01$).

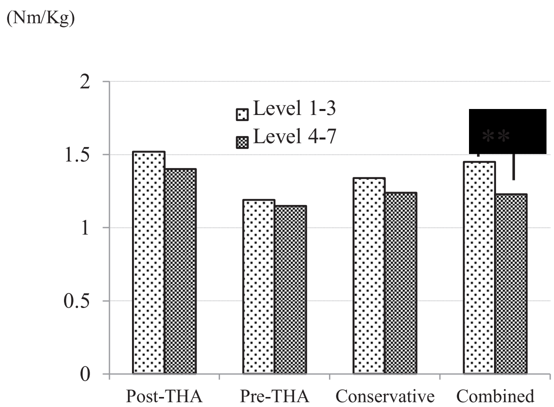

Fig. 3. The mean abductor strength in each group. There was a significance deference between GLFS-25 levels 1–3 and 4–7 in the three groups combined (**: $p < 0.01$). (Nm/Kg).

in abduction strength between patients from GLFS-25 levels 1–3 and GLFS-25 levels 4–7 in any of the groups (Fig. 3). When the three groups were combined, the mean SLR strength of patients classified into GLFS-25 levels 1–3 or levels 4–7 was 0.79 Nm/kg and 0.60 Nm/kg, respectively, while the mean abduction strength was 1.45 Nm/kg and 1.23 Nm/kg, respectively. A significance difference was noted between patients in GLFS-25 levels 1–3 and those in GLFS-25 levels 4–7 with respect to SLR strength and abduction strength (both $p < 0.01$).

4. Discussion

Several scoring systems have been widely used to evaluate hip joint function in patients with hip disease, including the Harris hip score (Harris, 1969), Merle d'Aubigne and Postel score (D'Augbine & Postel, 1954), Western Ontario and McMaster Universities osteoarthritis index (WOMAC) (Bellmy, Buchanan, Goldsmith, Campbell, & Stitt, 1988), and Oxford hip score (OHS) (Dawson, Fitzpatrick, Carr, & Murray, 1996; Naal et al., 2009). However, some disadvantages of each scoring method have been pointed out. The Harris hip score and the Merle d'Aubigne and Postel score are calculated by the examiner who evaluates the patient. Because physician-based evaluation is influenced by subjective impressions, it is possible that discrepancies will arise between the level of hip joint function experienced by the patient and that assigned by the rater, and it has been pointed out that the interobserver error is quite large with these scores (Brokelman, van Loon, & Rijnberg, 2003; Kuribayashi et al., 2010; Lieberman et al., 1996; Ragab, 2003). The WOMAC is a disease-specific quality of life (QOL) scale for osteoarthritis (OA) and the OHS is a score for evaluating patients with hip OA or post-THA patients. The WOMAC is derived from self-administered questionnaires. However, it has been pointed out that these scores were designed to evaluate patients living a Western lifestyle and are not adequate for evaluating the Asian lifestyle (Uesugi et al., 2009). The JHEQ was established as a patient-reported outcome for hip disorders for the patients living in Asian lifestyle. Reliability and validity of the JHEQ were confirmed in a previous study (Seki, Hasegawa, Ikeuchi, Ishiguro, & Hiejima, 2013), and it has been used for evaluation of outcomes after THA (Fukui et al., 2015).

Older persons are at risk of declining physical activity and this is one of the greatest threats to their independence. In recent years, health of the elderly has become a major concern in Japan, not only for the persons themselves, but also as a topic of public discussion. Motor function is one of the most important determinants of the quality of life (QOL), so it is essential to be able to assess motor activity in order to judge whether an elderly person can live independently or needs nursing care or other support. In this context, the Japan Orthopaedic Association (JOA) has proposed the concept of "Locomotive Syndrome" (LS), which refers to patients with conditions that require nursing services or patients at high risk of requiring such services due to motor dysfunction (Nakamura, 2008, 2009). LS, as well as motor disorders, is caused by orthopedic problems that are mainly related to aging, include knee and hip OA, degenerative spondylitis, osteoporosis, and lumbar spinal canal stenosis. In this study, we evaluated patients with osteoarthritis of the hip by determining the JHEQ and GLFS-25 scores to investigate the role of hip joint impairment in motor disorders. The JHEQ score increases as hip function improves, while the GLFS-25 score decreases as motor function improves. Accordingly, there was a significant negative correlation between the total JHEQ score and the GFLS-25 score in the present study, suggesting that deterioration of hip joint function had a strong influence on motor disorders. Therefore, if appropriate conservative treatment combined with exercise (Skou & Roos, 2017; Uesugi et al., 2018; Uusi-Rasi et al., 2017) or surgical procedures such as THA can improve hip joint dysfunction in elderly persons, motor function should also be improved, along with ADL and QOL.

It has been reported that leg strength decreases with age, and the loss is most pronounced after the age of 70 years (Hasegawa et al., 2008). As regards the relationship between reduced muscle strength and physical activity, studies have shown that a decline in leg extensor strength is associated with impairment of both physical activity and ADL (Carmeli, Imam, & Merrick, 2012; den Ouden et al., 2013; Hairi et al., 2010). Judd, Thomas, Dayton, and Stevens-Lapsley (2014) studied adults with end-stage hip OA and reported that the arthritic lower extremity was 10–38% weaker than the normal side. They also reported that patients with end-stage hip OA achieved worse results in functional tests (28–50% lower) and were less physically active than healthy adults. Quadriceps strength has a significant influence on daily activities, and patients with quadriceps weakness show impaired functional performance after THA (Hernandez, Goldberg, & Alexander, 2010; Horlings, van Engelen, Allum, & Bloem, 2008; Laroche, Cook, & Mackala, 2012; Maezawa et al., 2018). In the present study, we performed muscle strength testing to investigate whether muscle strength had an influence on the GLFS-25 score. Similar to previous reports, there was a significant difference of muscle strength between patients in GLFS-25 levels 1–3 and those in levels 4–7, which suggested that maintaining or increasing SLR strength is important for the maintenance of QOL and ADL. And it suggested that it may be useful to routinely measure SLR strength when examining patients in order to evaluate whether physical function is being maintained.

Although there are no obvious differences of motor function in daily life between young people and middle-aged people, it seems that differences of motor function develop and increase among older persons along with aging. However, there has been a lack of indicators that allow comprehensive age-based assessment of motor function. Under such circumstances, the GLFS-25 seems to be valuable because data on mean scores for different age groups are available. In our study, the mean scores of patients aged 60–69 years from the Post-THA group and patients aged 70–79 years from the Post-THA and Conservative groups were similar to the corresponding mean scores for healthy persons of the same age. And there was no significant difference of the mean GLFS-25 score between patients of the Post-THA group and the Conservative group. These results suggest the following two points. First, post-THA motor function of patients aged 60–79 years is at a similar level to that of healthy persons in the same age group. Second, motor function of patients in whom conservative treatment is successful reaches the same level as that after THA, when patients of the same age are compared. Our patients receiving conservative treatment performed exercise therapy. We think that special exercise classes are not necessary for patients to participate in exercise therapy. Instead, it is more important to perform exercise regularly at home and to positively participate in daily activities. It also seems important to evaluate the hip joint muscle strength of patients on a regular basis and provide immediate feedback regarding the results.

In conclusion, we determined the JHEQ and GLFS-25 scores in patients with osteoarthritis of the hip (including patients on conservative treatment, patients scheduled for THA, and patients after THA) to investigate the role of hip joint dysfunction in motor function. We found a significant correlation (r = −0.831) between the JHEQ total score and the GFLS-25 score, suggesting that hip joint dysfunction has a strong influence on overall motor function. When we evaluated motor function among patients who had undergone THA or had received appropriate conservative treatment in comparison with healthy persons of the same age, we found that post-THA motor function of patients aged 60–79 years was at the same level as that of healthy persons their age, while the motor function of patients with successful conservative treatment was the same as that of patients after THA. Moreover, we also found that SLR strength showed a significance difference between the patients in GFLS-25 levels 4–7 and those in levels 1–3, indicating that it is necessary for patients with osteoarthritis of the hip to preserve or improve their SLR strength in order to maintain adequate motor function.

Conflict of interest statement

The authors declare that they have no competing interests.

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