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# Functioning and Disability in Patients With Hip Osteoarthritis With Mild to Moderate Pain

Hip and knee osteoarthritis (OA) is a major cause of musculoskeletal pain and disability.[17,20] Primary symptoms of hip OA include pain, stiffness, and activity limitations.[16,23] Several studies have investigated impairments and function in patients with hip OA, such as lower extremity muscle strength,[1,40,44] hip range of motion (ROM),[2,43] and aerobic capacity.[38,41] Most of the studies have included patients with severe radiographic and symptomatic hip OA who were candidates for total hip replacement (THR) surgery.[38,40,41] However, data indicate that only 12% of the patients seeking help for hip pain ended up having THR within 3 years and 22% within 6 years.[29] The patient group not candidates for surgery represents, therefore, the majority of patients seeking primary care for hip pain, including patients with hip OA. Two studies have investigated muscle strength in patients with less-severe hip OA and found lower hip flexion[1] and knee extension strength[44] compared to matched controls. However, only 1 of these 2 studies investigated muscle strength in patients with hip OA compared to matched control subjects.[1] While other studies have compared muscle size and muscle strength of the affected compared to the unaffected limb,[40,44] it has been shown that muscle function is often affected in the healthy limb.[8] Hence, there is a lack of information available regarding functioning and disability in patients with hip OA not candidates for surgery, compared to a matched control group. Increased knowledge in this field would be of major importance both for clinicians performing physical examination and when developing active rehabilitation programs to improve functioning

• **STUDY DESIGN:** Cross-sectional study.

• **OBJECTIVE:** To compare functioning and disability in patients with hip osteoarthritis (OA) not candidates for surgery, to a matched control group, and thereby to examine the relationship between the functioning and disability components used in this study in patients with hip OA.

• **BACKGROUND:** It is well know that patients with severe hip OA have deficits in functioning and disability. However, in patients with hip OA not candidates for surgery, the knowledge regarding functioning and disability is sparse.

• **METHODS:** Twenty-six patients (12 men, 14 women; mean age, 60 years) with radiographic and symptomatic hip OA were matched to 26 controls without hip pain. The following variables were measured: muscle strength using isokinetic peak force, hip passive range of motion, submaximal aerobic capacity using a cycling test, walking ability using the 6-minute walk test, self-reported pain, stiffness, and physical function using the Western Ontario and McMaster University Osteoarthritis Index, and health-related quality of life using the SF-36.

• **RESULTS:** The patients with hip OA had mild to moderate pain, as indicated by the Western Ontario and McMaster University Osteoarthritis Index, and significantly lower knee extension strength (mean difference [95% confidence interval {CI}]: –19.5 [–34.3, –4.7] Nm). Hip range of motion was significantly less in the patients with hip OA, with mean (95% CI) differences of –10° (–14°, –6°) for extension, –18° (–26°, –11°) for flexion, –9° (–14°, –4°) for abduction, –2° (–5°, 0°) for adduction, –16° (–23°, –9°) for internal rotation, and –21° (–28°, –14°) for external rotation. The patients with hip OA walked a significantly shorter distance in 6 minutes (mean difference, –75 m; 95% CI: –131, –20 m). There were no significant differences in hip extension/flexion, knee flexion, ankle dorsiflexion/plantar flexion muscle strength, or aerobic capacity between the 2 groups. There were significant associations between body function and activity components.

• **CONCLUSION:** Physical therapists should consider including quadriceps-strengthening and hip range-of-motion exercises when developing rehabilitation programs for patients with hip OA, with mild to moderate pain, aiming to improve functioning and reduce disability. *J Orthop Sports Phys Ther 2010;40(10):616-624. doi:10.2519/jospt.2010.3346*

• **KEY WORDS:** *aerobic capacity, muscle strength, quality of life, range of motion, walking distance*

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and reduce symptoms in patients with hip OA. The aim of the present study was, therefore, to evaluate functioning and disability in terms of lower extremity muscle strength, hip ROM, walking distance, aerobic capacity, and health quality of life in patients with hip OA compared to a matched control group. An additional aim was to examine the relationship between functioning and disability in patients with hip OA.

## METHODS

### Patients

Twenty-six patients with hip OA (12 men and 14 women) between 40 and 80 years of age (mean ± SD, 60.3 ± 11.5), with bilateral or unilateral radiographic and symptomatic hip OA, were recruited consecutively from a randomized clinical trial carried out at Oslo University Hospital, Norway. For patients with bilateral hip OA (n = 15), the most painful hip was selected for analysis. Inclusion criteria were hip pain for more than 3 months, radiographically verified reduced minimal joint space according to Danielsson criteria,[15] and Harris Hip Score (HHS) (score range, 0-100) between 60 and 95 points.[25] At our institution a HHS below 60 points has been used for decades as a criterion for patients with hip OA who are candidates for THR. The radiographic evaluation was made by a senior orthopaedic surgeon (L.N.), and the clinical examination, including the HHS, was completed by a senior physical therapist (L.F.). Self-reported pain, joint stiffness, and physical function were registered using the Western Ontario and McMaster University Osteoarthritis Index (WOMAC VA3.1).[7] The WOMAC (score range, 0-100) is a self-administered and disease-specific instrument specially designed for patients with hip or knee OA. To categorize the patient's pain level we used the WOMAC pain subscale (10 to 40, mild pain; greater than 40 to 60, moderate pain; greater than 60 to 100, severe pain).[27] Psychometric studies have shown moderate to high validity and reliability for the WOMAC.[42]

The Physical Activity Score for Elderly[30] was used to quantify level of physical activity, including frequency and duration of strength training.

### Control Group

Twenty-six controls without hip pain (12 men and 14 women; mean ± SD age, 59.7 ± 10.4 years) were matched to the patients with hip OA based on age (±5 years), gender, and amount of strength training (frequency and duration) according to the last question in the Physical Activity Score for Elderly.[30] Inclusion criteria were no history of hip pain and a HHS above 95 points. The subjects in the control group were recruited from the local area, and through patients' friends and by colleagues. For isokinetic muscle strength tests and ROM tests, the same side as the patients involved hip joint was matched to the controls' hip. Both the patients with hip OA and the controls were excluded if they had any history of recent trauma or functional impairment in the lower extremity, or diseases that might interfere with participation in the study (eg, rheumatoid arthritis, cancer, osteoporosis, severe back pain, knee pain, or knee OA). Subjects with comorbidities not tolerating physical activity were excluded.

Research ethics approval was obtained from The Regional Committee of Medical Research Ethics and the Norwegian Data Inspectorate. All subjects signed an informed consent.

### Measurements

We used parts of the International Classification of Functioning, Disability, and Health (ICF)[46] framework to list the measurements of functioning and disability into (1) body function and (2) activity. Applying the ICF to OA, hip OA can lead to impairments of body function and activity limitations.

### Measurements of ICF Body Function

**Isokinetic Muscle Strength Test** Peak torque for hip and knee flexion and extension and ankle dorsiflexion and plantar flexion were tested using an isokinetic machine (REV 9000; Technogym SpA, Gambettola, Italy) set at 60°/s. The test protocol included a warm-up of 4 repetitions, followed by a 20-second rest prior to 5 repetitions of maximal muscle strength. The highest peak torque value of the 5 repetitions was used in both groups, and the isokinetic device was calibrated prior to every test. Isokinetic knee extension and flexion muscle strength tests were performed with the subject in a sitting position, with fixation over trunk and thigh. The knee joint testing range was set to 5° to 85° knee flexion. Knee isokinetic peak torque measurements at this angular velocity have been shown to have high reliability, with an intraclass correlation coefficient (ICC) of 0.91 for subjects without pain and for different age groups.[12] Isokinetic ankle dorsiflexion and plantar flexion muscle strength tests were performed with the subject in supine, the hip and knee joints extended, and the limb fixed. The ankle joint testing range was set at 5° dorsiflexion to 40° plantar flexion. Measurements of ankle isokinetic muscle strength in supine (30°/s, peak torque), have moderate to low intrarater reliability for plantar flexion (ICC = 0.53-0.72) and dorsiflexion (ICC = 0.20-0.49).[36] Measurements of hip extension and flexion strength were performed with the subjects in supine, with fixation over the pelvis. The hip joint testing range was set at 35° to 75° hip flexion, and the opposite limb was fixed, with the hip and knee extended. Measurements of hip flexion and extension strength (60°/s, peak torque) in supine have shown moderate to high reliability for patients with hip OA (ICC = 0.84-0.87).[1]

**Range of Motion** Joint ROM was measured using a half-circle 1°-increment plastic goniometer with a moveable arm. Hip flexion, adduction, and abduction were measured in supine, with the opposite thigh fixed in neutral position.[37] Internal and external rotation of the hip

**TABLE 1** CHARACTERISTICS OF PATIENTS WITH HIP OA AND MATCHED CONTROLS

| | Patients With Hip OA (n = 26)* | Controls (n = 26)* | Mean Difference (95% CI) | *P* Value |
|---|---|---|---|---|
| Age (y) | 60.3 ± 11.5 | 59.7 ± 10.4 | 0.6 (−0.8, 12.0) | .396 |
| Height (m) | 1.73 ± 0.09 | 1.72 ± 0.11 | −0.01 (−0.5, 0.4) | .740 |
| Body mass (kg) | 73.9 ± 10.9 | 71.7 ± 14.2 | 2.2 (−3.3, 7.6) | .426 |
| Body mass index (kg/m$^2$) | 24.6 ± 2.9 | 24.0 ± 3.3 | −6.6 (−2.6, 1.3) | .493 |
| Men/women (n) | 12/14 | 12/14 | | 1.000 |
| HHS (0-100) | 76.3 ± 7.9 | 99.5 ± 1.2 | 23.2 (20.0, 26.4) | <.001 |
| PASE (0-315) | 112.5 ± 50.4 | 137.0 ± 43.7 | -24.4 (−56.1, 7.3) | .125 |
| Strength training frequency score (0-4.3) (PASE) | 2.5 ± 4.8 | 2.1 ± 3.5 | 0.5 (−4.8, 1.4) | .327 |
| Duration of pain (y) | 2.3 ± 1.5 | | | |
| Bilateral/unilateral (n) | 15/11 | | | |
| Minimal joint space (mm) | 2.0 ± 1.1 | | | |
| WOMAC pain (0-100) | 30.8 ± 16.3 | | | |
| WOMAC stiffness (0-100) | 35.3 ± 19.0 | | | |
| WOMAC physical function (0-100) | 28.2 ± 16.2 | | | |

*Abbreviations: HHS, Harris Hip Score; OA, osteoarthritis; PASE, modified version of Physical Activity Score for Elderly; WOMAC, Western Ontario and McMaster University Osteoarthritis Index.*
** Data presented as mean ± SD.*

were measured in prone, with the hip extended and the knee in 90° flexion.[37] Hip extension was measured using the modified Thomas test.[18,37] Measuring hip ROM in patients with hip OA, using a goniometer, has shown to have a high intrarater reliability (ICC = 0.82-0.95), except for adduction (ICC = 0.50-0.72).[13,26]

**Aerobic Capacity** Subjects were tested using a submaximal ergometer cycle test. The cycle test was also used as a warm-up prior to performing the isokinetic muscle strength tests. Predicted maximal aerobic capacity was calculated according to the nomogram described by Astrand.[5] The load and sitting position were adjusted to each subject and the ergometer cycle was calibrated to kilopascal (kPa) prior to each test. Heart rate was corrected for age,[3] gender, and body mass, and expressed in ml/kg × min. The nomogram for calculation of the maximal aerobic capacity has shown to be valid for healthy subjects (age, 20-50 years), when the results are corrected for age ($r$ = 0.76-0.92; ICC = 0.94).[14,45] We calculated age, correcting factor for subjects above 69 years of age (n = 10), because the nomogram lacks age corrections for that age range.

## Measurements of ICF activity

**Six-Minute Walk Test (6MWT)** All subjects were asked to walk as far as possible during 6 minutes by walking back and forth in a 20-m long corridor.[19] The walking distance was registered in meters using a tape measure, and the time was monitored with a stopwatch. Immediately after, the test subjects were asked to score hip pain during walking on a visual analog scale ranging from 0 to 100 mm, where 0 represented no pain and 100 extreme pain. The 6MWT has been shown to have high intrarater reliability (ICC = 0.94) in patients with hip OA.[28]

**Health-Related Quality of Life** The self-administered generic 36-item short-form health survey (SF-36, v2) was completed by both the patients with hip OA and the controls. The SF-36 has shown to be reliable and valid for both physical and mental health.[33,34] The SF-36 consists of 8 subscales: physical function, role limitations due to physical problems, bodily pain, and general health perceptions, and role limitations due to emotional problems, mental health, social functioning, and vitality. Each score ranges from 0 to 100, were 0 is the poorest possible health state and 100 is the best health state. The physical function subscale score was used to examine the relationship between body function and activity components.

## Statistical Analysis

Sample size was based on a priori power calculations.[31] The primary outcome measure was isokinetic knee extension peak torque values, with estimation of 150 (±36) Nm for subjects without hip OA and 105 (±37) Nm for patients with hip OA.[32] Based on 5% significance level and 90% power, 17 subjects were needed to be included in each group. If a subject in 1 of the 2 groups dropped out from a test, the matched pair was excluded. We included 26 subjects per group to make sure that we had enough power, considering the risk of pairs dropping out. The data were analyzed using SPSS Version 15.0 (SPSS, Inc, Chicago, IL). The paired Student $t$ test was used to evaluate differences between the groups for normally distributed data, and the Wilcoxon rank sum test was used for nonnormally distributed data. Correlation analyses were performed with patients with hip OA, between body function and activities components, using a Speareman rho correlation coefficient. Results were regarded as significant at $P<.05$. The results were presented as mean, standard deviation, mean differences, and 95% confidence interval (CI).

## RESULTS

Complete baseline characteristics are presented in **TABLE 1**. The patients with hip OA had a mean ± SD duration of pain of 2.5 ± 1.5 years, minimal joint space of 2 ± 1 mm, and scores on 3 subscales of the WOMAC of 30.8 ± 16.3 for pain, 35.3 ± 19.0 for stiffness, and 28.2 ± 16.2 for physical function (**TABLE 1**). A flow chart is included and pairs of missing values are

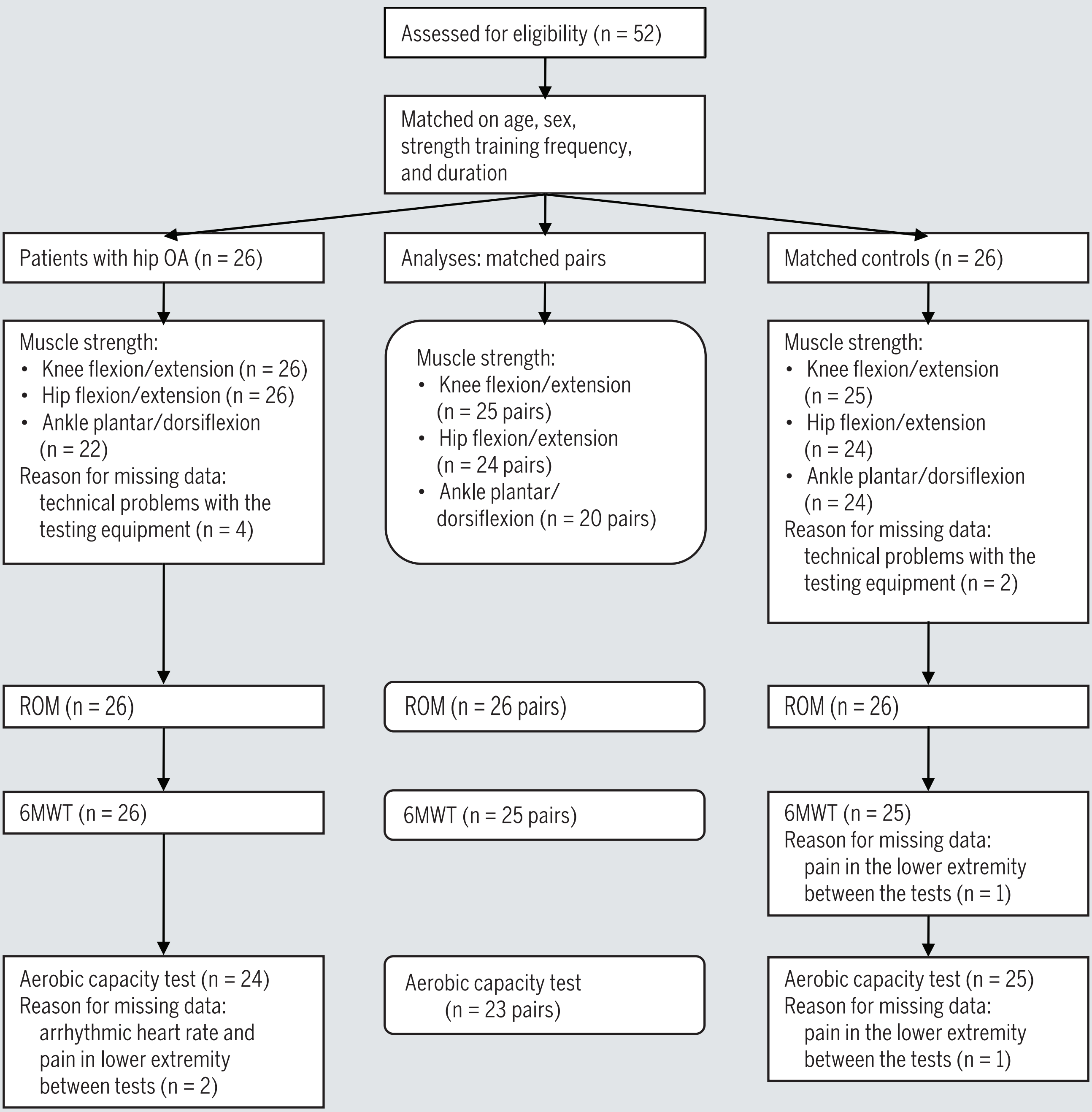


**FIGURE.** Study flowchart showing inclusion of subjects and measurements and analysis in matched pairs.
Abbreviations: 6MWT, 6-minute walk test; OA, osteoarthritis; ROM, range of motion.

**TABLE 2** ISOKINETIC PEAK TORQUE (NM AND NM/BM) AT 60°/S IN PATIENTS WITH HIP OA AND MATCHED CONTROLS

| | Patients With Hip OA* | Controls* | Mean Difference (95% CI) | *P* Value |
|---|---|---|---|---|
| Knee extension (25 pairs), Nm | 112.8 ± 40.6 | 132.4 ± 48.6 | –19.5 (–34.3, –4.7) | .012 |
| Knee extension (25 pairs), Nm/BM | 1.5 ± 0.4 | 1.8 ± 0.4 | –0.3 (–0.5, –0.1) | .003 |
| Knee flexion (25 pairs), Nm | 69.5 ± 32.2 | 71.7 ± 31.6 | –2.2 (–14.4, 10.0) | .714 |
| Knee flexion (25 pairs), Nm/BM | 0.9 ± 0.3 | 1.0 ± 0.3 | –0.1 (–0.2, 0.1) | .445 |
| Ankle dorsiflexion (20 pairs), Nm | 67.1 ± 25.0 | 66.6 ± 24.3 | –0.5 (–8.7, 9.7) | .911 |
| Ankle dorsiflexion (20 pairs), Nm/BM | 0.9 ± 0.3 | 0.9 ± 0.2 | 0.0 (–0.1, 0.1) | .948 |
| Ankle plantar flexion (20 pairs), Nm | 21.6 ± 6.0 | 22.1 ± 7.5 | –0.5 (–2.9, 2.0) | .703 |
| Ankle plantar flexion (20 pairs), Nm/BM | 0.3 ± 0.1 | 0.3 ± 0.1 | –0.0 (–0.0, 0.0) | .627 |
| Hip extension (24 pairs), Nm | 150.3 ± 68.8 | 161.3 ± 66.4 | –11.0 (–33.1, 11.2) | .317 |
| Hip extension (24 pairs), Nm/BM | 2.0 ± 0.7 | 2.2 ± 0.7 | –0.2 (–0.5, 0.0) | .177 |
| Hip flexion (24 pairs), Nm | 94.8 ± 38.4 | 95.5 ± 36.9 | –0.7 (–15.1, 13.8) | .920 |
| Hip flexion (24 pairs), Nm/BM | 1.3 ± 0.4 | 1.3 ± 0.4 | –0.0 (–0.2, 0.2) | .700 |

*Abbreviations: BM, body mass; CI, confidence interval; OA, osteoarthritis.*
** Data presented as mean ± SD.*

**TABLE 3** HIP ROM FOR PATIENTS WITH HIP OA AND MATCHED CONTROLS

| | OA (n = 26)* | Control (n = 26)* | Mean Difference (95% CI) | *P* Value |
|---|---|---|---|---|
| Extension | 1 ± 10 | 11 ± 5 | –10 (–14, –6) | <.001 |
| Flexion | 121 ± 16 | 139 ± 8 | –18 (–26, –11) | <.001 |
| Abduction | 24 ± 11 | 33 ± 8 | –9 (–14, –4) | .002 |
| Adduction | 25 ± 7 | 27 ± 5 | –2 (–5, 0) | .085 |
| Internal rotation | 30 ± 14 | 46 ± 12 | –16 (–23, –9) | <.001 |
| External rotation | 26 ± 12 | 47 ± 11 | –21 (–28, –14) | <.001 |

*Abbreviations: CI, confidence interval; OA, osteoarthritis; ROM, range of motion.*
** Data presented as mean ± SD degrees.*

**TABLE 4** 6MWT AND AEROBIC CAPACITY IN PATIENTS WITH HIP OA AND MATCHED CONTROLS

| | Patients With Hip OA* | Controls* | Mean Difference (95% CI) | *P* Value |
|---|---|---|---|---|
| 6MWT (25 pairs), m | 643 ± 122 | 719 ± 117 | –75 (–131, –20) | .010 |
| Pain while walking (25 pairs)† | 18 ± 17 | 0 ± 0 | 18 (11, 25) | <.001 |
| Aerobic capacity (23 pairs), ml/kg × min | 28 ± 8 | 31 ± 7 | –2 (–6, 2) | .257 |

*Abbreviations: 6MWT, 6-minute walk test; CI, confidence interval; OA, osteoarthritis.*
** Data presented as mean ± SD.*
*† Visual analogue scale, 0-100 mm.*

presented (**FIGURE**). The patients with hip OA had significantly lower peak torque for knee extension compared to the matched controls: mean difference (95% CI) of –19.5 (–34.3, –4.7) Nm (**TABLE 2**). There were no significant differences between groups for hip extension or flexion, knee flexion, ankle dorsiflexion, or plantar flexion muscle strength (**TABLE 2**). There were significant differences in hip ROM between the 2 groups: mean (95% CI) difference was –10° (–14°, –6°) for extension, –18° (–26°, –11°) for flexion, –9° (–14°, –4°) for abduction, –2° (–5°, 0°) for adduction, –16° (–23°, –9°) for internal rotation, and –21° (–28°, –14°) for external rotation (**TABLE 3**). Walking distance was significantly shorter during the 6MWT in patients with hip OA compared to matched controls (mean difference, –75 m; 95% CI: –131, –20 m). Furthermore, the patients with hip OA reported significantly higher mean ± SD pain intensity (visual analog scale, 18 ± 17) during the 6MWT, compared to the matched controls, who reported no pain (**TABLE 4**). No significant difference in aerobic capacity was found between the 2 groups (**TABLE 4**). The health-related quality of life was significantly lower among the patients with hip OA compared to the matched controls for 6 of 8 subscales of the SF-36 (**TABLE 5**). There were significant associations between body function and activity components. Muscle strength correlated significantly with walking distance ($\rho$ = 0.48 to 0.64). Hip ROM for abduction and flexion correlated significantly with WOMAC physical function ($\rho$ = –0.44 and –0.64, respectively). Hip flexion ROM correlated significantly with walking distance ($\rho$ = 0.52). WOMAC pain score was correlated with WOMAC physical function score ($\rho$ = 0.67), and pain during waking was correlated with WOMAC physi-

**TABLE 5** The 8 Subscales of the Health-Related Quality of Life Questionnaire, the SF-36, in Patients With Hip OA and Matched Controls*

| | Patients With Hip OA (n = 26)† | Controls (n = 26)† | Mean Difference (95% CI) | *P* Value |
|---|---|---|---|---|
| Physical functioning | 67 ± 14 | 97 ± 3 | −30 (−35, −24) | <.001 |
| Role limitations due to physical problems | 69 ± 25 | 97 ± 10 | −28 (−39, −16) | <.001 |
| Body pain | 53 ± 16 | 94 ± 9 | −40 (−47, −34) | <.001 |
| General health | 59 ± 19 | 86 ± 15 | −27 (−37, −18) | <.001 |
| Vitality | 52 ± 19 | 75 ± 14 | −22 (−32, −12) | <.001 |
| Role limitations due to emotional problems | 90 ± 16 | 95 ± 13 | 6 (−3, 15) | .187 |
| Mental health | 75 ± 15 | 88 ± 11 | −13 (−22, −4) | .004 |
| Social functioning | 88 ± 14 | 96 ± 14 | −7 (−15, 1) | .066 |

*Abbreviations: CI, confidence interval; OA, osteoarthritis; SF-36, 36-item short-form health survey.*
** Each score ranges from 0-100, where 0 is the poorest possible health state and 100 is the best health state.*
*† Data presented as mean ± SD.*

**TABLE 6** Correlation Coefficient (Spearman Rho) Between Body Function and Activity Components

| | ICF, Activity | | |
|---|---|---|---|
| ICF, Body Functions | Physical Function (WOMAC) | Physical Function (SF-36) | Walking Distance (6MWT) |
| Muscle strength | | | |
| Knee extension | −0.14 | 0.36 | 0.57* |
| Knee flexion | −0.11 | 0.18 | 0.48* |
| Ankle dorsiflexion | −0.08 | 0.24 | 0.58* |
| Ankle plantar flexion | −0.26 | 0.24 | 0.64* |
| Hip extension | −0.09 | 0.18 | 0.57* |
| Hip flexion | −0.21 | 0.39 | 0.58* |
| Hip ROM | | | |
| Extension | −0.33 | 0.21 | 0.03 |
| Flexion | −0.64* | 0.20 | 0.52* |
| Abduction | −0.44† | 0.24 | 0.24 |
| Adduction | −0.08 | 0.09 | 0.28 |
| Internal rotation | −0.29 | 0.37 | 0.06 |
| External rotation | 0.03 | 0.14 | 0.25 |
| Stiffness WOMAC stiffness | 0.81* | −0.22 | −0.49* |
| Pain WOMAC pain | 0.67* | −0.37 | −0.25 |
| Pain while walking (VAS) | 0.44† | −0.51* | −0.28 |
| Aerobic capacity Astrand cycle test | 0.12 | −0.23 | 0.11 |

*Abbreviations: 6MWT, 6-minute walk test; ICF, International Classification of Functioning, Disability and Health framework; ROM, range of motion; SF-36, 36-item short-form health survey; VAS, visual analogue scale; WOMAC, Western Ontario and McMaster University Osteoarthritis Index.*
** Significant (P<.01).*
*† Significant (P<.05).*

cal function score and SF-36 physical function score ($\rho$ = 0.44 and −0.51, respectively). WOMAC stiffness correlated significantly with WOMAC physical function ($\rho$ = 0.81) and with walking distance ($\rho$ = −0.49). Aerobic capacity did not correlate to any activity components ($\rho$ = 0.11 to −0.23) (**TABLE 6**).

## DISCUSSION

This study reports significantly lower knee extension muscle strength (15%) in patients with hip OA, not candidates for surgery, compared to matched controls. We also found significantly lower hip ROM and shorter walking distance for the patients with hip OA compared to the matched controls. The patients with hip OA in this study were categorized as having mild to moderate hip pain on the WOMAC pain subscale (minimum-maximum, 5.2-59.4).[27] Despite the mild to moderate pain reported by the patients with hip OA, they had significantly lower scores on the physical functioning and role limitations physical subscales of the SF-36, compared to the matched control group.

Earlier studies have reported higher knee extension muscle strength deficits (20%-29%) in patients with hip OA compared to our study.[40,44] But these studies have included patients presurgery, with an average HHS of 52.6 (±9.2).[40,44] Additionally, both Rasch et al[40] and Suetta et al[44] used the contralateral side as the control limb for their patients with unilateral hip OA. Other studies have previously shown that, for patients with unilateral pathologies, strength of the contralateral side of an affected limb is also affected and may, therefore, not be optimal as a control limb.[8] Consequently, we used a group of matched controls for the comparison. We also matched the groups based on strength training frequency, to ensure that the potential difference in muscle strength between groups would not be due to higher strength training frequency in one of the groups. Our controls showed isokinetic knee extension peak torque values similar to those reported in previous studies of healthy men and women (130 ± 25 Nm, 1.68 ± 0.3 Nm/BW).[6,22] This indicates that our controls were representative of normative quadriceps strength data. In contrast to other studies, we found no significant differences in muscle strength for knee flexion or hip extension or flexion.[1,40,44] But the patients with hip OA who participated in these earlier studies had severe hip OA and might have had larger muscle strength deficits.[40,44] Based on current evidence of lower knee extension muscle strength in patients with mild to moderate hip OA, physical therapists should consider including quadriceps muscle strengthening exercises when developing rehabilitation programs.

Although the patients with hip OA in our study only had mild to moderate pain, they had significantly lower hip ROM compared to the matched controls, except for adduction. These findings are consistent with previous studies.[2,43] Hence, ROM deficits should be targeted during rehabilitation of patients with hip OA.

The patients with hip OA in our study covered a significantly shorter distance during the 6MWT (643 versus 719 m) compared to the controls. The patients with hip OA had significantly more hip pain compared to the controls during walking (visual analog scale), which might have led to the shorter walking distance; although there was no significant difference in aerobic capacity between the groups. Two studies have shown significantly reduced aerobic capacity in patients with severe hip and knee OA compared to controls.[8,41] In our study, both the patients with mild to moderate hip OA and the controls showed average maximal aerobic capacity similar to normative data corrected for age (patients with hip OA, 28 ml/kg × min; controls, 31 ml/kg × min; normative data, 27-35 ml/kg × min).[4]

In this study, we found significant associations between body function and activity components. The primary finding was that muscle strength was significantly correlated with walking distance ($\rho$ = 0.48 to 0.64); but we found no significant association with the WOMAC physical function or SF-36 physical function outcome measures. In contrast, Pua et al[39] found a significant association between knee extension muscle strength and SF-36 physical function in patients with hip OA. The nonsignificant association between muscle strength and self-reported activity in our study might be a consequence of a small sample size (n = 26). Furthermore, we found that hip abduction and flexion ROM were associated with WOMAC physical function ($\rho$ = −0.44 and −0.64), and hip flexion ROM was associated with walking distance ($\rho$ = 0.52). Stiffness, as measured by the WOMAC, was associated with walking distance and WOMAC physical function ($\rho$ = 0.49 and 0.80, respectively). Reduced hip ROM and increased stiffness in patients with hip OA may, therefore, have an impact on their functioning and disability, such as putting on socks, getting in and out of a car, or picking something up from the floor. Pain measured with the WOMAC was associated with physical function measured with the WOMAC, and pain perceived while walking was associated with physical function measured with the WOMAC and the SF-36. Because the 2 pain measures were associated with physical function measured with the WOMAC but not to the 6MWT or with the SF-36 physical functioning score, the result of pain and its association to physical function is ambiguous. Hence, no conclusions of the association of pain and physical function can be drawn from this study.

Some limitations of this present study need to be discussed. The subjects in the control group did not undergo radiological examination of the hip joint before inclusion. We, therefore, cannot completely rule out radiographic signs of hip joint OA for those subjects. We used a cut-off below 60 points on the HHS as the criterion to be a candidate for hip surgery. There is no study that has investigated the cut-off of 60 points for surgery, but a preoperative HHS below 60 points has been found in several studies evaluating patients with hip OA for THR.[11,24] Power calculations were based on knee extension muscle strength only, possibly resulting in a lack of statistical power for some of the other variables measured in this study.

The results of this study provide further evidence that even patients with mild to moderate pain related to hip OA have significant impairments and activity limitations that reduce function and increase disability. The knowledge of function and disability for patients with hip OA, with mild to moderate pain, may help clinicians to evaluate and develop rehabilitation programs aimed at improving functioning and disability for this population. Targeting impairments early, preventing loss of function, and reducing lifetime disability in patients with OA has been listed among the leading health priorities in the United States.[21] Because the criteria for THR surgery mainly are based on the patient's symptom state, better-targeted rehabilitation might in the long run help delay or reduce the need for THR surgery.[10,35]

## CONCLUSION

THE PRESENT STUDY SHOWED THAT patients with hip OA, with mild to moderate pain, have significantly lower knee extension muscle strength, less hip ROM, and shorter walking distance compared to a matched control group. The impairments of body functions in this study were associated with activity limitations, suggesting that impairments of body function should be targeted during rehabilitation of patients with hip OA.[9,43] ◉

### KEY POINTS

**FINDINGS:** Patients with hip OA and mild to moderate pain had significantly lower knee extension strength, less hip ROM, and shorter walking distance during the 6MWT compared to a matched control group.

**IMPLICATION:** Rehabilitation programs should consider including quadriceps muscle strength training and hip ROM exercises to improve function and disability in this population.

**CAUTION:** The results of this study may not apply to individuals with either less- or more-severe hip OA.

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