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Strength and Functional Deficits in Individuals with Hip Osteoarthritis Compared to Healthy, Older Adults

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Abstract

Purpose—Hip osteoarthritis compromises quality of life for many individuals. This study quantified deficits in functional capacity for use in rehabilitation goal setting by combining assessments of muscle strength, function and physical activity in patients with hip osteoarthritis and healthy adults.

Methods—Twenty-six patients with end-stage hip osteoarthritis and 18 healthy adults participated. Isometric muscle strength around the hip and knee was measured. Function was assessed using stair climbing, five-time-sit-to-stand, timed-up-and-go and six minute walk tests. The UCLA activity rating scale assessed physical activity. Analyses of covariance (ANCOVA) were used to assess differences between groups.

Results—Patients had 30% less knee extensor ($P<0.001$), 38% less knee flexor ($P<0.001$), 10% less hip flexor ($P=0.47$), 23% less hip extensor ($P=0.24$), and 17% less hip abductor strength ($P=0.23$) than healthy adults. Hip adductor strength was equal between groups ($P=0.93$). Patients were 50% slower on the stair climbing test ($P=0.001$), 34% slower on the timed-up-and-go test ($P=0.004$), 34% slower on the five-time-sit-to-stand test ($P=0.001$), and walked 28% less during the six-minute walk test ($P<0.001$). Patients were less physically active ($P=0.001$).

Conclusions—Patients had deficits in muscle strength, function and physical activity compared to healthy adults. Quantifying these deficits provides benchmarks for improvement during rehabilitation.

Introduction

Osteoarthritis (OA) is the most common joint disease, creating frequent health problems and compromising the quality of life for almost 27 million Americans.[1] Specifically, hip OA affects up to 28% of adults over the age of 65 [2] and the lifetime risk of developing hip OA is 25%, indicating that one in four adults will suffer from hip OA during their lifetime.[3]

Additionally, 21 million Americans report activity limitations directly related to their arthritic condition,[4] potentially posing a significant burden on the healthcare system.[5]

Generally, OA is characterized by cartilage loss,[6] stiffness and pain,[2] and frequently leads to disability.[7] In addition to the loss of articular cartilage, the subchondral bone suffers changes as well including formation of cysts and osteophytes.[6] The specific reasons for the onset of OA are unknown [6, 8] and the risk factors for developing OA are numerous. For the rehabilitation professional, the impact of hip OA on muscle strength, physical functioning and physical activity is of interest and should serve to guide intervention planning.[9, 10] However, setting therapy goals for patients based on their physical status can be challenging, as the degree of improvement desired or required is unknown. Therefore, it is imperative to quantify muscle strength and functional deficits in patient populations and in non-patient populations before therapy goals can be determined.

Studies establishing estimates of muscle strength and physical function for people with and without OA can aid rehabilitation professionals in their goal setting and intervention planning. To our knowledge, no studies are available that compare patients with end-stage hip OA to healthy adults on the combined outcomes of muscle strength, physical functioning and physical activity. Therefore, the purpose of this study was to quantify the deficits in muscle strength, functional performance and physical activity in patients with end-stage hip OA compared to healthy adults to provide benchmarks for rehabilitation goal setting.

Materials and Methods

Participants

Patients with end-stage hip osteoarthritis who were scheduled for total hip arthroplasty (THA) were recruited from four community hospitals between June 2010 and August 2011 (figure 1). Patients were recruited by physician referral or advertisement at pre-operative educational sessions. Healthy adults with no history of hip or knee osteoarthritis or joint replacement were recruited from the community via email advertisement between January 2011 and March 2011. All participants were between the ages of 45–80 and were excluded if they had: uncontrolled hypertension, uncontrolled diabetes, body mass index ≥ 40 kg/m², additional lower extremity orthopaedic pathology (e.g. hip dysplasia) or neurologic disorders that impaired daily function. All participants attended one testing session to assess muscle strength, functional performance, and physical activity levels. Each testing session followed the same test sequence. Each participant was provided written, informed consent and the study was approved by the Colorado Multiple Institutional Review Board.

Outcome Measures

Muscle Strength—Strength of the hip flexors, extensors, abductors, and adductors and the knee extensors and flexors was assessed using an electromechanical dynamometer (HUMAC NORM, CSMI Solutions, Stoughton, MA) connected to a Biopac Data Acquisition System (Biodex Medical Systems, Inc., Shirley, NY) running AcqKnowledge software (v 3.8.2). Strength was measured in the affected limb for patients with hip OA and in the right limb of healthy adults. For hip flexor and extensor strength assessment, participants were positioned

in supine with the hip flexed to 40° (figure 2a). Hip abductor and adductor strength were measured while participants were positioned side-lying with 0° of hip flexion/extension and 0° of hip abduction/adduction (figure 2b). Knee extensor and flexor strength were assessed while the participants were seated with 85° of hip and 60° of knee flexion as previously described (figure 2c).[11, 12] Participants performed a series of maximal voluntary isometric contractions (MVICs) which were preceded by two sub-maximal warm-up contractions. All participants were given visual targets and strong verbal encouragement during each MVIC to aid in eliciting maximal effort. All MVICs were performed by allowing the patient to gradually increase force to his/her maximum ability; maximal effort was maintained for three to five seconds. Patients were allowed 30 second rest periods between repetitions. MVICs for all muscle groups were performed twice and the trial with the highest torque (Nm) was normalized to participant body mass (kg) and used for analysis.

Functional Performance—Measures of functional performance included the stair climbing test (SCT), five time sit-to-stand test (FTSTS), timed-up-and-go test (TUG) and six minute walk test (6MW). The SCT determines how long it takes a patient to ascend and descend 12 stairs.[13] Participants were instructed to climb a flight of 12 stairs, turn around at the top and descend the same flight as quickly and safely as possible. They were permitted to use the handrail for balance but were instructed not to use the handrail to push or pull themselves up or down the stairs. The FTSTS test measures the time it takes to stand up from and sit down in a chair five consecutive times.[14] Each participant was seated in a standard chair (height 43.2 cm) and was instructed to transfer to a standing position and return to a sitting position as quickly as possible five times. Participants were instructed not to use their arms to push themselves up from the chair unless they were unable to complete the task without the use of their arms. The TUG measures the time to rise from a chair, walk 3 meters, turn around, and return to a sitting position in the same chair without physical assistance.[15] The 6MW test assesses how far a person can walk in six minutes.[16] Each participant performed this test in a 30.5m hallway and the total distance covered, in meters, was recorded. [17]

Physical Activity—All participants reported their physical activity level using the UCLA Activity Scale.[18] This scale consists of 10 activity levels ranging from “wholly inactive” (level 1) to “regular participation in impact sports” (level 10) and has been used to effectively to monitor physical activity in individuals with OA.[19]

Statistical Analysis

Since no preliminary data were available, sample size estimates were determined using data from the 6MW test from the first eight THA and eight healthy adults tested. Using the means and standard deviations from the 6MW test in each group, our effect size was 0.67. Using a type I error protection of 0.05 and a power of 0.95, we anticipated 18 patients were needed to detect a difference in 6MW distance (primary outcome). The sample size of THA patients was conservatively increased to 26 to account for the potential to follow-up after THA or possible data collection problems.

Study data were collected and managed using REDCap electronic data capture tools hosted at the University of Colorado Anschutz Medical Campus.[20] REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies. Analyses of covariance (ANCOVA) were used to assess differences in each independent variable between hip OA patients and healthy adults, using sex as a covariate. An alpha level of 0.05 was designated for statistical significance. Statistical analyses were performed using IBM SPSS software (version 19, Armonk, NY). To further describe the differences between groups in each outcome measure, percentage differences between groups, using group means, were calculated.

Results

Twenty-six patients with end stage OA and 18 healthy adults participated in the study (table 1). There were no differences in age or BMI between the hip OA group and the healthy group. Further, the ANCOVA results showed no effect of sex on any of the outcomes measured.

Muscle Strength

Patients with hip OA had 30% less knee extensor strength ($P<0.001$) and 38% less knee flexor strength ($P<0.001$) than healthy adults (figure 3). Further, patients demonstrated 10% less hip flexor strength ($P=0.47$), 23% less hip extensor strength ($P=0.24$), and 17% less hip abductor strength ($P=0.23$) than healthy adults. Hip adductor strength was nearly equal between groups ($P=0.93$) (figure 2).

Functional Performance

Compared with healthy adults, patients with end-stage hip OA had increased difficulty with all functional tasks (figure 4). Specifically, patients were 50% slower on the SCT ($P=0.001$) and 34% slower on the TUG ($P=0.004$). Further, adults with hip OA performed the FTSTS 34% slower than healthy adults ($P=0.001$) and walked 28% less distance during the 6MW ($P<0.001$).

Physical Activity

Participants with end-stage hip OA were less physically active than healthy adults ($P=0.001$). The average UCLA activity scale response for patients with hip OA was 5.5 ± 1.7 , indicating they participate in moderate activity, but not on a regular basis. Comparatively, the average UCLA activity scale response for healthy adults was 7.6 ± 1.9 , indicating they regularly participate in active events.

Discussion

Due to the fact that not all individuals with end-stage hip OA are candidates for total hip arthroplasty, developing appropriate and effective rehabilitation interventions to improve physical functioning is imperative. This study evaluated the combined outcomes of muscle strength, functional performance, and physical activity in a group of people with and without end-stage OA to quantify the differences in these outcomes. These data suggest that adults

with end-stage hip OA have less knee extensor and flexor strength, poorer performance on physical function tests and are less physically active than their healthy peers indicating that rehabilitation professionals should consider a comprehensive approach at improving these aspects in this population.

While 10–25% deficits in hip muscle strength were observed, differences compared to healthy adults were not significant, which was unexpected. However, strength differences of 10% or greater have been considered clinically meaningful for other lower extremity muscle groups;[21] therefore, the differences observed in the current study could be considered clinically meaningful. Nevertheless, our hip strength results are similar to the results reported by Rydevik *et al.*[22] who found no differences in isokinetic hip flexor and extensor strength in individuals with hip OA compared with healthy adults. Additionally, Grimaldi *et al.*[23] reported no differences in hip muscle cross sectional area compared with healthy adults. However, Arokoski *et al.*[24] did report differences in hip muscle strength in patients with hip OA compared with healthy controls and Rasch *et al.*[25] found differences in isometric hip muscle strength when comparing the diseased hip to the healthy hip in patients. The current study results, combined with the differing results previously reported, [22–25] suggest considerable variability in muscle strength outcomes around the hip joint. Such variation might be explained by difficulties isolating specific muscles during testing or related to the choice of testing positions. Additionally, this study included participants in a wide range of ages, including those considered young for joint replacement surgery. The inclusion of this younger cohort could have contributed to lack of significant differences between our patient and healthy groups, as strength loss due to OA in younger individuals may not be as dramatic. Due to the varied outcomes in previous work, and in light of the fact that clinically significant differences in hip muscle strength were observed, we recommend that rehabilitation specialists do evaluate the muscle strength surrounding the hip to guide clinical decision making.

In contrast with the strength findings in the hip musculature, our results do suggest that individuals with end-stage OA exhibit weakness in the knee extensor and flexor muscles compared to healthy adults. The presence of knee extensor weakness is a clinically important finding in this population due to the relation between knee extensor strength and functional mobility[26] and may explain the reason adults with hip OA struggle with daily activity[27] and performed poorly on the functional tasks evaluated in this study. However, whether quadriceps weakness is related to hip disease itself, or a secondary product of disuse and physical inactivity is less clear. In agreement with our findings, Rydevik *et al.*[22] indicated that adults with only mild to moderate hip OA displayed knee extensor weakness of up to 20% compared with healthy adults. Similarly, Rasch *et al.*[25] also reported knee extensor weakness in the arthritic limb compared to the contralateral limb in patients with hip OA. Nonetheless, quadriceps strength plays an important role in daily function[26] and quadriceps weakness is clearly present in this population, suggesting that individuals with hip OA may benefit from a rehabilitation program which includes a quadriceps strengthening component.

In combination with strength deficits, individuals with hip OA were slower on the SCT, FTSTS, TUG and walked less distance during the 6MW test than healthy adults. The deficits

in functional performance all exceeded values considered to be clinically meaningful.[28, 29] These findings are consistent with others who have reported that patients with hip OA have difficulty with daily activity.[30, 31] Additionally, several studies [22, 30, 32] have indicated that individuals with hip OA report lower scores on the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) physical functioning subsection. Overall, these previous studies support our findings that individuals with hip OA have difficulty with daily activities such as walking[30, 31], stair climbing[30] and rising from a chair.[31] However, the current study provides a more comprehensive examination of functional performance and muscle strength in patients with hip OA compared to healthy adults by combining several assessments of functional capacity. These data provide values for goal setting and intervention planning for patients living with end-stage hip OA and offer estimates of the amount of improvement which may be meaningful.

Finally, individuals with hip OA are less physically active than their healthy peers. This finding is consistent with previous studies.[33, 34] Specifically, Venhoff *et al.*[34] and Pisters *et al.*[35] not only observed lower levels of physical activities in individuals with hip OA, but also found that this was related to diminished functional ability[36] and was a risk factor for future physical limitations.[35] Further, Holsgaard-Larsen, *et al.*[33] suggest that the increase in mortality risk experienced by those with OA may be ameliorated with increases in physical activity. Therefore, it is important to ensure that rehabilitation interventions not only consist of muscle strengthening and functional training, but that techniques to improve physical activity levels are included.

The results of this study provide a comprehensive description and quantification of the deficits in muscle strength, functional performance, and physical activity in patients with end-stage hip OA. Since many people with end-stage OA may not be candidates for THA, or may elect not to have surgery, rehabilitation professionals may play an integral role in improving function in this population. These data suggest that rehabilitation should focus on knee extensor and flexor strengthening, functional training and techniques to improve physical function, the combination of which may not be the standard of care presently. Further, rehabilitation professionals should implement a plan of care which aims to improve muscle strength by 30–40% and physical functioning by 40–50% to restore patients' level of function to that of their healthy peers.

Study Limitations

We acknowledge limitations to this study. First, the relatively small sample size may affect the generalizability of the study. However, our findings were consistent with other studies investigating function and strength in patients with hip OA.[22, 24, 37, 38] Second, we did not collect bilateral data in either cohort. The collection of these data might have shown muscle strength differences between limbs as in other studies[24, 37] further depicting the existence of strength impairments in this population.

Conclusions

Adults with end-stage hip OA were 10–38% weaker in their arthritic lower extremity, performed 28–50% poorer on functional tests and were less physically active than healthy

adults. These results establish estimates of the deficits in muscle strength, physical function and physical activity for people with and people without osteoarthritis. This information can aid rehabilitation professionals in their goal setting and intervention planning for individuals living with end-stage hip OA. Further, muscle strength, function and physical activity should be studied after THA to assess the time course of recovery following surgery and the success of post-operative management.

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Declaration of Interest

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References

1. Buckwalter JA, Martin JA. Osteoarthritis. *Adv Drug Deliv Rev.* 2006; 58(2):150–167. [PubMed: 16530881]
2. Buckwalter JA, Saltzman C, Brown T. The impact of osteoarthritis: implications for research. *Clin Orthop Relat Res.* 2004; (427 Suppl):S6–S15. [PubMed: 15480076]
3. Murphy LB, Helmick CG, Schwartz TA, Renner JB, Tudor G, Koch GG, Dragomir AD, Kalsbeek WD, Luta G, Jordan JM. One in four people may develop symptomatic hip osteoarthritis in his or her lifetime. *Osteoarthritis Cartilage.* 2010; 18(11):1372–1379. [PubMed: 20713163]
4. Centers for Disease Control and Prevention. Prevalence of doctor-diagnosed arthritis and arthritis-attributable activity limitation --- United States, 2007–2009. *MMWR Morb Mortal Wkly Rep.* 2010; 59(39):1261–1265. [PubMed: 20930703]
5. Seeman TE, Merkin SS, Crimmins EM, Karlamangla AS. Disability trends among older Americans: National Health And Nutrition Examination Surveys, 1988–1994 and 1999–2004. *Am J Public Health.* 2010; 100(1):100–107. [PubMed: 19910350]
6. Valdes AM, Spector TD. The contribution of genes to osteoarthritis. *Med Clin North Am.* 2009; 93(1):45–66. x. [PubMed: 19059021]
7. van Dijk GM, Dekker J, Veenhof C, van den Ende CH. Course of functional status and pain in osteoarthritis of the hip or knee: a systematic review of the literature. *Arthritis Rheum.* 2006; 55(5): 779–785. [PubMed: 17013827]
8. Sandell LJ. Etiology of osteoarthritis: genetics and synovial joint development. *Nat Rev Rheumatol.* 2012; 8(2):77–89. [PubMed: 22231237]
9. Juhakoski R, Malmivaara A, Lakka TA, Tenhonen S, Hannila ML, Arokoski JP. Determinants of pain and functioning in hip osteoarthritis - a two-year prospective study. *Clin Rehabil.* 2013; 27(3): 281–287. [PubMed: 22843354]
10. Cibulka MT, White DM, Woehrle J, Harris-Hayes M, Ensey K, Fagerson TL, Slover J, Godges JJ. Hip pain and mobility deficits--hip osteoarthritis: clinical practice guidelines linked to the international classification of functioning, disability, and health from the orthopaedic section of the American Physical Therapy Association. *J Orthop Sports Phys Ther.* 2009; 39(4):A1–A25. [PubMed: 19352008]
11. Stevens-Lapsley JE, Balter JE, Kohrt WM, Eckhoff DG. Quadriceps and hamstrings muscle dysfunction after total knee arthroplasty. *Clin Orthop Relat Res.* 2010; 468(9):2460–2468. [PubMed: 20087703]

12. Mintken PE, Carpenter KJ, Eckhoff D, Kohrt WM, Stevens JE. Early neuromuscular electrical stimulation to optimize quadriceps muscle function following total knee arthroplasty: a case report. *J Orthop Sports Phys Ther.* 2007; 37(7):364–371. [PubMed: 17710905]
13. Lin YC, Davey RC, Cochrane T. Tests for physical function of the elderly with knee and hip osteoarthritis. *Scand J Med Sci Sports.* 2001; 11(5):280–286. [PubMed: 11696212]
14. Whitney SL, Wrisley DM, Marchetti GF, Gee MA, Redfern MS, Furman JM. Clinical measurement of sit-to-stand performance in people with balance disorders: validity of data for the Five-Times-Sit-to-Stand Test. *Phys Ther.* 2005; 85(10):1034–1045. [PubMed: 16180952]
15. Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc.* 1991; 39(2):142–148. [PubMed: 1991946]
16. Steffen TM, Hacker TA, Mollinger L. Age- and gender-related test performance in community-dwelling elderly people: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and gait speeds. *Phys Ther.* 2002; 82(2):128–137. [PubMed: 11856064]
17. Parent E, Moffet H. Comparative responsiveness of locomotor tests and questionnaires used to follow early recovery after total knee arthroplasty. *Arch Phys Med Rehabil.* 2002; 83(1):70–80. [PubMed: 11782835]
18. Zahiri CA, Schmalzried TP, Szuszczewicz ES, Amstutz HC. Assessing activity in joint replacement patients. *J Arthroplasty.* 1998; 13(8):890–895. [PubMed: 9880181]
19. Terwee CB, Bouwmeester W, van Elsland SL, de Vet HC, Dekker J. Instruments to assess physical activity in patients with osteoarthritis of the hip or knee: a systematic review of measurement properties. *Osteoarthritis Cartilage.* 2011; 19(6):620–633. [PubMed: 21251989]
20. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009; 42(2):377–381. [PubMed: 18929686]
21. Krishnan C, Williams GN. Evoked tetanic torque and activation level explain strength differences by side. *Eur J Appl Physiol.* 2009; 106(5):769–774. [PubMed: 19396616]
22. Rydevik K, Fernandes L, Nordsletten L, Risberg MA. Functioning and disability in patients with hip osteoarthritis with mild to moderate pain. *J Orthop Sports Phys Ther.* 2010; 40(10):616–624. [PubMed: 20811166]
23. Grimaldi A, Richardson C, Stanton W, Durbridge G, Donnelly W, Hides J. The association between degenerative hip joint pathology and size of the gluteus medius, gluteus minimus and piriformis muscles. *Man Ther.* 2009; 14(6):605–610. [PubMed: 19695944]
24. Arokoski MH, Arokoski JP, Haara M, Kankaanpää M, Vesterinen M, Niemitukia LH, Helminen HJ. Hip muscle strength and muscle cross sectional area in men with and without hip osteoarthritis. *J Rheumatol.* 2002; 29(10):2185–2195. [PubMed: 12375331]
25. Rasch A, Dalen N, Berg HE. Muscle strength, gait, and balance in 20 patients with hip osteoarthritis followed for 2 years after THA. *Acta Orthop.* 2010; 81(2):183–188. [PubMed: 20367414]
26. Pua YH, Clark RA, Bryant AL. Physical function in hip osteoarthritis: relationship to isometric knee extensor steadiness. *Arch Phys Med Rehabil.* 2010; 91(7):1110–1116. [PubMed: 20599051]
27. Mizner RL, Petterson SC, Stevens JE, Axe MJ, Snyder-Mackler L. Preoperative quadriceps strength predicts functional ability one year after total knee arthroplasty. *J Rheumatol.* 2005; 32(8):1533–1539. [PubMed: 16078331]
28. Bohannon RW. Reference values for the five-repetition sit-to-stand test: a descriptive meta-analysis of data from elders. *Percept Mot Skills.* 2006; 103(1):215–222. [PubMed: 17037663]
29. Kennedy DM, Stratford PW, Wessel J, Gollish JD, Penney D. Assessing stability and change of four performance measures: a longitudinal study evaluating outcome following total hip and knee arthroplasty. *BMC Musculoskelet Disord.* 2005; 6:3. [PubMed: 15679884]
30. Arokoski MH, Haara M, Helminen HJ, Arokoski JP. Physical function in men with and without hip osteoarthritis. *Arch Phys Med Rehabil.* 2004; 85(4):574–581. [PubMed: 15083432]
31. Vissers MM, Bussmann JB, de Groot IB, Verhaar JA, Reijman M. Walking and chair rising performed in the daily life situation before and after total hip arthroplasty. *Osteoarthritis Cartilage.* 2011; 19(9):1102–1107. [PubMed: 21723401]

32. Mahon JL, Bourne RB, Rorabeck CH, Feeny DH, Stitt L, Webster-Bogaert S. Health-related quality of life and mobility of patients awaiting elective total hip arthroplasty: a prospective study. *CMAJ*. 2002; 167(10):1115–1121. [PubMed: 12427702]
33. Holsgaard-Larsen A, Roos EM. Objectively measured physical activity in patients with end stage knee or hip osteoarthritis. *Eur J Phys Rehabil Med*. 2012; 48(4):577–585. [PubMed: 22641252]
34. Veenhof C, Huisman PA, Barten JA, Takken T, Pisters MF. Factors associated with physical activity in patients with osteoarthritis of the hip or knee: a systematic review. *Osteoarthritis Cartilage*. 2012; 20(1):6–12. [PubMed: 22044842]
35. Pisters MF, Veenhof C, van Dijk GM, Heymans MW, Twisk JW, Dekker J. The course of limitations in activities over 5 years in patients with knee and hip osteoarthritis with moderate functional limitations: risk factors for future functional decline. *Osteoarthritis Cartilage*. 2012; 20(6):503–510. [PubMed: 22330176]
36. Veenhof C, Huisman PA, Barten JA, Takken T, Pisters MF. Factors associated with physical activity in patients with osteoarthritis of the hip or knee: a systematic review. *Osteoarthritis Cartilage*. 2011
37. Grimaldi A, Richardson C, Durbridge G, Donnelly W, Darnell R, Hides J. The association between degenerative hip joint pathology and size of the gluteus maximus and tensor fascia lata muscles. *Man Ther*. 2009; 14(6):611–617. [PubMed: 19121974]
38. Suetta C, Aagaard P, Magnusson SP, Andersen LL, Sipila S, Rosted A, Jakobsen AK, Duus B, Kjaer M. Muscle size, neuromuscular activation, and rapid force characteristics in elderly men and women: effects of unilateral long-term disuse due to hip-osteoarthritis. *J Appl Physiol*. 2007; 102(3):942–948. [PubMed: 17122381]

Figure 1.
Participant enrollment flowchart.

Figure 2.

(A–C). Muscle Strength Testing Positions.

A) Study participant positioned on the dynamometer for hip flexor and hip extensor strength testing B) Study participant positioned on the dynamometer for hip abductor and hip adductor strength testing C) Study participant positioned on the dynamometer for knee extensor and knee flexor strength testing

Figure 3. Hip and knee muscle strength in hip OA group and healthy adult group. Mean $\pm$ standard error. * differences between groups ($P<0.05$).

Figure 4.

Functional performance measures for participants in hip OA group and healthy adult group. Mean $\pm$ standard error. SCT= stair climbing test; FTSTS=five time sit to stand; TUG=timed up and go; 6MW= six minute walk test. *difference between groups ($P<0.05$).

Table 1

Participant Demographics

	Hip OA	Healthy Adults	p-value
Sample Size	n=26	n=18	--
Sex	18 female; 8 male	11 female; 7 male	--
Age (years)*	61.4±8.1	58.7±7.3	p=0.27
BMI (kg/m²)*	27.9±5.1	29.9±14.3	p=0.50

* Mean ± standard deviation, unless otherwise noted.

BMI= body mass index. OA= osteoarthritis