

# Functional and Physiological Determinants of Perceived Disability in Individuals Diagnosed with Osteoarthritis of the Hip

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## Abstract

**Objectives:** The main objective of this pilot study was to investigate which standardized functional and physiological test best predicted perceived disability in a single group of 21 individuals diagnosed with osteoarthritis of the hip.

**Design:** Men and women between 60 and 70 years old with osteoarthritis of the hip were selected. If participants passed study criteria, the Western Ontario McMaster University questionnaire (WOMAC), 6 Minute Walk Test (6MWT) and Timed up and Go (TUG), strength testing and aerobic testing were obtained in one single assessment.

**Results:** Regression analysis revealed that wait time, hip abduction strength of the affected side, Aerobic Capacity (VO<sub>2</sub> Peak), hip Extension Peak Torque, hip Flexion Peak Torque, TUG and 6MWT were significantly correlated with the WOMAC. Yet, the 6MWT had the highest significant correlation ( $r = -0.86$ ,  $p \leq 0.0001$ );  $R^2 = 0.75$  or 75% with the WOMAC total scores, ( $r = -0.82$ ,  $p \leq 0.0001$ );  $R^2 = 0.67$  or 67% with the WOMAC function and ( $r = -0.60$ ,  $p = .002$ );  $R^2 = 0.36$  or 36% with the WOMAC stiffness. While the VO<sub>2</sub> Peak revealed the highest significant correlation ( $r = 0.76$ ,  $p \leq .0001$ );  $R^2 = 0.57$  or 57% with the WOMAC pain.

**Conclusions:** The 6MWT and the VO<sub>2</sub> Peak seem to be essential functional and physiological assessment tools to determine perceived disability in individuals with hip OA. The perceived disability may provide new or comprehensive knowledge of the disability problems experienced by individuals with osteoarthritis of the hip, and the association of patient perception with objective measures of functional and physiological capacity might strengthen the clinical value of this knowledge.

**Keywords:** Osteoarthritis; Hip; Perceived disability; Total joint replacement

## Introduction

Osteoarthritis (OA) is the most common chronic joint condition and it may place considerable limitation on function and quality of life, increasing an individual's chances of becoming disabled [1]. Approximately 3 million Canadians (1 in 10) have OA and it is estimated that 85% of Canadians will have been diagnosed with OA by the age of 70 years [2,3]. According to Statistics Canada, the 1996 to 1997 National Population Health Survey revealed that the prevalence of OA is 2.5 times and 6 times greater than that of heart disease and cancer, respectively [4]. Moreover, given the lengthening of life-span as a direct result of rising standards of living and advances in modern medicine, the prevalence of osteoarthritis and its subsequent burden are projected to increase significantly [4]. It has been estimated that total health care costs to treat Canadians with OA will rise from \$1.8 billion dollars in 2010 to \$8.1 billion dollars in 2031 [5].

OA is the wearing down of cartilage in the joints of the body, causing varying degrees of pain, stiffness and swelling [6]. The hip joint is one of the joints most frequently affected by OA [6]. For those over the age of 65, OA of the hip accounts for greater physical disability in lower extremity tasks, such as walking, stair climbing, and rising from a chair, than any other condition [7,8]. As a result, many individuals end up requiring a total hip replacement surgery (THR). However, the prioritization criteria for a total joint replacement surgery (TJR) remain highly subjective and lacks consensus [9]. Such inconsistency may lead some individuals to wait longer for surgery than others [9,10]. A shorter wait for surgery, on the other hand, has been associated with larger gains in health-related quality of life and better functional performance [10]. Therefore it is expected that those who wait longer to have surgery may self-report higher rates of disability.

According to The World Health Organization (WHO) disability is an 'umbrella term' which covers impairment, activity limitations

and participation restrictions. WHO defines these concepts as: "Impairment is a problem in body function or structure, an activity limitation is a difficulty encountered by an individual in executing a task or action, while a participation restriction is a problem experienced by an individual in involvement in life situation" [11]. In the context of those over the age of 65 with hip OA, the damaged joint represents the problem in body function or structure, as part of the impairment domain; mobility limitations such as those observed during walking, stair climbing, and rising from a chair represent the activity domain; whereas restriction in involvement in social or personal life situations, represents participation restriction.

Hip OA is a well-known cause of physical limitations and decrease in quality of life, resulting in disability which is usually measured with questionnaires or with the use of standardized functional and physiological tests. However, the functional or physiological test that best predicts disability in this population is not clearly defined in the literature. Therefore, this small scale preliminary study or pilot study was conducted to evaluate feasibility, time, adverse events, and effect

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size and to investigate which standardized test, here called determinant of disability, best predicted disability in a single group of individuals diagnosed with hip OA.

## Methods

### Subjects

This study involved patients referred to three orthopedic surgeons who operate at the Kingston General Hospital (KGH) in Kingston, Ontario. The patients were identified using the current caseload of these surgeons and were contacted directly by a research assistant during their consultation with the surgeons. Ethical approval was obtained from the Health Sciences Research Ethics Board of Queen's University before contacting potential participants for the study. The study sample consisted of 21 individuals who agreed to participate. Those individuals were diagnosed with hip OA during the consultation time with the participating surgeons and were deemed potential candidates for a THR.

**Eligibility criteria included the following:** had been diagnosed with moderate to severe OA of the hip by one of the three participating surgeons according to their radiological findings using Kellgren and Lawrence scale and surgeon judgment. The subjects also had to be able to tolerate moderate activity for one to two hours and have the ability to provide informed consent. Patients were excluded if they presented with any neurological, cardiac, or psychiatric disorders or other medical conditions that would limit their function enough for them to be unable to participate. If these conditions were mild or did not limit their function, they were allowed to participate.

### Outcome measures

Disability was assessed using the Western Ontario McMaster Universities Osteoarthritis Index (WOMAC). The WOMAC questionnaire can be divided into four parts: WOMAC total score, WOMAC pain score, WOMAC stiffness and WOMAC function. The determinants of disability were investigated by using functional and physiological tests. The 6MWT and TUG were the objective measures of function. Strength as measured on a Biodex isokinetic dynamometer, and  $VO_2$  peak, based on a monogram proposed by Helgerude J, et al for calculation of upper body aerobic power from heart rate during submaximal arm cycling using an arm ergometer, were the objective measures of physiological function. In order to prevent any potential influencing factors that could affect the performance on the test for  $VO_2$  peak, subjects were requested not to eat, smoke, or exercise for two hours prior to testing. All tests were administered in a randomized order.

The WOMAC function section consists of 17 items related to the degree of difficulty of performing the activities of daily living (e.g., walking or sitting) to assess the individual's level of physical function. The Likert Scale version of WOMAC was the one used in this study. The patients were asked to identify, on a scale from 0 (none) to 4 (extreme), the degree of difficulty they had been experiencing in the past 72 hours. The maximal score for this questionnaire section ranges from 0 to 68, with higher scores indicating greater disability. The WOMAC pain section consists of 5 items with a total score ranging from 0 to 20, with higher scores indicating greater levels of pain. Finally, the WOMAC stiffness section corresponds to the degree of stiffness individuals with knee OA were experiencing. This section consists of 2 items with a total score of 8 which indicates a high degree of stiffness [12].

The 6MWT is generally conducted in an enclosed, quiet corridor on a 25-meter track delineated by two lines marked on the floor [13].

Patients were instructed to walk from one line to the other, covering as much ground as possible in six minutes. Individuals were told that they could rest if they became too short of breath or tired, but to continue walking when they were able to do so. To calculate the walking distance, a meter wheel was used to measure the additional steps of any incomplete lap (in meters). The procedure for the TUG requires documenting the time, in seconds, that an individual takes to rise from a standard armchair, walk 3 meters, turn, walk back to the chair and sit down quickly and safely [14]. The subjects were allowed to use any assistive device that they would normally use for walking in order to make them feel safe and comfortable during the test. Prior to testing, the subjects were warned that there would be two trials and then they were instructed about the basic sequence of the test, as described: "When I say, 'go', you will stand up pushing from the arm of the chair, walk to the mark (line) on the floor, turn around, walk back to the chair and sit down. 'I will be timing you using a stopwatch.'" The subjects were allowed to rest as much as they needed between each trial. A shorter time taken to complete a task indicates a lower risk for falling and greater functional status.

A Biodex isokinetic dynamometer was used in this study to test functional muscle performance in subjects with hip OA. The concentric maximum peak torque of hip flexion and extension during a single testing session was measured in Newton/meters as a measurement of force. The testing protocol involved the subjects standing on the isokinetic dynamometer platform with straps placed over their shoulders and across their waist to ensure that the torso was stable. In addition, a cushion was placed between the subject's back and the back of the seat to provide more comfort and stability to the subject during the test. An adjustable lever arm was attached to the subject's thigh by a padded cuff, approximately midway between hip and knee. The axis of rotation of the dynamometer arm was positioned just lateral to the greater trochanter while the subject was standing. The subject's hips were set in a  $0^\circ$  angle ( $0^\circ$  = anatomical position) as a starting position, and then the concentric isokinetic test was performed. During the test, the subject started from  $0^\circ$  and then pushed the lever arm of the isokinetic device up and down through a range of motion between a  $90^\circ$  hip flexion to a  $10^\circ$  hip extension. A set of two trials was conducted, each consisting of continuous range of motion (ROM) for hip flexion-extension, repeated five times at an angular velocity of  $60^\circ/\text{sec}$ . The greatest peak torque between the two trials was recorded [15-17]. The subject was instructed to push their thigh up and down in a constant motion and to apply as much force as they could in a consistent way during each repetition. Standardized verbal encouragement such as "push up hard" and "pull down hard" was given during the testing. Each subject was given a minimum of one-minute recovery between trials and then the test was repeated.

The arm ergometry test was used to predict the  $VO_2$  peak in subjects with hip OA. The subjects were asked to pedal at a frequency of 70 revolutions per minute (rpm) against a constant workload of 21 Watts (125 kg/m) for females and 42 Watts (250 kg/m) for males. The workload was adjusted and maintained using the weights from the arm ergometer as proposed by Helgerude et al. [18]. To predict  $VO_2$  peak using an arm cycling submaximal test, the subjects should achieve a continuous steady state heart rate either equal or above 110 beats per minute (bpm) during the last 30 seconds of submaximal test [18]. The heart rate was monitored constantly using a chest strap heart rate monitor and a digital watch set (Polar Electro, Inc Woodbury, NY) during the test. The test length of time was four minutes and pulse rate was recorded every 10 seconds during the last 30 seconds, between the third and fourth minutes. If the difference between the lowest and

the highest pulse rate, recorded in the last 30 seconds of exercising, did not exceed 5bpm, a steady state heart rate was considered to be present [18,19]. The average HR from the steady state, was used to find a corresponding VO<sub>2</sub> peak (L.min) on the monogram's table [18]. Further to that, VO<sub>2</sub> peak was calculated in ml/kg/min based on the monogram's equation: VO<sub>2</sub> peak (L.min) X 1000 / Body Weight (BW). All the subjects reached at least 110 bpm or more and, consequently, a new test were not needed. However, if their heart rates had not reached at least 110 bpm during the last 30 seconds of testing, the workload would have been increased by 21 W (125 kg/min) and a new test would have been initiated.

### Study design

A cross-sectional design study was conducted using a sample of patients with hip OA who were deemed potential candidates for a THR by an orthopedic surgeon. After passing study criteria, these individuals were assessed in order to investigate which determinant of disability, measured with functional and physiological tests, better predicts disability in a single group of individuals diagnosed with hip OA. All functional and physiological tests were randomly assigned.

### Data analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS 21) and Microsoft Office Excel 2010. In the first set of analysis, a univariate descriptive statistics (mean, standard deviation, frequency counts and percentages) were calculated for demographic and outcome data. Variables such as age, gender, body mass index (BMI) and wait time (from the time patients were referred to a surgeon to the day they were assessed in the study) were recorded to summarize the group characteristics. The analysis was conducted with a power level of 0.8 and alpha (α) level of 0.05. Results were presented as mean ± standard deviation (SD) and/or median range or as counts with proportion as appropriate.

In the second set of analysis, an independent T-test was performed in order to observe gender differences. Then, a paired T-test was carried out to compare the range of motion (ROM) between the affected and non-affected leg. A paired samples T-test assumes that the groups (affected and non-affected legs) were related to each other [20], which could have been the case for ROM between both sides. Finally a stepwise regression analysis was used to observe which variable better predicts disability according to the WOMAC questionnaire. Before starting the stepwise linear regression, we performed a collinearity statistical test to ensure that a possible collinearity effect was not cause for concern; thus, we could proceed with the Stepwise linear regression analysis.

### Results

The descriptive composition of all 21 individuals is summarized in Table 1. The independent T-test indicated that joint stiffness was significantly higher (p = 0.014) in men than women based on the WOMAC stiffness score (Table 2). However, no other significant differences were observed. These results indicate that gender had minimal or no influence in our final results, in which all subjects are grouped together. The paired T-test showed significant differences (p ≤ 0.001) between extension, flexion and abduction of the hip joint when comparing the affected leg with the non-affected one (Table 3). These results indicate that the ROM of the affected leg may be an important determinant of disability for those individuals.

Our regression analysis indicated that wait time, hip abduction of the affected side, VO<sub>2</sub> Peak, hip Extension Peak Torque, hip Flexion Peak Torque, TUG, 6MWT and joint pain right after the 6MWT were

significantly correlated with the WOMAC total score (Table 4). Yet, the 6MWT revealed the highest significant correlation (r = - 0.86, p ≤ 0.0001). The stepwise regression analysis automatically selects or removes predictors from the model, therefore, a higher perceived disability measured with the WOMAC total score, was explained by a decrease in 6MWT (Figure 1) where the coefficient of determination or proportion of variation (R<sup>2</sup>) was R<sup>2</sup> = 0.75 or 75% (F = 58.7, p ≤ 0.0001). With regard to WOMAC function and stiffness, both revealed that the 6MWT also had the highest significant correlation (r = - 0.82, p ≤ 0.0001) and (r = - 0.60, p = .002) respectively. In view of that, the stepwise regression analysis respectively [1,19] indicated that decrease in function (high WOMAC function scores) was explained by a decrease in 6MWT (Figure 2) where R<sup>2</sup> = 0.67 or 67% (F = 38.8, p ≤ 0.0001) and an increase in joint stiffness (high WOMAC stiffness scores) was explained by a decrease in 6MWT (Figure 3)

Where R<sup>2</sup> = 0.36 or 36% (F = 10.8, p = 0.004). With respect to the WOMAC pain, however, the VO<sub>2</sub> Peak revealed the highest significant correlation (r = 0.76, ≤ p.0001). The stepwise regression analysis indicated that R<sup>2</sup> = 0.57 or 57% (F = 25.9, p ≤ 0.0001). Consequently, an increase in pain was explained by the decrease in aerobic capacity (Figure 4).

### Discussion

There are different approaches to measuring disability [21]. In this pilot study and as part of our main objective, we used standardized functional and physiological tests to assess disability in elderly individuals who were candidates for total hip replacement surgery.

Variables	Mean	Std. Deviation (SD)
Age	67.19	8.24
BMI	26.47	4.03
Time (months)	8.14	4.61
Weight	77.95	14.67
WOMAC-total	59.2	14.9
WOMAC-function	43.2	9.92
WOMAC-pain	11.0	4.56
WOMAC-stiff	5.3	1.64

Table 1: Participant's characteristic.

Variables	Mean (SD)		p-value
	Female	Male	
ALExt	7.0 (3.3)	5.27 (2.45)	.192
ALFlex	83.6 (13.0)	81.82 (16.1)	.785
ALAbd	15.0 (9.1)	15.1 (5.6)	.978
VO <sub>2</sub> Peak	27.1 (7.9)	27.05 (5.9)	.988
HipFlex(PeakTorque)	69.8 (17.1)	78.03 (22.7)	.363
HipExt(PeakTorque)	58.6 (19.6)	50.23 (12.4)	.253
TUG	11.6 (4.7)	11.3 (2.6)	.840
6MWT	363.8 (129.1)	321.6 (106.4)	.422
6MWT-Pain	4.75 (2.0)	6.58 (2.11)	.057
BMI	26.46 (5.2)	26.48 (3.0)	.993
Wait Time	6.70 (3.65)	9.45 (5.24)	.183
Age	64.8 (10.2)	69.4 (5.6)	.215
WOMAC	57.7 (14.6)	60.55 (15.7)	.673
WOMAC-pain	11 (4.76)	10.82 (4.6)	.930
WOMAC-stiff	<b>4.4 (1.2)</b>	<b>6.09 (1.64)</b>	<b>.014</b>
WOMAC-function	42.7 (9.7)	43.64 (10.6)	.835

Table 2: Independent T-test. Mean and Standard deviation (SD) - gender differences. Range of motion: Affected Leg Extension (ALExt), Affected Leg Flexion (ALFlex), Affected Leg Abduction (ALAbd).

	Mean Difference (SD)	p-value	95% Confidence Interval of the Difference		
			Lower	Upper	
Pair 1	ALExt - NALExt	-3.0 (2.45)	.000	-4.115	-1.885
Pair 2	ALFlex - NALFlex	-16.1 (11.6)	.000	-21.428	-10.857
Pair 3	ALAbd - NALabd	-7.2 (5.2)	.000	-9.607	-4.869

**Table 3:** Paired T-test: Range of Motion (ROM) - Affected and Non-Affected legs; Affected Leg Extension (ALExt), Affected Leg Flexion (ALFlex), Affected Leg Abduction (ALAbd).

	Mean (SD)	WOMAC	WOMAC-pain	WOMAC-stiff	WOMAC-function
WOMAC	59.2 (14.9)	-	.876**	.562**	.970**
WOMAC-pain	11.0 (4.5)	.876**	-	.377	.764**
WOMAC-stiff	5.3 (1.6)	.562**	.377	-	.483*
WOMAC-function	43.2 (9.9)	.970**	.764**	.483*	-
Weight	78 (14.7)	.181	.172	.212	.143
BMI	26.5 (4.0)	.223	.299	.049	.174
Wait Time	8.1 (4.66)	.497*	.466*	.190	.495*
ASExt	6.1 (3.0)	-.170	-.025	-.230	-.230
ASFlex	82.7 (14.4)	.154	.375*	.198	.012
ASAbd	15.0 (7.2)	-.494*	-.246	-.227	-.559**
VO <sub>2</sub> Peak	27.0 (6.7)	-.741*	-.760**	-.387*	-.679**
HipFlex (PeakTorque)	74.1 (20.2)	-.656**	-.561**	-.159	-.640**
HipExt (PeakTorque)	54.2 (16.4)	-.616**	-.430*	-.359	-.643**
TUG	11.4 (3.7)	.671**	.607**	.341	.652**
6MWT	341.7 (116.7)	-.869**	-.741**	-.603**	-.820**
6MWT-Pain	5.7 (2.2)	.533**	.382*	.409*	.521**

**Table 4:** Correlations table: \*\*Correlation is significant at 0.01 level (2-tailed); \*Correlation is significant at 0.05 level (2-tailed). Affected Leg Extension (ALExt), Affected Leg Flexion (ALFlex), Affected Leg Abduction (ALAbd).

All participants waited approximately 8 months from the time they were referred to a surgeon to the day they were assessed in the study. Wait time was significantly correlated with the WOMAC total score ( $p \leq 0.05$ ;  $r = 0.50$ ) and its subcategories of pain ( $p \leq 0.05$ ;  $r = 0.46$ ) and function ( $p \leq 0.05$ ;  $r = 0.49$ ). This result suggests that in the last 8 months, from the day patients were referred to a surgeon to the day they were assessed in the study, the patients' perception of disability were likely to increase based on the WOMAC score.

Even though the hip joint is commonly affected by OA, several research studies have explored disability as a result of OA of the knee joint [12,22,23]. Therefore, extrapolating from previous studies with individuals with knee OA, it has been observed that the 6MWT, TUG, and stair-climbing tests provide the same information, largely reflected in self-efficacy for physical tasks [12,22]. In other words, independent of which of these tests are used in the clinical setting, a similar result may be observed. However, our findings with candidates for THR indicated that the 6MWT alone explained 75% of the variance in WOMAC total scores, 67% of the variance in WOMAC function and 36% of the variance in WOMAC stiffness. Therefore, the 6MWT appears to be the best functional predictor of disability in this group.

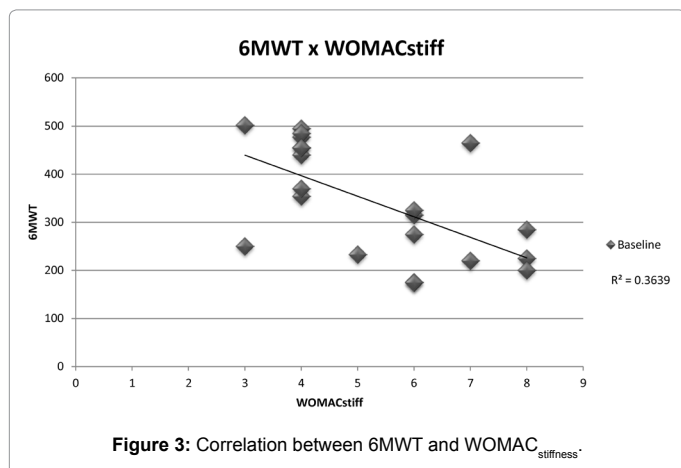
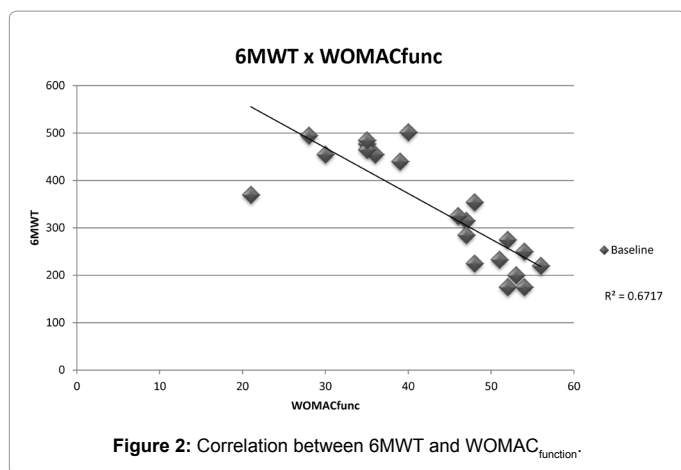
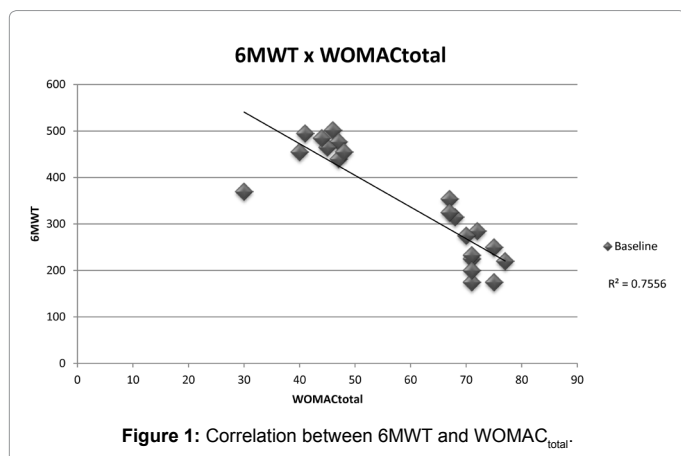
Similar to our results, a previous study with eligible candidates for THR observed that at baseline, 30 participants walked an average of  $339 \text{ m} \pm 103.5$  during the 6MWT [24]. We found that our participants walked an average of  $341.7 \text{ m} \pm 116.7$  at baseline (Table 4). The authors indicated that the 6MWT was significantly correlated with both WOMAC function ( $p \leq 0.05$ ;  $r = 0.54$ ) and WOMAC stiffness ( $p \leq 0.05$ ;  $r = 0.57$ ) improvement after THR surgery. We found that the 6MWT of our 21 participants was negatively correlated with WOMAC function ( $p \leq 0.01$ ;  $r = -0.82$ ) and WOMAC stiffness ( $p \leq 0.01$ ;  $r = -0.63$ ). While the previous study was focused on improvement after surgical outcome, we were looking at the relationship between disability, measured by WOMAC scores, and 6MWT; our results showed significant but,

negative correlations, meaning that high WOMAC were equivalent to lower walking capacity (shorter distance reached) or lower function.

Moreover, the 6MWT has been recommended as an important performance-based test to assess function in people with established hip and knee OA [25]. In accordance with these recommendations, we observed that this functional tests as well as physiological tests of muscle strength and aerobic capacity were associated with high levels of disability (Table 4). Therefore, performance-based tests seem to be important tools that can be used to assess disability in individuals with hip OA.

Other studies with patients diagnosed with hip OA [26,27] indicated that individuals who are considered preoperative candidates for hip replacement usually tend to be older and overweight or obese. Such characteristics may represent important reasons why these individuals self-report higher rates of disability. Without disparaging the legitimacy of these previous findings, our results indicated that age or body weight did not play a significant role in increasing the perception of disability in individuals with hip OA. As much as aging and excessive body weight may aggravate disability in people with osteoarthritis of the hip [7,28], the same could be applied to elderly overweight or obese individuals who have never been diagnosed with hip OA [29]. Excess body weight contributes significantly to a large scope of chronic diseases independent of osteoarthritis and is also responsible for disability, lost work days, restricted activity of daily living, and mobility limitations, thus incurring huge costs for the health care system [6,30,31]. Therefore, aging and excessive body weight could not be attributed as major determinants of disability in our study, yet lower mobility, observed with 6MWT and TUG, reduced muscle strength, aerobic capacity, and limited ROM directly contributed to a decrease in the ability to perform the basic tasks of daily activities and hence, increasing functional disability.

As part of our functional measurements we also observed a

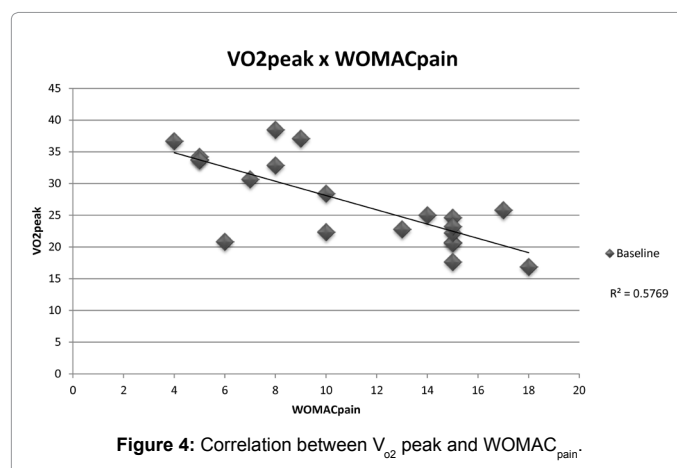


difference in ROM between both legs and a relationship between lower ROM with disability. A similar study observed that the level of disability was found to be dependent on the level of joint mobility [32]. The authors found that hip extension had a significant ( $p < 0.01$ ) correlation ( $r = -0.29$ ) with self-reported disability. While hip flexion ( $p < 0.01$ ;  $r = -0.25$ ), hip extension ( $p < 0.001$ ;  $r = -0.35$ ) and hip abduction ( $p < 0.001$ ;  $r = -0.33$ ) were significantly correlated with observed disability. Our findings indicated that hip abduction was significantly correlated with WOMAC total scores ( $p \leq 0.05$ ;  $r = -0.49$ ) and WOMAC function ( $p \leq 0.01$ ;  $r = -0.56$ ) and hip flexion significantly correlated with WOMAC

pain ( $p \leq 0.05$ ;  $r = -0.35$ ) (Table 4). Even though decreased ROM alone did not play a major role in predicting disability in our study, it should be always taken into consideration when other factors, such as diminished walking capacity, and aerobic capacity and lower extremity weakness are concurrently observed during functional assessments in the clinical setting.

Lower extremity weakness, particularly of the quadriceps muscles, is a common feature of persons with hip and knee OA (Osteoarthritis) [26,33-35]. Cross-sectional and longitudinal studies have indicated that quadriceps weakness may not only be a consequence of hip and knee OA (Osteoarthritis) [24,36], but also a risk factor for disease development [24,33]. Quadriceps muscle weakness is also implicated as a determinant of physical disability in hip and knee OA [26,35-37]. Most studies measuring lower extremity weakness were relevant to knee OA, rather than hip OA. Therefore extrapolating from previous studies including individuals with knee OA (Osteoarthritis) [33] observed that about 50% of their subjects with knee pain indicated voluntary quadriceps strength lower than 71%, while similar findings were observed in only 15.7% of controls. With respect to hip OA, we observed that hip flexion (peak torque) was significantly correlated with WOMAC total scores ( $p \leq 0.01$ ;  $r = -0.65$ ), WOMAC pain ( $p \leq 0.01$ ;  $r = -0.56$ ) and WOMAC function ( $p \leq 0.01$ ;  $r = -0.64$ ). While hip extension was significantly correlated with WOMAC total scores ( $p \leq 0.01$ ;  $r = -0.61$ ), WOMAC pain ( $p \leq 0.05$ ;  $r = -0.43$ ) and WOMAC function ( $p \leq 0.01$ ;  $r = -0.64$ ) (Table 4). Therefore, muscle weakness for both hip and knee is strongly associated with joint pain and disability.

It is also expected that reduced muscle strength in individuals with knee and hip OA may decrease their ability to perform general daily tasks that involve aerobic activities such as walking [38-40]. As a consequence, it might elevate oxygen costs to a point where these individuals may function very close to their maximum aerobic capacity. Thus, they may slow their cadence and/or adopt different motor strategies [41] to compensate for their limitations. Cardiorespiratory capacity is considered an essential component of physical fitness [42,43] and is defined as the physical ability to sustain a constant pace of activity or exercise without reaching an exhaustive level of fatigue and tiredness [44]. However, cardiorespiratory capacity tends to be lower in individuals diagnosed with knee and hip OA [45]. A study with individuals diagnosed with knee OA compared a vigorous aerobic exercise group and resistance exercise group with a health education group [46].  $VO_2$  Peak was significantly higher in the aerobic group compared to the health education group [46]. If improvement in oxygen uptake was reached, it could be expected that individuals with



knee OA may perceive themselves as less disabled and they may be able to walk further distances without reaching higher levels of tiredness and respiratory stress. However, the author did not measure participants' perception of disability. Interestingly, our results indicated that the VO<sub>2</sub> Peak revealed the highest significant correlation ( $r = 0.76, p \leq .0001$ ) with the WOMAC pain. The stepwise regression analysis indicated that  $R^2 = 0.57$  or 57% ( $F = 25.9, p \leq .0001$ ) and therefore, an increase in pain was explained by the decrease in aerobic capacity (Figure 4). Moreover the VO<sub>2</sub> Peak significantly correlated with the WOMAC total scores ( $p \leq 0.05; r = -0.74$ ), and its subcategories, WOMAC pain ( $p \leq 0.01; r = -0.76$ ), WOMAC stiffness ( $p \leq 0.05; r = -0.39$ ) and WOMAC function ( $p \leq 0.01; r = -0.68$ ). These results indicate that a lower aerobic capacity is a strong determinant of disability as shown by the WOMAC pain scores. Moreover, it indicates that these individuals may be at risk of other chronic conditions, particularly, cardiovascular disease [45].

Functional performance, the general day-to-day activity such as walking, climbing stairs, standing and rising from sitting, is directly affected by functional capacity measured by functional and physiological tests [47]. A debilitating condition, such as OA, imposes great physical and physiological challenges to those individuals affected [6,48]. For example, joint pain may limit an individual to maintain a proper walking pattern [34,49-51]. Over time, this modified walking pattern may affect muscle strength and increase oxygen consumption compromising an individual's level of functional performance [15,45,47]. Therefore, hip OA may impose substantial challenges to individuals' activities of daily living which ultimately affects their level of physical independence.

Our present pilot study provided new or comprehensive knowledge of the disability problems experienced by individuals with hip OA, and the association of the perceived level of disability with objective measures of functional and physiological capacity might strengthen the clinical value of this knowledge. Therefore, both the 6MWT and the VO<sub>2</sub> Peak seem to be important functional and physiological tools to determine disability in individuals with hip OA. It is also expected that the knowledge gained from this study may have the potential to inform clinical practice to develop targeted interventions to reduce levels of disability and increase levels of function and mobility for this population.

This study's results were based on a group level assessed at a single time point and therefore, it cannot determine what happens at the level of the individual. Despite of the significant findings obtained, a total of 21 participants was probably a small number. Another limitation was the lack of time over which the study was performed. Rather a longitudinal study may provide more information because measurements can be taken at different points in time.

Furthermore, a second group with control individuals should be recruited to compare with the patients findings.

Future studies need to include a larger sample of subjects with hip OA and potentially a control group of matched healthy individuals. Further investigations are needed to determine deterioration in hip flexion and extension muscle strength, as well as in hip abduction and adduction muscle strength that occur among those individuals who are waiting for total hip replacement. Additionally, a longitudinal design would be preferable over a cross sectional one in order to observe changes in functional and physiological status of individuals with hip OA.

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