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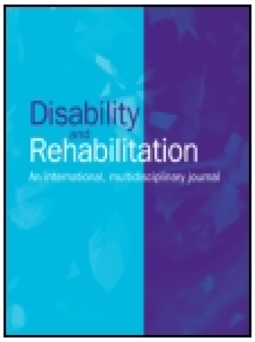

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RESEARCH PAPER

Changes in self-reported disability after performance-based tests in obese and non-obese individuals diagnosed with osteoarthritis of the knee

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Abstract

Purpose: The purposes of this study are three-fold: (1) To examine whether the WOMAC questionnaire should be obtained before or after performance-based tests. (2) To assess whether self-reported disability scores before and after performance-based tests differ between obese and non-obese individuals. (3) To observe whether physical activity and BMI predict self-reported disability before and after performance based tests. *Methods*: A longitudinal study included thirty one participants diagnosed with knee osteoarthritis (OA) using the Kellgren-Lawrence Scale by an orthopedic surgeon. *Results*: All WOMAC scores were significantly higher after as compared to before the completion of performance-based tests. This pattern of results suggested that the WOMAC questionnaire should be administered to individuals with OA after performance-based tests. The obese OA was significantly different compared to the non-obese OA group on all WOMAC scores. Physical activity and BMI explained a significant proportion of variance of self-reported disability. *Conclusion*: Obese individuals with knee OA may over-estimate their ability to perform physical activities, and may under-estimate their level of disability compared to non-obese individuals with knee OA. In addition, self-reported physical activity seems to be a strong indicator of disability in individuals with knee OA, particularly for individuals with a sedentary life style.

Keywords

Knee, obesity, osteoarthritis

History

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➤ Implications for Rehabilitation

- Osteoarthritis is a progressive joint disabling condition that restricts physical function and participation in daily activities, particularity in elderly individuals.
- Obesity is a comorbidity commonly associated with osteoarthritis and it appears to increase self-reported disability in those diagnosed with osteoarthritis of the knee.
- In a relatively small sample, this study recommends that rehabilitation professionals obtain self-report questionnaires of disability after performance-based tests in obese individuals with osteoarthritis of the knee as they are more likely to give an accurate representation of their level of ability at this time.

Introduction

The Canadian population is aging. As a result, multiple chronic health conditions and associated disabilities are expected to increase [1,2]. Disability due to knee osteoarthritis (OA) affected approximately 4.4 million Canadians in 2010, and it is estimated that as many as 10.4 million Canadians will be diagnosed with knee OA by 2040 [3]. Given the lengthening of life-span as a direct result of rising standards of living and advances in modern medicine, the prevalence of OA and its subsequent burden are projected to increase and be higher among those over the age of 70 years [4]. In 2010, approximately 49% of seniors over the age of 70 years were living with symptomatic OA [3,5]. By 2040, this number is expected to increase to 71%. The total direct health care cost to treat Canadians with OA in 2010 was approximately $10 billion and the total cumulative cost in direct health care expenditures in 30 years is expected to reach almost $550 billion [3].

For those over the age of 65, OA of the knee accounts for greater physical disability in lower extremity tasks, such as walking, stair climbing, and rising from a chair, than any other condition [6]. Therefore, many studies have focused on patient's functional and physical improvement and therapeutic aspects of knee OA [7,8]. Despite providing relevant contributions to the literature, these studies did not target patients' self-reported disability. Previous studies that have assessed self-reported disability scores on measures such as the Western Ontario

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McMaster University Index (WOMAC) have shown that individuals diagnosed with OA tend to indicate strong negative association with functional tests and positive association with joint pain and radiographic diagnosis of knee OA [9,10]. These studies have indicated that patients' self-report questionnaires and functional tests are essential to assess functional disability.

According to The World Health Organization (WHO), disability is an umbrella term which covers impairment, activity limitations and participation restrictions. WHO defines each of these domains 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 who are obese and have been diagnosed with knee OA, the damaged joint represents the problem in body function or structure, as part of the impairment domain; mobility limitations such as difficulty walking, stair climbing, and rising from a chair represents the activity domain; whereas a restriction in involvement in social/personal life situations represents participation restriction.

OA is considered to be the product of a complex interaction between systemic and local biomechanical risk factors [12,13]. Obesity is a primary modifiable risk factor for OA and its effect includes both biomechanical and metabolic causes [14,15]. Previous researchers have found that as Body Mass Index (BMI) increases, the risk of OA in lower extremity joints also increases [12,16]. From a biomechanical point of view, excessive weight increases the load on these joints during weight-bearing activities, intensifying a deterioration process of the cartilage inside the joints, causing varying degrees of stiffness, swelling, and pain [17,18]. Therefore, BMI is an important factor used to predict disability and worsening of many chronic conditions including osteoarthritis [19,20]. Considering a current growth of obese individuals in our population [3], obesity may have a substantial effect on self-reported disability, particularly for those diagnosed with knee OA.

When patients report high levels of pain and self-reported disability due to knee OA, it is also expected that these individuals will have a lower rate of participation in daily physical activities [21]. A higher level of self-reported physical activity is generally used as a predictor of good health and well-being [22,23]. However, lower self-reported physical activity has also been used to predict disability in different chronic conditions such as cardiovascular disease and neurological disease [24,25], but less so for individuals diagnosed with knee OA [21,26]. Although no studies to date have used physical activity as a predictor of self-reported disability in obese individuals diagnosed with knee OA, several studies have used low impact physical activity and short-term exercise as interventions to improve self-reported disability and knee pain, suggesting that physical activity and self-reported disability are related [27–31]. Even though physical activity and short-term exercises may improve aerobic capacity, walking time, self-reported function, increase strength, decrease pain and improve physical function in patients with knee OA [29,32], many individuals who claim to have knee pain or have been diagnosed with knee OA avoid physical activities and consequently become more physically disabled [21,28,32]. Therefore, self-reported physical activity should be considered an important factor to predict self-reported disability.

Even though self-reported questionnaires of disability such as the WOMAC have been traditionally used to explain disability among individuals with knee OA [33,34], previous research has also recommended using both self-reported disability questionnaires and performance-based tests to further explore the disablement experience of individuals with knee OA [9,10,35,36]. Yet, there is no standardized recommendation emphasizing whether measures of self-reported disability should be obtained before or after performance-based tests in individuals with knee OA.

The disablement experience due to a serious chronic condition may influence how individuals view themselves in terms of disability. However, the way individuals respond to their disablement experience during daily activities, depends on whether they have high or low expectations of what they are capable of doing [37]. Therefore, performance-based tests that can reproduce some activities of daily living are important tools to understand self-reported disability.

The aims of this study were three-fold: (1) to examine whether self-reported disability should be obtained before or after performance-based tests, based on whether the WOMAC score would change from before to after the completion of performance-based tests. We hypothesized that there would be an increase on the WOMAC scores of disability, pain, stiffness and function after the completion of performance-based tests. (2) To assess whether self-reported disability scores before and after performance-based tests differ between obese and non-obese individuals, and whether their self-reported disability scores would change from before to after the completion of performance-based tests. We hypothesized that the WOMAC scores of disability, pain, stiffness and function would be higher in obese than in non-obese individuals and that only obese individuals with knee OA would show an increase on the WOMAC scores after performance-based tests. (3) To observe whether physical activity and BMI predict self-reported disability before and after performance-based tests. As no other previous research has used physical activity as a predictor for self-reported disability in individuals with knee OA, no hypothesis is stated; this issue will be explored as a research question of interest.

Methods

Ethical approval was obtained from the Health Science Research Ethics Board (HSREB) of Queen's University. Patients were recruited from the orthopedic surgical case load of one participating orthopedic surgeon at Kingston General Hospital, Kingston, Ontario, Canada. Patients were identified as potential participants for the study by the surgeon during an initial consultation. Those who showed moderate to severe radiological knee OA using the Kellgren-Lawrence Scale [38] were subsequently contacted by a research associate who described the study procedures and invited them to participate in the study once informed consent was obtained.

This study population was a sample of convenience and 50 patients were invited to participate but only 31 were eligible to participate. Therefore, the patient group consisted of 31 participants between the ages of 50 and 80 years with knee OA. All participants were able to tolerate moderate activity for 60 to 90 minutes. Additionally, they were free from severe comorbidities that would prevent them from participating in the study, such as unstable angina and/or heart disease, uncontrolled blood pressure (systolic pressure >140 mmHg, diastolic pressure >90 mmHg) and non-knee OA related mobility restrictions (neurological and musculoskeletal). All 31 participants were eligible for the study and they were scheduled for an initial assessment conducted in a university laboratory. Participants were recruited between March 2013 and October 2013.

Upon arrival at the laboratory, participants were given a letter of information and consent form. Upon agreement to participate, their demographic data including height and weight, responses

Disabil Rehabil, 2015; 37(13): 1152–1161

regarding their perceived need for surgery (PNS), data related to the functional tests, and responses to questionnaires were obtained. Disability was assessed using the Western Ontario McMaster University Index (WOMAC), see below. WOMAC scores were obtained before (Time 1) and after (Time 2) the performance-based tests of the 6 Minute Walk Test, Timed Up and Go, stair climbing test, and a submaximal aerobic test (peak of oxygen consumption or VO_2 peak), obtained in a single visit.

Outcome measures

Self-report measurements

The WOMAC questionnaire provides a total score and three subscale scores: pain, stiffness and function [10,36]. Patients were asked to identify on a scale from 0 (none) to 4 (extreme) the degree of difficulty they have been experiencing in the past 72 hours. The pain subscale consists of 5 items with a total score ranging from 0 to 20. The function subscale consists of 17 items related to the degree of difficulty of performing activities of daily living (e.g. walking or sitting) to assess the individual's self-reported level of physical function. Scores on this subscale range from 0 to 68. Finally, the stiffness subscale corresponds to the degree of stiffness experienced by individuals with knee OA. This section consists of two items (range from 0 to 8). Higher scores indicate greater pain, stiffness, and physical limitation [39]. This instrument is recommended by the Osteoarthritis Research Society International (OARSI) as the health status measure of choice for older adults with knee OA. It has been validated for use in orthopedic and pharmacologic interventions [35,40]

Physical activity was assessed using the physical activity scale based on the values of Common Physical Activities (classified as Light, Moderate, and Vigorous Intensity) originally reported in the *Compendium of Physical Activities: An Update of Activity Codes and MET Intensities* [41] which was summarized and modified by the American College of Sports Medicine (ACSM) in their guidelines for exercise testing and prescription [22]. The Physical Activity method described by the ACSM will be referred to as PA. According to the ACSM, light, moderate, and vigorous intensity activity could be divided according to the amount of Metabolic Equivalents (METs) a given physical activity requires to be completed. For example: light physical activities require <3 METs, while moderate and vigorous activities require 3 to 6 METs and >6 METs, respectively. Three groups of daily physical activities (Walking, Household and occupation, and Leisure time and sports) were divided into three subcategories (light, moderate, and vigorous intensity activity) based on ACSM modified guidelines. For example, walking was divided into three subcategories: 1 – Light (walking slowly around the house of office: <3 METs), 2 – Moderate (walking at 3 miles per hour or at a very brisk pace: 3 to 6 METs), and 3 – Vigorous (walking, jogging and running at 4.5 miles per hour or higher pace: >6 METs). The participants were asked to select within each group, one subcategory that was most appropriate with his/her normal daily level of activity (Figure 1).

Obesity is commonly measured by the individual's Body Mass Index (BMI). The standard categories for BMI include normal weight (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2) and obese (30 kg/m^2 or more) [42]. The obesity category is divided into three subcategories: class I obesity (BMI 30–34.9 kg/m^2), class II obesity (BMI 35–39.9 kg/m^2), and class III obesity (BMI $\geq$40 kg/m^2) [42].

Imaging examination

The Kellgren–Lawrence scale (KL) method of radiographic examination [38] was used to score the severity of knee OA and to detect differences between groups. KL is the earliest and by far the most commonly used global scale that gives an overall score of OA severity ranging from zero to four [38,43]. The confirmation of several features were graded as an evidence of OA: grade 0, no radiographic findings of OA; grade 1, possible osteophytes and doubtful narrowing of joint space; grade 2, definite osteophytes and narrowing of joint space; grade 3, moderate multiple osteophytes and definite narrowing of joint space; and grade 4, large osteophytes and marked narrowing of joint space [38]. Both tibiofemoral compartments of the knee were assessed using a standard set of radiographs for reference [38].

Performance-based tests and physiological test

Three performance-based tests of physical functioning and one physiological test were obtained during a single testing session. The functional tests consisted of the Six Minute Walk Test (6MWT), The Timed Up and Go Test (TUG), and the modified Margaria stair climbing test [44]. Peak of oxygen

Figure 1. Physical Activity questionnaire – modified from the American College of Sports Medicine (ACSM) version – Metabolic Equivalents (METs).

Walking

□ Walking slowly around the house/office/one block (< 3 METs)

□ Walking at a very brisk pace (3 - 6 METs)

□ Jogging or running, hiking at moderate pace (> 6 METs)

Household and occupation

□ Computer work at the desk, light hand tools, light house work activities (< 3 METs)

□ Heavy cleaning, washing windows, carpet cleaning, mowing lawn (3 - 6 METs)

□ Shovelling snow, carrying heavy loads (bricks or wood), farming, digging (> 6 METs)

Leisure time and sports

□ Arts & crafts, playing cards, darts, fishing, playing instruments, croquet (< 3 METs)

□ Bicycling light effort, dancing (ballroom slow/fast), golf, walking, swimming (3 - 6 METs)

□ Basketball game, bicycling (moderate to heavy gear), cross country skiing, soccer (> 6 METs) consumption (VO_2 peak), based on a nomogram previously used [45,46] for calculation of upper body aerobic power from heart rate during submaximal arm cycling using an arm ergometer, was the physiological test used.

The 6MWT is generally conducted in an enclosed, quiet corridor on a 25-meter track delineated by two lines marked on the floor [47]. 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. The procedure for the TUG requires documenting the time, in seconds, that an individual takes to rise from a standard armchair, walk 3 m, turn, walk back to the chair and sit down [48]. The subjects were allowed to use any assistive devices that they would normally use for walking, to increase feelings of safety and comfort during the test. Prior to testing, the subjects were warned that there would be two test trials and then they were instructed about the basic sequence of the test as follows: ''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. The average of these two trials was used as the final score. A shorter time taken to complete the task indicates a lower risk for falling and thus, greater functional status.

Lower limb mechanical power output was assessed by a stair climbing test. This test is a modified version from the original test proposed by Margaria et al. [49] and has been previously validated in obese individuals [50–52]. Participants were asked to climb one step at time, at the highest speed possible. Even though they were allowed to use railings, participants were encouraged to use them only if they felt extremely necessary. An ordinary stair of 13 steps covering a total vertical distance of 2.0 m was used. The final climbing time of the participants was obtained with a stop watch. The average mechanical power (W) was calculated by multiplying body mass (BM), gravity (g) and vertical distance (h) and dividing its outcome by time (t).

The arm ergometry test was used to predict the VO_2 peak in participants with knee OA. The participants were asked to pedal at a frequency of 70 revolutions per minute (rpm) against a constant workload of 21 Watts (125 kg/min) for females and 42 Watts (250 kg/min) for males. The workload was adjusted and maintained using the weights from the arm ergometer [46,53]. To predict VO_2 peak using an arm cycling submaximal test, the subjects should achieve a continuous steady state heart rate either equal to or above 110 beats per minute (bpm) during the last 30 seconds of submaximal test [46]. 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's length of time was four minutes and pulse rate was recorded every 10 s during the last 30 s, between the third and fourth minutes. If the difference between the lowest and the highest pulse rate, recorded in the last 30 s of exercising, did not exceed 5 bpm, a steady state heart rate was considered to be present [45,46]. The average HR, from the steady state, was used to find a corresponding VO_2 peak (L.min) on the nomogram. VO_2 peak was calculated in ml/kg/min based on the nomogram's equation: *VO_2 peak (L.min) × 1000/Body Weight (BW).* All of the participants reached at least 110 bpm or more; consequently, a new test was not needed. However, if their heart rates had not reached at least 110 bpm during the last 30 s of testing, the workload would have been increased by 21 W (125 kg/min) and a new test would have been initiated.

Data analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 21 (Version 21.0, IBM Corp., Armonk, NY) and Microsoft Excel 2010. The alpha (α) level was set at $p < 0.05$. Results are presented as mean ± standard deviation (SD) unless otherwise specified.

Manipulation checks and group composition analyses

Of the 31 participants diagnosed with knee OA, 15 were considered obese (BMI $\geq$30 kg/m^2) and 16 were non-obese. Specifically, of the 16 non-obese participants, 9 were overweight (BMI = 25–29.9 kg/m^2) and 7 were healthy weight (BMI = 18.5–24.9 kg/m^2). A one-way ANOVA between overweight and healthy weight participants with knee OA demonstrated that they did not differ significantly on any demographic or main variables of interest, including radiographic examination findings (p's > 0.05). Likewise, a chi-square analysis did not reveal any significant difference in gender ($p > 0.05$) between the overweight and healthy weight groups. Therefore, we combined the overweight and healthy weight groups into one group: the non-obese OA group. Radiographic examination was obtained from all 31 participants diagnosed with knee OA. A one-way ANOVA between the obese OA and non-obese OA groups was conducted to examine whether knee OA severity was significantly different between these two groups. The analysis indicated no significant differences between-groups on knee OA severity ($p > 0.05$). Please find baseline information of both groups in Table 1.

Further analyses between obese OA and non-obese OA groups indicated that body weight (F (1, 29) = 24.4; $p \leq 0.0001$) and BMI (F (1, 29) = 28.8; $p \leq 0.0001$) were significantly different between groups (Table 1). Analyses indicated that PA (F (1, 29) = 41.6; $p \leq 0.0001$) was significantly different between groups (Table 1). The three performance-based tests (stairs climbing, 6MWT, and TUG) and the VO_2 peak (physiological test) were also compared between obese OA and non-obese OA groups. Analyses indicated that results from the stairs climbing test (F (1, 29) = 21.3; $p \leq 0.0001$), 6MWT (F (1, 29) = 30.5; $p \leq 0.0001$), TUG (F (1, 29) = 18.4; $p \leq 0.0001$) and the VO_2 peak (F (1, 29) = 30.5; $p \leq 0.0001$) were significantly different between groups (Table 1).

Results

In order to test our first hypothesis that self-reported disability should be obtained after performance-based tests because there would be an increase in the WOMAC scores of disability, pain, stiffness and function after performance-based tests, four repeated measures ANOVA were conducted. The repeated measures ANOVA examined whether the WOMAC total scores of disability, pain, stiffness, and function of all 31 participants changed from before (Time 1) to after (Time 2) performance-based tests (Figure 2). Results indicated that the WOMAC total scores of disability significantly changed (F (1, 30) = 10.9; $p = 0.002$) from Time 1 (mean = 41, SD = 13.3) to Time 2 (mean = 50.2, SD = 20.4). The WOMAC pain scores also changed significantly (F (1, 30) = 7.1; $p = 0.012$) from Time 1 (mean = 8.3, SD = 3.2) to Time 2 (mean = 9.7, SD = 4.6). In addition, the WOMAC stiffness scores changed significantly (F (1, 30) = 5.2; $p = 0.022$) from Time 1 (mean = 4.3, SD = 1.7) to Time 2 (mean = 4.9, SD = 1.9). Finally, the WOMAC function scores changed significantly (F (1, 30) = 10.3; $p = 0.003$) from Time 1 (mean = 29.4, SD = 9.6) to Time 2 (mean = 35.4, SD = 14.4; Figure 2).

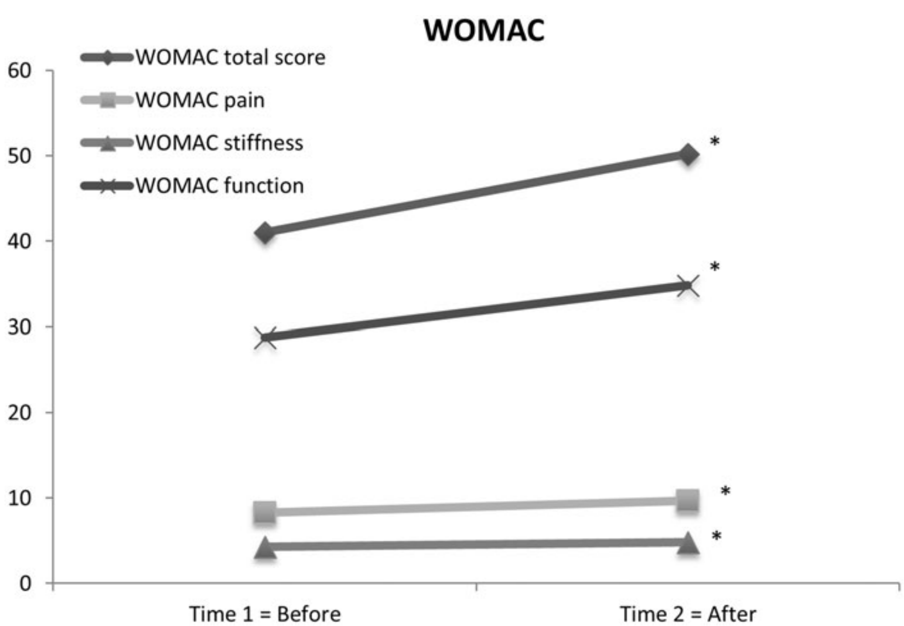
In order to test our second hypothesis that the WOMAC scores of disability, pain, stiffness, and function would be higher in obese

Table 1. Baseline information.

Baseline information/Group	Mean (SD)	Minimum	Maximum	F	p Value
Age					
Obese OA	65.9 (8.3)	50	80	3.3	0.80
Non-obese OA	70.6 (5.9)	62	81		
BMI					
Obese OA	39.0 (8.4)	29.3	62.1	24.4	0.000
Non-obese OA	27.0 (2.6)	23.4	28.4		
Body weight					
Obese OA	104.3 (19)	70	143.7	28.8	0.000
Non-obese OA	76.8 (11.2)	62	82		
X-ray (KL)					
Obese OA	3.3 (0.97)	2.0	4.0	.056	0.48
Non-obese OA	3.3 (0.8)	2.0	4.0		
PA					
Obese OA	3.3 (0.8)	2.0	5.0	41.6	0.000
Non-obese OA	5.5 (1.0)	4.0	8.0		
Stair climbing					
Obese OA	171.5 (66.1)	79.95	344.00	30.5	0.000
Non-obese OA	328 (114.6)	170.00	579.75		
VO_2 peak					
Obese OA	15.6 (5.3)	8.36	28.47	18.4	0.000
Non-obese OA	27.6 (6.6)	14.28	36.56		
TUG					
Obese OA	11.0 (2.8)	6.65	18.94	21.3	0.000
Non-obese OA	7.7 (1.2)	5.17	9.32		
6 Minute walk					
Obese OA	270.2 (109.4)	75.0	425.0	30.5	0.000
Non-obese OA	447.7 (65.6)	325.0	555.0		

(SD) Standard deviation; X-ray (Kellgren–Lawrence or KL); PA: physical activity – Metabolic Equivalents (METs); Stair Climbing - Lower limb mechanical power- Watts (W); Six Minute Walking Test (6MWT) – meters (m); Timed Up and Go Test (TUG) – seconds (s); Peak of oxygen consumption (VO_2 peak) – (ml kg/min). Obese OA ($n=15$) and Non-obese OA ($n=16$) All significant values between groups were ($p \le 0.0001$).

Figure 2. Repeated measures ANOVA – WOMAC scores before (Time 1) and after (Time 2) performance-based tests. $N=31$ individuals with knee OA and $p<0.05$. *Indicates that at time 2 WOMAC scores were significantly higher than at time.



than in non-obese individuals and that only obese individuals with knee OA would show an increase in the WOMAC scores after performance-based tests, four additional repeated measures ANOVA were conducted. The repeated measures ANOVA examined whether the obese OA group had higher scores of WOMAC total disability, pain, stiffness, and function as compared to the non-obese OA group (Figure 3). The results indicated that the WOMAC total score (F (1, 29) $=31.7$; $p<0.0001$) and the WOMAC pain (F (1, 29) $=24$; $p<0.0001$), stiffness (F (1, 29) $=14$; $p=0.001$), and function (F (1, 29) $=31.6$; $p<0.0001$) subscale scores were significantly different between groups, with the obese OA group

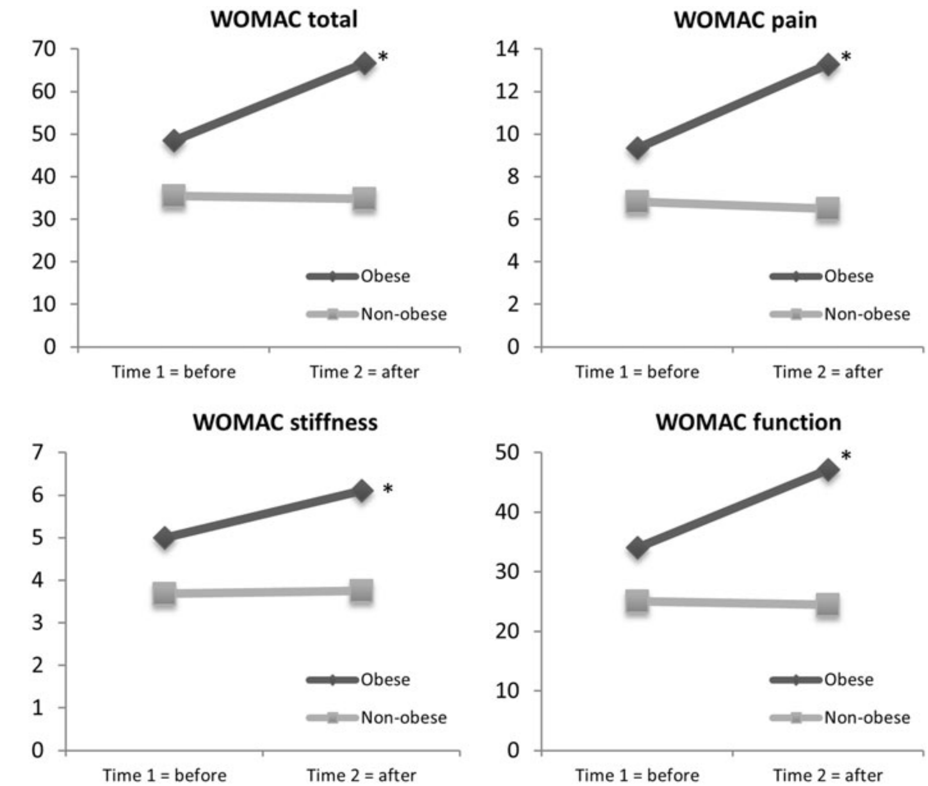


Figure 3. Repeated measures ANOVA – WOMAC scores before (Time 1) and after (Time 2) performance-based tests. Groups: Obese OA ($N = 15$) and Non-obese OA ($N = 16$). $p \leq 0.001$ (between groups) and $p < 0.05$ (within groups – obese OA only). *Indicates that at time 2 WOMAC scores were significantly higher than at time.

Table 2. Summary table of stepwise regression analysis – physical activity and BMI were predictors of disability.

WOMAC total
- Time 1:
  - PA alone explained a significant proportion of variance of the WOMAC total, $R^2 = 30\%$, F (1, 29) = 11.8; $p = 0.002$
- Time 2:
  - PA and BMI explained a significant proportion of variance of the WOMAC total, $R^2 = 60\%$, F (1, 29) = 20.1; $p < 0.0001$

WOMAC pain
- Time 1:
  - BMI alone explained a significant proportion of variance of the WOMAC pain, $R^2 = 16.3\%$, F (1, 29) = 5.6; $p = 0.024$
- Time 2:
  - PA alone explained a significant proportion of variance of the WOMAC pain, $R^2 = 37\%$, F (1, 29) = 17.4; $p < 0.0001$

WOMAC stiffness
- Time 1:
  - BMI alone explained a significant proportion of variance of the WOMAC stiffness, $R^2 = 17.3\%$, F (1, 29) = 6.0; $p = 0.020$
- Time 2:
  - BMI alone explained a significant proportion of variance of the WOMAC stiffness, $R^2 = 32\%$, F (1, 29) = 13.6; $p = 0.001$

WOMAC function
- Time 1:
  - PA explained a significant proportion of variance of the WOMAC function, $R^2 = 32\%$, F (1, 29) = 13.9; $p = 0.001$)
- Time 2:
  - PA and BMI explained a significant proportion of variance of the WOMAC function, $R^2 = 63.7\%$, F (1, 29) = 24.6; $p < 0.0001$)

demonstrating higher WOMAC total (mean = 57.5), pain (mean = 11.5), stiffness (mean = 5.5) and mobility (mean = 40.5) scores as compared with the non-obese OA group (total: mean = 35.1, pain: mean = 6.6, stiffness: mean = 3.7, mobility: mean = 24.7). The within-groups factor examined whether the mean scores of each group changed after performance-based tests were completed. Results indicated that only the obese OA group changed significantly from Time 1 to Time 2 on all WOMAC scores: WOMAC total (Time 1 mean = 48.4 and Time 2 mean = 66.6; F (1, 29) = 21.2 $p < 0001$), pain (means = 9.33 and 13.3; F (1, 29) = 12; $p = 0.002$), stiffness (means = 5.0 and 6.1; F (1, 29) = 7.2; $p = 0.012$), and mobility (means = 34.0 and 47.0; F (1, 29) = 19; $p < 0.0001$). No significant changes in mean values were observed in the non-obese OA group from Time 1 to Time 2 (Figure 3).

In order to test our exploratory question as to whether physical activity and BMI would predict WOMAC scores of disability, pain, stiffness, and function, we conducted a stepwise regression analyses between the WOMAC scores and BMI and PA. Prior to the analyses, we ensured that there was no evidence of strong multicollinearity among the independent variables (all Pearson correlation coefficients (r) were < 0.80) [54]. Two initial stepwise regression analyses were conducted to explore whether BMI and PA would predict the WOMAC total score *before* (Time 1) and *after* (Time 2) the completion of performance-based tests. At Time 1, the regression analysis indicated that PA alone explained a significant proportion of variance of the WOMAC total, $R^2 = 30\%$, F (1, 29) = 11.8; $p = 0.002$. Remarkably, at Time 2, PA and BMI explained a significant proportion of variance of the WOMAC total, $R^2 = 60\%$, F (1, 29) = 20.1; $p < 0.0001$. This finding indicates that after performance-based tests, BMI and physical activity accounted for 60% of variance in participants' self-reported disability. Given that there were significant levels of association between the WOMAC total score and physical activity and BMI, we then conducted six stepwise regressions between WOMAC subscale scores (pain, stiffness, and mobility) and BMI and PA at Time 1 and Time 2 (Table 2).

Disabil Rehabil, 2015; 37(13): 1152–1161

At Time 1, the stepwise regression analysis indicated that the BMI alone significantly (F (1, 29) = 5.6; $p = 0.024$) explained $R^2 = 16.3\%$ of the variance in the WOMAC pain subscale score. However, at Time 2, the PA alone significantly (F (1, 29) = 17.4; $p < 0.0001$) explained $R^2 = 37\%$ of the WOMAC pain subscale score variance (Table 2). These results indicate that BMI accounted for just over 16% of the variance in self-reported knee pain at Time 1, while at Time 2 PA accounted for 37% of the variance in self-reported knee pain.

Stepwise regression analysis indicated that at Time 1 BMI explained a significant proportion of variance of the WOMAC stiffness subscale scores $R^2 = 17.3\%$, F (1, 29) = 6.0; $p = 0.020$). Likewise, at Time 2, BMI explained a significant proportion of variance of the WOMAC stiffness subscale scores $R^2 = 32\%$, F (1, 29) = 13.6; $p = 0.001$; Table 2). These findings suggest that at Time 1, BMI accounted for just over 17% of the variance in self-reported stiffness in the knee joint, while at Time 2, BMI accounted for 32% of the variance in self-reported stiffness.

Stepwise regression analyses indicated that PA alone explained a significant proportion of variance of the WOMAC function subscale score, $R^2 = 32\%$, F (1, 29) = 13.9; $p = 0.001$) at Time 1. At Time 2, BMI and PA explained a significant proportion of the variance of the WOMAC function subscale score, $R^2 = 63.7\%$, F (1, 29) = 24.6; $p < 0.0001$; Table 2). These results indicate that PA accounted for 32% of variance in participants' self-reported functional limitation at Time 1, but at Time 2, the combination of PA and BMI accounted for 63.7% of variance in participants' self-reported functional limitation.

Discussion

The results of the current study demonstrated that all WOMAC scores were significantly higher *after* as compared to before the completion of performance-based tests. This pattern of results suggests that measures of self-reported disability, when possible, should be administered to individuals with OA *after* performance-based tests (Figure 2) because it captures participants' experience of physical limitations in real time. Further analyses indicated significant differences between the obese OA and non-obese OA groups on all WOMAC scores, with the obese OA group demonstrating higher scores for disability (Figure 3). In addition, when comparing the groups, the non-obese OA group did not show any significant change in WOMAC scores from Time 1 to Time 2, whereas all scores from the obese OA group changed significantly from Time 1 to Time 2 (Figure 3). Finally, we observed that physical activity and BMI explained a significant proportion of variance of self-reported disability, particularly after performance-based tests were completed. These results indicate that physical activity and BMI accounted for greater variability in self-reported disability scores from individuals with knee OA (Table 2).

Increase in WOMAC scores after performance-based tests in individuals with knee OA

As reported in previous studies, individuals with higher severity of knee OA tend to indicate higher WOMAC scores of disability [9,29]. A review study indicated that WOMAC total scores ranging from 23 to 33 or higher than 33 are suggestive of high disability levels [55]. When clustered as one group we observed that our participants had an average score of 41 for the WOMAC total before performance-based tests. This number increased significantly ($p = 0.002$) to 50.2 after performance-based tests (Figure 2). The increase of the WOMAC total score suggests that our participants had a more realistic perception of their physical limitations once they engaged in related physical activity tasks, suggesting that relying on self-reported disability alone may lead to an overestimation of one's abilities. Even though the conclusion from a previous study stated that self-report measures should always be obtained before performance-based tests to avoid the influence that these tests may have on participant's answers [56], the authors did not justify why the influence of performance-based tests should be avoided. OARSI (Osteoarthritis Research Society International), on the other hand, has recommended that a set of performance-based tests of physical functioning (e.g. stair-climbing test, timed up-and-go test, 6-MWT) be used as a complementary assessment tool to self-reported measures [35]. Yet, there is no standardized recommendation emphasizing whether measures of self-reported disability should be obtained before or after performance-based tests in individuals with knee OA.

Larsson and Mattsson [57] obtained a fair to good correlation ($r = 0.56$) between self-reported disability and functional limitations in obese women and in a normal-weight control group. Yet, the authors found that neither severely obese nor older women self-reported more disability than less obese and younger ones, suggesting that relying on self-report alone is not ideal. This finding supports our idea that self-report questionnaires may be more reliable if the questionnaires are administered after performance-based tests are completed. This way, an answer for a simple question such as ''how difficult do you think it is to complete a task'', may be different if the same question is asked after someone actually completes the given task.

In a study with 93 patients awaiting total hip or knee replacement, Stratford et al. [9] argued that performance-based tests of physical functioning based on time alone inadequately represents the breadth of health concepts associated with functional status. The authors correlated a self-report measure (the Lower Extremity Functional Scale, LEFS) with the summed score of three performance-based functioning scores (self-paced walk, timed up-and-go, and stair test) to increase reliability. Then they separately correlated the LEFS with the 40-meter fast self-paced walk test. They found that the correlation of the LEFS with the summed timed performance-based tests scores was not higher than the correlations of the LEFS with the 40-meter fast self-paced walk. By adding pain scores and exertion scores into the model, the correlation between performance-based tests and self-reported physical functioning increased. Therefore, they considered this as evidence for a lack of content validity of the performance-based test of physical functioning. On the other hand, Terwee et al. [58] indicated that self-report measures of physical functioning are more influenced by the amount of pain experienced than performance-based tests of physical functioning. In fact, Terwee et al. [58] indicated that the study from Stratford et al. [9] is evidence for a lack of content validity of self-report measures, not performance-based tests. Terwee et al. [58] observed that, correlations between (two) self-reported measures of functioning (WOMAC and SF-36) and (two) pain measures were higher ($r = 0.57$ and $r = 0.74$) than correlations between performance-based tests of functioning and the two pain measures ($r = 0.20$ and $r = 0.26$) [58].

Apart from the studies mentioned above, another study [59] indicated that performance-based tests used to assess joint pain and function offer a more distinct method of assessing these attributes than can be obtained by self-reports alone and that performance measures should be viewed as core measures for people with OA of the hip or knee and those progressing to arthroplasty. Self-reports of physical function, on the other hand, represent what people experience when performing activities rather than their ability to perform activities [59,60]. Therefore, extrapolating from the authors' conclusion and based on our results (Figure 2), we suggest that if self-report measures are to be obtained during a clinical assessment, it should be obtained after performance-based tests are completed.

Change in WOMAC scores in obese and non-obese individuals after performance-based tests

Even though individuals with knee OA tend to report higher levels of disability [4,9], we noticed in our study that only the obese OA group reported a significant increase on WOMAC scores from before to after performance-based tests (Figure 3). No changes in self-reported disability score were observed in the non-obese OA group following performance-based tests. According to Terwee et al. [58], self-report measures of physical functioning are more influenced by the amount of pain experienced than performance-based measures of physical functioning. Our obese OA group reported higher levels of pain, based on the WOMAC score, before and after performance-based tests (Figure 3). Therefore, we suggest that obese individuals with knee OA tend to underestimate their level of disability until a higher level of pain is triggered; consequently, for these individuals, performance-based tests should be completed prior to self-reported measures of disability.

It has been well documented that obese individuals diagnosed with knee OA tend to score poorly on performance-based tests of physical functioning and that they have higher levels of pain [7,61,62]. A previous study [61] compared obese control subjects with obese individual diagnosed with knee OA. Results indicated that VO_2 peak was significantly higher in obese controls (mean = 1.58 ± 0.23 L/Kg) compared to obese individuals with knee OA (mean = 0.98 ± 0.20 L/Kg). The authors also found that obese control subjects walked for significantly longer distances ($p < 0.001$) compared with their counterparts with knee OA. Unfortunately, the authors did not indicate the total walking distance from both obese groups and did not use a healthy weight group to compare with the obese control group. Even though the obese control group performed better during the walking test, walking is often impaired as a direct consequence of obesity through excess weight-bearing [63]. Obesity is also a major risk factor for knee OA development [64,65]. Therefore, the ability to participate in physical activity and exercise seems to be worse in obese individuals with knee OA, but not necessarily better in obese individuals without knee pain. Yet, recent studies emphasize that physical activity and exercise are essential to decrease pain and attenuate progression of knee OA particularly in obese individuals [14,29]. Our results indicated that the obese OA group had a significant increase in disability scores before and after performance-based tests, and that compared to the non-obese OA group, their performance-based tests were significantly lower, including the walking test and VO_2 peak (Table 1).

Verbrugge and Jette [37,66] speculated that perception of disability due to serious chronic conditions makes a great difference in the disablement experience and therefore influences how individuals view themselves in terms of disability, and whether the individuals have high or low expectations during their daily activities. Similar to our study findings, knee pain in the non-obese OA group, who have higher levels of physical activity, may cause some decrease in walking ability and therefore, it might be seen as a limiting factor in daily activities. On the other hand, other individuals diagnosed with knee OA who are obese had already adapted to walking short distances, and may not have rated their self-report disability in walking very high. Yet, we found that the obese individuals with knee OA will likely give a more accurate rating of their self-report disability when they find themselves exposed to a situation where their physical and functional capacities are tested in real-time.

Physical activity and knee OA

Studies using diet and exercise as part of an intervention to decrease disability in individuals with knee OA indicated that after losing weight and engaging in moderate levels of physical activity, obese individuals seem to improve on their levels of function and knee pain [7,14,29,67]. One particular study [67], found that after 18 months of exercise and diet followed by 5.7% of body weight loss, an obese group diagnosed with knee OA self-reported a significantly ($p < 0.05$) lower WOMAC pain score of 5.07 ± 0.47 (24% of pain improvement) and walked a significantly ($p < 0.05$) longer distance of 477 meters, measured with 6 MWT, compared to their baseline results (7.27 ± 0.41 and 416.1 ± 11.3). Even though the previous study [67] used diet and exercise to improve disability levels, and we did not, we may extrapolate from their findings to compare to our findings. Compared to our obese OA group, who participated in low levels of daily physical activity, the WOMAC pain scores were 9.8 before and 13.2 after performance tests and the walking distance was 270 ± 109.4 meters. Compared to our non-obese OA group, who participate in moderate levels of daily physical activity, their obese group still did slightly better after 18 months of diet and exercise. Our non-obese OA group self-reported scores of 6.8 before and 6.5 after performance-based tests on the WOMAC pain and the walking distance was 447.7 m. Even though the findings from this previous study suggested that weight-loss therapy and exercise are important to decrease disability in individuals with OA [67], their findings also support our results by suggesting that participating in exercise or increasing the amount of physical activity is also an important factor in decreasing disability and improving pain. Consequently physical activity may be a strong predictor of self-reported disability for obese individuals diagnosed with knee OA.

Our results indicated that physical activity and BMI explained a significant proportion of variance of self-reported disability, as measured by the WOMAC (Table 2). We also observed that individuals with lower levels of daily physical activity (obese OA group), were likely to indicate higher levels of self-reported disability, joint pain, stiffness and lower function before and particularly after performance-based tests (Figure 3). A recent study [68] observed that vigorous, but not moderate, physical activity was found to be associated with 1.35-times greater risk for worsening cartilage lesions (increase in disability). Another study [69], indicated that low levels and higher levels of physical activity are strongly related to progression of knee OA, based on structural damage of the cartilage. The authors indicated that those who walked either less than 8103 or more than 10 580 steps per day had significantly higher odds of middle cartilage worsening compared to those who walked between 8126 and 10 580 steps per day [69]. Our obese OA group self-reported low levels of daily physical activity (3.3 METs) which was significantly lower ($p < 0.0001$) compared to the non-obese OA group, who self-reported moderate levels of daily physical activity (5.7 METs). Interestingly, only our obese OA group showed an increased change in self-reported disability scores after performance-based tests. Therefore, in agreement with the above mentioned studies [68,69], moderate levels of physical activity rather than low levels of physical activity may be beneficial to reduce the progression of knee OA. Considering that low levels of physical activity may not stimulate the beneficial metabolic activity to decrease knee OA progression, moderate levels of physical activity may be the ideal level of physical activity that can contribute to decreased self-reported disability in these individuals [70]. Consequently, according to our results and supported by recent scientific findings we may suggest that self-reported physical activity is a strong predictor of disability particularly for those individuals with low levels of physical activity (obese OA group).

Despite some limitations such as difficulty to recruit patients within a BMI category of 18.5–24.9 kg/m^2 during consultation with an orthopedic surgeon and lack of external funding to intensify recruiting and consequently increasing sample size, we obtained important findings of significant impact and relevance to clinical setting. Future studies should include a larger sample, a longitudinal design, and variables such as weight loss and varying levels of physical activity in the view to developing a series of physical activities and related exercises suitable for individuals with knee OA. This study would provide additional information on long-term changes in self-reported disability and performance-based tests. Further investigations are needed to determine whether change in self-reported disability is consistent over time and if so, to observe whether such change in perception would support patient's adherence in weight loss treatment.

In conclusion, self-reported disability scores of obese individuals diagnosed with knee OA were significantly worse after they completed performance-based tests. Obese individuals with knee OA may over-estimate their ability to perform physical activities, and may under-estimate their level of disability compared to non-obese individuals with knee OA. In addition, self-reported physical activity seems to be a strong indicator of disability in individuals with knee OA, particularly for individuals with a sedentary life style. The findings of this study suggest that especially for obese individuals with knee OA, performance-based tests should be included in any assessment of disability, and specifically these tests should be completed prior to self-reported measures of disability.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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