ORIGINAL ARTICLE

Relationship Between Muscle Performance and Perceived Fatigue in Individuals With Knee Osteoarthritis

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ABSTRACT

Introduction: Knee osteoarthritis (KOA) is a painful degenerative joint disease that may limit movement. This study aimed to compare muscle performance (strength of handgrip strength, lower limb muscles, and lower limb function) and perceived fatigue between individuals with and without KOA, and determined the relationship between muscle performance and perceived fatigue in individuals with KOA. **Methods:** This cross-sectional study recruited 33 female patients (Age=54.76±5.54 years) diagnosed with KOA and 33 healthy participants (Age=53.30±5.55 years). Handgrip strength was assessed by using a Hand Dynamometer. The strength of the lower limb muscles (Hip extensors, flexors, abductors, and adductors; knee extensors and flexors) was assessed by the push and pull dynamometer. Lower limb functional strength was assessed by the Five Times Sit to Stand Test. The Fatigue Severity Scale was used to measure the perception of fatigue related to daily function. Data were analyzed using an independent t-test and Pearson's correlation. **Results:** Individuals with KOA were significantly higher in handgrip strength and perceived fatigue, and poorer in lower limb functional strength (All $p<0.05$). There were no significant differences in all measures of lower limb muscles between individuals with and without KOA (All $p>0.05$). Hip flexors, knee extensors, and knee flexors were significant correlated with perceived fatigue (All $p<0.05$) in individuals with KOA. **Conclusion:** Findings of this study suggest that individuals with KOA may have lower functional strength and higher perceived fatigue. The hip flexors, knee extensors, and knee flexors may be associated with a higher level of perceived fatigue among individuals with KOA.

Keywords: Fatigue, Functional strength, Muscle performance, Osteoarthritis

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INTRODUCTION

Knee osteoarthritis (KOA) is a degenerative joint disease due to changes in the articular cartilage, osteophyte formation, and synovial tissue inflammation (1-3). It was reported that about 9.6% of men and 18.0% of women have symptomatic KOA (3). Women have a higher prevalence than men after menopause due to a decline in the hormone level (4). In the Asian populations, the prevalence of KOA is more than 60% and it is common in people aged 40 and above (5-7). By 2020, osteoarthritis will be the fourth leading cause of disability in the general population (3) and is also the fourth main cause of disability in women (7).

Pain which is the dominant symptom of KOA can lead to a limitation in physical activity that may in turn affects muscle performance. Leg muscles play important roles in modifying the loading environment at the knee and an essential predictor for functional performances such as walking, standing up from sitting, and climbing stairs (8). However, these muscles are prone to a decrease in strength in individuals with knee OA (9-12), which can further lead to muscle imbalances and generalized muscle weakness of the lower limb (9,13). The weakness of knee extensor muscles especially the quadriceps can lead to alteration in the joint knee mechanics (14). Individuals with KOA may also experience weakness in the upper limb especially the handgrip (3), which represents the overall strength or functional status of an individual (15,16).

Individuals with KOA may experience fatigue when doing functional activities such as walking, sit to stand, and climbing stairs (17,18). Impairment in the velocity of the muscle contraction can lead to a high chance of the muscle to fatigue easily and produce painful loading on the articular surface at the knee joint (8,14). Fatigue is the sense of persistent tiredness or exhaustion that disturbs

the individual and can be measured by the reduction of physical performance (19, 20). The feeling or perception of fatigue limits physical activities and in turn, negatively affects muscle strength and functional performance (21). Besides, individuals with KOA may experience a decrease in exercise capacity due to impaired joint mobility and pain (22). Several studies have shown that women with KOA have poor performance on 6-minute walk test and sit to stand test (9, 22), however, it is not known whether similar consequences to the perception or subjective feeling of fatigue. Perception of fatigue in a long term may eventually affect the quality of life of individuals (23-25).

There are limited studies on the relationship between muscle performance and subjective feeling of fatigue in individuals with KOA. Muscle performance has been shown to be associated with the severity of the KOA (8) and that a decrease in muscle strength may lead to avoidance in physical activity (21) that may, in turn, lead to lower overall physical fitness. It has been suggested that the relationship between pain, muscle strength, and functional performance are important factors in the quality of life of individuals with KOA (17). Thus, it is important to know whether a reduction in muscle performance is associated with the subjective feeling of fatigue, as these changes may lead to limitations in the ability to perform their activities of daily living. Hence, the purpose of this study was to compare the differences between muscle performance (upper and lower limb muscle strength and functions) and the level of fatigue in individuals with and without KOA. This study also aimed to determine whether muscle performance is associated with the level of fatigue.

MATERIALS AND METHODS

Sample

This is a cross-sectional study, involving 33 female individuals diagnosed with KOA, recruited from the Physiotherapy Clinic in a selected public university, and 33 healthy subjects. Recruitment was done by setting an appointment with newly referred patients with KOA at the clinic and the healthy subjects from the family of the patients or the university staff. The participants were included in the study when the following criteria were satisfied: 1. Female patients, aged from 40 to 60 years old; 2. Had referral from a medical doctor; 3. Unilateral or bilateral radiographic knee OA; 4. Able to understand and respond to Malay or English language and able to follow instructions on testing procedures. The participants were excluded when they presented with, 1. Recent surgery, less than 6 months; 2. Joint replacement (total knee replacement); 3. Pregnant and had other rheumatic diseases, cardiovascular problems, gastrointestinal tract disease, or neurologic problems. Ethical approval was received from the Research Ethics Committee of Universiti Teknologi MARA (UiTM) (600-IRMI (5/1/6)). All of the participants included in this study signed informed consent before data collection.

Measurements

The sequence of measurements of variables is shown in Fig. 1. For screening purpose, co-morbidities and surgical history were noted. Sociodemographic data such as such as age and occupation were documented for each participant. The level of pain was measured by the Visual Analogue Scale (0 indicates no pain at all, to 10 as too intense to be tolerated). Anthropometric characteristics, including height (m) and weight (kg) were measured in each participant using a measuring tape and weighing scale, respectively. The body mass index (kg/m^2) was calculated as the body weight (kg) divided by the square of the body height (m^2).

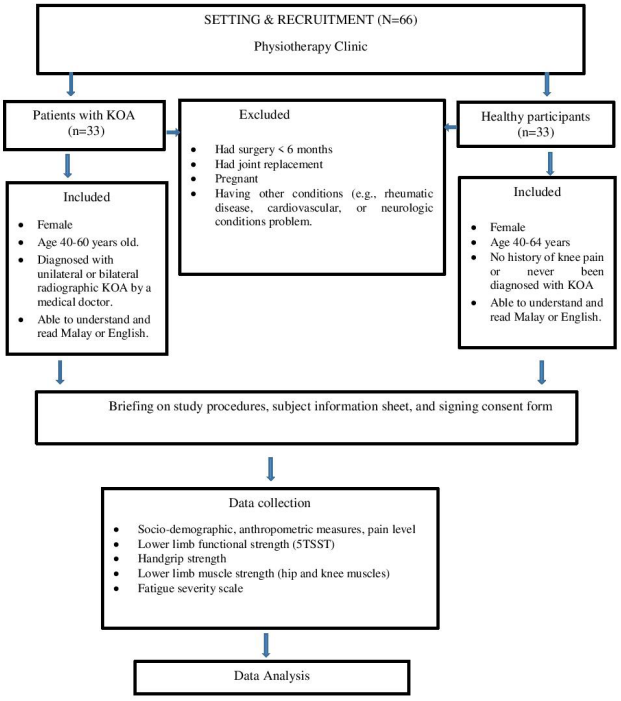

Fig. 1 : The study flow chart

The Five Times Sit to Stand Test (5TSST) was used to measure the lower limb functional strength. The 5TSST has been shown to be valid, safe and reliable to assess the lower limb muscles strength and functional performances in a patient with KOA (ICC = 1) (26,27). The participants were instructed to sits on a 45-cm tall chair with arms folded across the chest and back against the chair. Then, they were asked to repeatedly stand up and sit down five times. The timing began when the participants' buttocks leave the chair and were stopped when the buttocks touched the chair on the fifth repetition. The longer the time to complete the test the poorer is the functional performance. Generally, a score of lesser than 10 seconds is considered a good performance (28).

The strength of the handgrip was assessed using a Jammar Analogue Hand Dynamometer which has been shown to have good reliability and validity for measuring handgrip strength (29). The participants were instructed to sit with their elbows in 90-degree flexion parallel to the trunk. Then, they were asked to squeeze the dynamometer as hard as possible. The assessment was repeated three times on each hand with 1-minute rest between each attempt. The highest score among all the attempts was recorded was the final score (30). The score was recorded in kg, and the higher the value, the greater the handgrip strength.

The strength of the lower limb muscles was assessed using a push and pull-pull dynamometer which has been proven to have good reliability in measuring the force production of the muscles (31). A total of six muscle groups were targeted to measure the strength which is the hip extensors, flexors, abductors and adductors as well as the knee extensors and flexors. To measure the hip extensors, the participants were instructed to lie in a prone position while a push-pull dynamometer was placed at the bulky area of the hamstring muscles. Then, the participants were asked to extend the hip and push the dynamometer. For the hip flexors, the participants were instructed to lie in a supine position while a push-pull dynamometer was placed at the bulky area of quadriceps muscles. Then, the participants were asked to flex the hip and push the dynamometer. For the hip abductors and hip adductors, the participants were asked to lie in a side-lying position. To test the hip adductors, the dynamometer was placed below the tested leg, and to test the hip abductors, the dynamometer was placed above the tested leg, about 5 cm proximal to the medial and lateral femoral condyle, respectively. Then, the participants were asked to adduct and abduct the leg and push the dynamometer. To measure the knee extensors, the participants were instructed to sit on a stool and a push-pull dynamometer was placed 5-centimeter proximal to the lateral aspect of the lateral malleolus. Then, the participants were asked to extend the knee and press the dynamometer. For the knee flexors, the participants were instructed to lie in a prone position while a push-pull dynamometer was placed 5-centimeter proximal to the distal aspect of the lateral malleolus. Then, the participants were asked to flex the knee to 90-degree and push the dynamometer. Each measurement was taken by asking the participant to hold for about five seconds, while breathing normally and ensuring that no trick movement was produced. The measurements were taken 3 times in each group of muscles, with a 30-second rest in between measurements of each muscle groups, and the average measurement was obtained and recorded in kg.

The perceived level of fatigue was measured using the Fatigue Severity Scale (FSS). The FSS has been shown to have good validity and reliability in assessing fatigue and how it will affect the patient's daily life (32). FSS is a self-administration questionnaire that consists of nine items and has seven points in each item. The seven-point Likert scale ranges from 1 which is "strongly disagree" to 7 which is "strongly agree". The results of the FSS is presented by using the mean score of the nine items. The minimum score is 9 and the maximum score is 63 in which the higher the score the greater the perceived fatigue severity and the lower the score indicates a low level of fatigue (33).

Data analysis

The Statistical Package for the Social Science (SPSS) version 25 was used to analyze the data. Descriptive analysis was used to describe the characteristics of the participants based on frequency, means, standard deviations, and ranges. The normality of data was checked using the Kolmogrov-Smirnov test. An independent t-test was used to compare the variables of interest between individuals with and without knee OA. Meanwhile, Pearson's correlation was used to determine the relationship between muscle performance and level of perceived fatigue. All analyses were performed at an alpha level of $p<0.05$.

RESULTS

Table 1 shows the comparisons in the characteristics of the participants. There is no significant difference in age between individuals with and without KOA. The individuals with KOA were significantly higher in the level of pain, height, weight, and BMI (ALL $p<0.05$). As shown in Table 2, individuals with KOA were significantly stronger in the handgrip strength, weaker in the lower limb functional strength, and a higher level of perceived fatigue. There were no significant differences in the muscles of the lower limb between individuals with and without KOA (All $p>0.05$). Table 3 shows the relationship between muscle performance and level of fatigue. There was a significant negative correlation between hip flexors, knee extensors, and knee flexors with perceived fatigue in individuals with KOA (All $p<0.05$).

DISCUSSION

The results of this study showed that individuals with KOA have a higher handgrip strength compared to the healthy individuals. However, previous studies have found that individuals with KOA have weakness of the handgrip compared to individuals without KOA (3), which supports another study that individuals with radiographic KOA tend to have weakness of handgrip due to poor physical function (34). Eventhough handgrip strength has been suggested as the overall proxy for muscle strength performance (35), patients with KOA

Table I : Characteristics of individuals with and without knee osteoarthritis (N=66)

Characteristics	All (N=66)	With OA (n=33)	Without OA (n=33)	
	Mean ± SD (range)	Mean ± SD (range)	Mean ± SD (range)	t (p-value)
Age (Years)	54.03 ± 5.56 (40-60)	54.76 ± 5.54 (40-60)	53.30 ± 5.57 (41-60)	1.064 (0.292)
Occupation				
Housewife	17	15	2	-
Working	49	18	31	
Level of Pain	0.98 ± 1.49 (0-6)	1.97 ± 1.59 (0-6)	0.0 ± 0.00 (0)	7.113 (**0.001**)*
Weight (kg)	68.84 ± 13.72 (45.7-111.8)	74.56 ± 12.46 (52.8-111.8)	63.12 ± 12.62 (45.7-94.8)	3.702 (**0.001**)*
Height (cm)	154.61 ± 5.90 (143.0-167.0)	156.05 ± 5.86 (147.0-167.0)	153.17 ± 5.65 (143.0-165.0)	2.037 (**0.046**)*
BMI (kg/m2)	28.87 ± 5.34 (19.3-40.1)	30.85 ± 4.98 (21.0-40.1)	26.88 ± 5.00 (19.3-38.5)	3.231 (**0.002**)*

Note: BMI=body mass index; SD=Standard deviation. *Independent t-test significant at p<0.05significant at

Table II : Comparisons muscle performance and perceived fatigue between individuals with and without knee osteoarthritis (N=66)

Variables	All (N=66)	With OA (n=33)	Without OA (n=33)	
	Mean ± SD (range)	Mean ± SD (range)	Mean ± SD (range)	t (p-value)
Handgrip (kg)	14.45 ± 6.39 (2-30)	16.71 ± 5.94 (4-30)	12.19 ± 6.09 (2-25)	3.049 (0.003)*
Lower limb muscles strength (kg)				
Hip extensors	5.96 ± 1.82 (2.5-12.5)	5.82 ± 2.01 (2.5-12.5)	6.09 ± 1.62 (2.5-10.0)	-0.593 (0.556)
Hip flexors	5.96 ± 2.03 (2.5-11.0)	6.28 ± 2.37 (2.5-11.0)	5.63 ± 1.59 (2.5-10.0)	1.318 (0.192)
Hip abductors	5.96 ± 1.78 (2.5-12.0)	5.59 ± 1.94 (2.5-12.0)	6.33 ± 1.53 (2.5-10.0)	-1.723 (0.090)
Hip adductors	4.67 ± 1.19 (2.5-7.5)	4.67 ± 1.14 (2.5-7.5)	4.67 ± 1.27 (2.5-6.5)	0.000 (1.000)
Knee extensors	6.38 ± 2.00 (2.5-12.0)	6.34 ± 2.13 (3.0-12.0)	6.42 ± 1.89 (2.5-11.0)	-0.171 (0.865)
Knee flexors	5.46 ± 1.95 (2.5-10.0)	5.91 ± 2.22 (2.5-10.0)	5.02 ± 1.53 (2.5-8.0)	1.901 (0.062)
Lower limb functional strength (5TSST) (sec)	12.35 ± 4.32 (7.0-26.0)	14.83 ± 4.67 (9.6-26.0)	9.88 ± 1.86 (7.0-15.8)	5.654(0.001)*
Fatigue (Total score)	18.98 ± 10.73 (6-54)	23.88 ± 11.51 (9-54)	14.09 ± 7.22 (6-39)	4.138(0.001)*

Notes:SD=Standard deviation. *Indpedent t-test significant at p<0.05

Table III : Relationship between muscle performance and perceived fatigue in individuals with knee osteoarthritis

Muscle performance	Perceived fatigue (n=33)	
	r	p value
Handgrip	0.040	0.824
Hip extensors	-0.065	0.718
Hip felxors	-0.349	0.047*
Hip abductors	-0.294	0.097
Hip adductors	-0.198	0.270
Knee extensors	-0.435	0.011*
Knee flexors	-0.433	0.012*
Lower limb function (5TSST)	-0.013	0.943

Note: *Pearson's correlation, *r*, significant at p<0.05)

may depend more on the upper limb for activities of daily living and other physical activities that may explain why they have stronger handgrip. Furthermore, the effect of the KOA on the handgrip performance may not be impactful yet as participants recruited for this study were below the age of 60 and newly diagnosed with KOA that may explain early progression of the disease. However, further study is recommended to elucidate the the mechanism or the role of KOA on upper limb strength.

In terms of lower limb functional strength, the current finding is consistent with a previous study who found women with KOA has poor performance in sit to stand test thus explains the indifference in the functional strength between individuals with and without KOA (22). It has been found that patients with KOA typically present with reduced force-generating as well as muscular inhibition, which is the inability to fully and volitionally activate the muscle (36), thus leading to muscle weakness. Furthermore, pain in the knee joint may have limited lower limb activities such as walking, climbing stairs, and running that led to the weakening of the muscles responsible for the function. This is supported with a previous study that explained KOA lead to chronically low levels of physical activity in daily life, that in turn cause may cause declining of muscle strength of the lower limbs (37). Pain due to KOA may have also lead to activation deficit and atrophy that contribute to muscle impairment that is the primary underlying cause of functional impairments, and further deterioration of the joint cartilage (38).

With regards to the perception of fatigue, individuals with KOA have a higher level of fatigue in their daily function compared to individuals without KOA. Previous studies suggested that pain and impairment in muscle function on the lower limb muscles may cause muscle fatigue thus decrease the functional performance and increase the level of fatigue when performing activities of daily living (14,24). This finding is also consistent with another study that reported individuals with total knee replacement experienced fatigue before surgery based on self-reported fatigue using the visual analog scale (20).

Even though KOA impacted lower limb functional strength and fatigue negatively, however, the correlational analysis did not observe a significant association between these variables in individuals with KOA. Instead, the strength of the knee flexor and extensor seemed to be significantly correlated with perceived fatigue. The 5TSST is a test that represents the strength of the overall lower limb muscles or involvement of the majority of the lower limb muscles as opposed to the knee flexion and extension that were tested individually. This may explain why the lower limb functional strength may not contribute to perceived fatigue. The 5TSST requires more mechanical force and sufficient strength of lower limb muscles to complete the repeated action (39). On the other hand, a previous study has found that there is a significant association between self-reported fatigue and physical performance (10-time sit to stand) in young and older adults (40). The inconsistency of the results from the previous study and the current study may be due to the repetitions of the sit to stand test. Since the age of the participants in this current study is 60 and below, thus the five repetitions may not be long enough to cause fatigue even though the participants took a longer time to complete the test than those without KOA.

In this study, it was found that handgrip strength was not associated with perceived fatigue. This is partly because individuals with KOA have a higher score for handgrip which explains that they tend to rely mostly on their upper limb strength. A similar finding was found in a previous study that there is no correlation between the level of fatigue using the Neurological Fatigue Index and handgrip strength in patients with multiple sclerosis (41). In contrast, one study among inactive young and older adults reported a significant correlation between self-reported fatigue and handgrip strength (40). Regardless of these findings, handgrip strength has been established as an indicator of the improvement in function after total knee replacement (16).

In terms of the relationship between the individual muscle of the lower limb, there was a significant negative association between hip flexor, knee flexor, and knee extensor with perceived fatigue. Individuals with KOA may limit activities such as ascending and descending stairs, walking, and kneeling that in turn lead to a decrease in muscle strength due to knee pain that further leading to physical inactivity and changes in the fatigue level compared to the healthy subjects (42). This current finding confirmed a previous study that there is a significant correlation between the isokinetic strength of hip, knee, and ankle muscles and level of fatigue as measured by the Fatigue Severity Scale in patients with multiple sclerosis (43). Understanding the relationship of these specific muscles with perceived fatigue may

guide health care providers to focus on strengthening the affected muscles in patients with KOA (44).

Several limitations can be noted in this study. Firstly, the small sample size may have contributed to the lack of significant differences and relationships in the variables of interest. Secondly, the participants for this study were limited to those aged between 40 and 60, and the majority are still working. Thus, the findings may not reflect the real burden of having KOA as compared to the general population who are much older and have retired.

CONCLUSION

In conclusion, findings from this study showed individuals with KOA have higher upper limb function, reduced lower limb functional strength, and higher perceived fatigue. Muscle functions may have influenced the perceived fatigue as the lower the muscle function, namely, the hip flexor, knee extensor, and knee flexor, the higher is the perceived fatigue. Thus, improving muscle strength and endurance may be suggested in the management of patients with KOA.

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