DOI 10.26773/smj.210213

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ORIGINAL SCIENTIFIC PAPER

The Comparison of Analogue Pain Scale, Quadriceps Muscle, and Knee Joint among Obese Women with Knee Osteoarthritis

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Abstract

Introduction: Patients with knee osteoarthritis were reported to have quadriceps weakness and impaired knee function, related to pain. It is unclear whether body composition is a causal factor to the above findings. Aim: The purpose of this study was to investigate differences in pain, quadricep strength, and knee function among obese women and women of normal weight with knee osteoarthritis. Methods: Fifty women with a mean age of 55 years were involved in this study. The inclusion criteria were bilateral knee of knee osteoarthritis with a visual analogue pain scale difference (>1) between each knee. Patients all underwent assessment of the pain intensity, isokinetic strength of knee muscles, and knee function. Results: The analysis showed that there were significant differences between groups in pain intensity (p=0.004) and quadriceps strength (p=0.003) but were not significant on the Lequesne index score (p=0.05). Significant differences in the intensity of knee pain and quadriceps strength occurred between the obesity II group with the normal weight group (p=0.004), overweight (p=0.017) and with obesity I (p=0.017) suffering from knee osteoarthritis. Conclusion: Normal weight people with knee osteoarthritis are at risk of suffering knee pain that causes reduced physical activity. This inactive condition will also result in a decrease in quadriceps muscle strength, which can increase the risk of knee deformity. Therefore, proper education and training programmes are required to anticipate this, so as to prevent the progression of knee osteoarthritis.

Keywords: *obesity, knee osteoarthritis, analogue pain scale, quadriceps muscle, knee joint*

Introduction

Obesity prevalence has increased in all age groups; specifically, in 2018, 21.83% of the Indonesian population was considered obese (Kesehatan et al., 2019). Obesity is a complex and multifactorial disorder arising from interactions between genotypes and environmental factors, namely social, behavioural, cultural, physiological and metabolic (Michael, Schlüter-Brust, & Eysel, 2010; Ng et al., 2014). Some chronic diseases are associated with obesity, such as hypertension, type 2 diabetes mellitus, cardiovascular disease, respiratory disorders, and various musculoskeletal complications.

One of the most common musculoskeletal complications is knee osteoarthritis, which is a chronic disease that manifests as pain, stiffness, swelling, and muscle weakness (Neogi, 2013); it causes functional impairment due to lower limb muscle weakness and is one of the most common diseases in older persons (Bindawas & Vennu, 2015). Knee osteoarthritis very often causes disability and is progressive, which is expe-

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rienced by nearly 80% of people aged 55 years (Im & Kim, 2014). Pain in knee osteoarthritis is closely related to decreasing quadriceps strength (Messier, Glasser, Ettinger, Craven, & Miller, 2002). Meanwhile, quadriceps muscle weakness may contribute to the worsening of knee pain (Segal et al., 2010). Also, quadriceps strength is one of the intrinsic factors affecting knee functions (Palmieri-Smith, Thomas, Karvonen-Gutierrez, & Sowers, 2010).

Obesity is a critical risk factor in the progression of knee osteoarthritis. Various studies have consistently shown an association between obesity as measured by body weight or body mass index (BMI), with the prevalence and incidence of knee osteoarthritis. One of them is a survey conducted by the National Health and Nutrition Examination Survey, showing that the risk of knee osteoarthritis increases almost four times in women with obesity, and 4.8 times in men who are obese (Ho-Pham, Lai, Mai, Doan, & Nguyen, 2016). During the single-leg stance phase, the knee will take 3-6 times body weight (Melchiorre, 1996). Each weight gain will be multiplied by this number, illustrating how much weight passes through the knee on someone who has more weight when walking. The increase in axial load will cause a resultant shift in the force acting on the knee joint towards the medial and an increase in knee adduction movement on the knee thereby increasing the load that passes through the medial compartment of the knee, which can trigger knee osteoarthritis, especially in the medial compartment of the knee (Melchiorre, 1996). Among obese people who also experience knee osteoarthritis, there is an increase in knee pain that causes limited activity, as well as the risk of needing a knee joint replacement (Ho-Pham et al., 2016).

According to Landsmeer et al. (2019) a linear relationship between BMI and the incidence of disability due to knee pain due to knee osteoarthritis exists, which is thought to be because an increase in body weight will increase the axial load that passes through the knee joint, resulting in higher pain intensity. Patients will tend to rest their knees by decreasing physical activity, causing quadriceps muscle weakness and atrophy. Furthermore, quadriceps muscle weakness that occurs in obese sufferers who experience knee osteoarthritis can be aggravated by the fatigue in quadriceps muscle due to the large load at the time of weight-bearing and sedentary lifestyle that is common among obese people. Weakness in the knee extensor muscle can cause knee weights to increase 21% higher compared to healthy knees (Mikesky et al., 2006). Furthermore, overloading with quadriceps muscle weakness can increase the risk of deformity in the knee of an osteoarthritis sufferer. The above factors are thought to cause higher progression in obese people with knee osteoarthritis in comparison to people of normal weight with knee osteoarthritis (Madry et al., 2016). Disease progression that is not handled properly can increase a person's disability, especially in walking, the ability to climb stairs, rise from sitting and standing for an extended period. The disability will reduce independence in the activities of daily life and the quality of life and ultimately can cause handicaps. However, there are limited studies regarding pain, quadriceps strength, and knee function in obese women with knee osteoarthritis compared to normal-weight people with knee osteoarthritis.

The purpose of this study was to investigate the differences in the analogue pain scale, quadriceps muscle, and knee joint between obese and normal-weight sufferers with knee osteoarthritis.

Methods

Study design and Participants

The design of this study was cross-observational. Fifty female participants were included in this study: 25 participants with normal weight (BMI<25 kg/m²) and 25 participants with obesity (BMI≥25 kg/m²), classified as Asian Pacific (World Health Organization, 2000), aged 40-59 years old, who had a diagnosis of knee osteoarthritis, according to the American College of Rheumatology criteria (Altman et al., 1986). Both knee joints had arthritic change grade 2 or higher in the Kellgren-Lawrence grading scale (Kellgren & Lawrence, 2006); both knees had pain without swelling confirmed by ultrasonography, performed by a senior radiologist who had performed ultrasonography for more than five years; the difference of visual analogue scale (VAS) was less than eight points between each knee joint. The satisfaction of the inclusion criteria was confirmed based on a health history questionnaire.

Subjects who experienced knee joint infections or other joint abnormalities in the lower extremities were obese after the occurrence of knee osteoarthritis, had impaired balance, proprioceptive sense and coordination, laxity in the collateral ligament of the knee joint, valgus and varus deformity, prosthesis and orthosis which serves to correct the joints of the knee joint limitations of the scope of the knee joint, neuromuscular disease (i.e., stroke and peripheral neuropathy), cardiovascular disease and hypertension were excluded.

Settings and locations of data collection

The research was conducted in Central Java, Indonesia (Semarang and Gombong). The testing took place in the Rehabilitation Laboratory of the Physical Education of Universitas PGRI Semarang and the Laboratory of Midwifery of the Sekolah Tinggi Ilmu Kesehatan Muhammadiyah Gombong. The baseline study was started in May 2019 and ended in July 2019.

Outcome measures

In this study, the participants were given a clear explanation of the measured parameters and methods of measurement. For each testing protocol, all participants received verbal directives and visual demonstrations from the examiner. The participants warmed up prior to the measurement.

Each subject had X-ray radiographs of both knees and completed pain evaluation as part of the study. Using the VAS scale, a score between 0 to 10 points of the combined pain in both knees was obtained, followed by separate scores for each knee, to identify which was more and less painful. At the same time, quadriceps strength tests were performed after approximately 10 min of warm-up consisting of the stretches to hamstring, quadriceps, and calf muscles, and then a light level of stationary bike exercise.

An a priori power analysis was performed to determine the sample size using a two-sided hypothesis test at an alpha level of 0.05 and a power of 0.8. The results of a previous study indicated that 25 knees would be required to detect a significant between-group joint proprioception difference of >1°, the primary outcome measure (Hurley, Scott, Rees, & Newham, 1997).

All observations and measurements were carried out by the same investigator. The body mass and height of each participant were measured to calculate their BMI by dividing body

mass (kg) by height in meters squared (m^2). After an overnight fast, body composition was measured by bioelectrical impedance analysis equipment (Body Composition Analyser Tanita AB-140 Viscan, Tanita Corporation of America, Inc., USA). Height was measured with a stadiometer. The strength and endurance of the knee extensor and flexor muscles were evaluated using an isokinetic dynamometer (CSMI Medical Solutions, MA, USA). The maximal strength of the quadriceps and hamstring was measured for each knee at 60 °/s (4 repetitions) and 180 °/s (20 repetitions), and mean power for each was calculated (Gur & Cakin, 2003). The maximum peak torque (Nm) for each velocity was also recorded. This measure has excellent intra-rater reliability in patients with knee osteoarthritis (Kean, Birmingham, Garland, Bryant, & Giffin, 2010). VAS scale measurements, quadriceps strength, and Lequesne Functional Index (Basaran, Guzel, Seydaoglu, & Guler-Uysal, 2010) from the normal weight and obese women groups were compared at the end of the study.

Written informed consent was provided by the participants, and all procedures were handled according to the Declaration of Helsinki. The study obtained approval from the ethics committee of Universitas PGRI Semarang.

Statistical analysis

Statistical analysis was performed using SPSS version 22 (SPSS Inc., Chicago, IL, USA). The normality of all data was checked using the Shapiro-Wilk test ($p>0.05$). A paired t-test was used to compare the difference in muscle strength between the two groups. The difference in pain intensity and quadriceps strength was determined using the One Way Anova test, while differences in knee function were determined using the Kruskal Wallis test. Post hoc analysis was carried out to find differences between groups. Statistical significance was accepted at $p<0.05$.

Results

There was a total of 50 female patients in this study. The detail of the demographic data was shown in Table 1.

Table 1. Characteristics of subjects

Characteristics	Obesity	Non-obesity
Age (years)	55±2.7	55±17
BMI (kg/m^2)	28.93±2.33	23.84±1.3
Dominant leg (right/left)	23/2	18/7
More painful knee (right/left)	17/8	14/11
Duration of knee pain		
<6 months	5	7
6-12 months	9	12
>12 months	11	6
Visual analogue scale	5.90±1.39	3.53±1.37

This study showed no significant difference in the intensity of knee pain as measured by VAS ($p=0.06$). In the obese and normal groups, the mean VAS reported was 5.86±0.96 cm and 5.3±1.13 cm, respectively, for the obese group with knee osteoarthritis and the normal group with knee osteoarthritis. Obese subjects with knee osteoarthritis had lower quadriceps strength (127.87±13.51 N) compared to those in the normal group with knee osteoarthritis (117.82±15.02 N). The difference in quadriceps strength was statistically significant between the two ($p=0.016$). The Lequesne index score describes the knee function sufferers of knee osteoarthritis. In the obese group, the median score was 8, with a minimum score of 4 and a maximum score of 12.5. There was no significant difference between this group and the normal group who had a median of 6, with a minimum score of 4 and a maximum score of 12 ($p=0.139$). With respect to knee extensor muscle strength, the knees of obese subjects showed significantly lower strength than the knees of normal weight subjects at angular velocities of both 60°/s (54.98±13.36 Nm vs 63.00±9.96 Nm, $p=0.01$) and 180°/s (37.78±9.55 Nm vs 44.68±11.77 Nm, $p=0.01$). However, there was no statistically significant difference in knee flexor muscle strength at angular velocities of 60°/s or 180°/s either (Table 2).

Table 2. Results pain, quadriceps strength and knee function

Variable	Obesity M±SD	Non-obesity M±SD	p
VAS	5.86±0.96	5.3±1.3	0.06
Quadriceps strength	127.82±13.51	117.82±15.02	0.016*
Isokinetic peak torques (Nm)			
Extensor 60 °/sec	54.98±13.36	63.00±9.96	0.01*
Extensor 180 °/sec	37.78±9.55	44.68±11.77	0.01*
Flexor 60 °/sec	27.10±6.70	29.88±6.57	0.06
Flexor 180 °/sec	23.30±7.25	25.50±5.61	0.07
Lequesne index score	8 (4-12.5)**	6 (4-12)**	0.139

Legend: M±SD - mean ± standard deviation (*$p < 0.05$; *Median (min-max))

The analysis showed that there were significant differences between groups in pain intensity (p=0.004) and quadriceps strength (p=0.003), but they were not significant on the Lequesne index score (p=0.05). Significant differences in intensity of knee pain and quadriceps strength occurred between the obesity II group both with the normal weight group (p=0.004), overweight (p=0.017) and with obesity I (p=0.017) suffering from knee osteoarthritis. There were no significant differences in the Lequesne index scores between the four groups. No significant differences in pain intensity, quadriceps strength, and knee function were also found between normal-overweight, normal-obesity I, and over-obese I weight groups (Table 3).

Table 3. Differences in pain, quadriceps strength and knee function based on BMI classification

Variable	p
Pain	
Normal weight-obesity II	0.004
Overweight-obesity II	0.017
Obesity I-obesity II	0.017
Quadriceps strength	
Normal weight-obesity II	0.014
Overweight-obesity II	0.002
Obesity I-obesity II	0.025
Knee function	
Normal weight-obesity II	0.118
Overweight-obesity II	0.066
Obesity I-obesity II	0.121

Discussion

The results of this study indicate that there is no significant difference in pain intensity in the obese and normal groups with knee osteoarthritis. This result is not in accordance with the research of Marks (2007), which shows that there is a relationship between obesity and pain intensity: subjects who have a higher BMI complain of significantly higher pain intensity than subjects who have a lower BMI do. The research of Cimmino, et al. (2005) states that in addition to body mass index, pain intensity is also influenced by several other factors: female sex, age over 70 years, low level of education (defined as formal education less than five years), BMI >30, duration of illness more than seven years, the presence of comorbidities, and generalized knee osteoarthritis. The population of the study subjects were all women, none were over 70 years old, there was only one person who had knee pain longer than seven years, three people who had comorbidities (dyslipidaemia and diabetes mellitus), all were in the obesity group, and there were no subjects who experienced generalized knee osteoarthritis. Homogeneity and the low sample size with accompanying factors that emerged in the study population caused researchers to suspect that these factors did not affect the absence of differences in the intensity of knee pain experienced by subjects in the two study groups. This study shows a statistically significant difference in pain intensity between the obesity II BMI (>30 kg/m^2) with the normal weight, overweight, and obese I groups who suffer from knee osteoarthritis. This is consistent with the research of Cimmino, et al. (2007), which determined there is a significant relationship between BMI >30 kg/m^2 with the intensity of pain complained of by patients with knee osteoarthritis. Also, Jinks et al. (2006) asserted that a BMI >30 kg/m^2 was also a strong predictor for the progression of mild pain to pain with severe intensity after three years. The available evidence corroborates the alleged relationship between an increase in body mass index and variations in pain conditions. In weight-bearing joint osteoarthritis, such as knee and hip, mechanical-structural factors are thought to play a greater role in the relationship between BMI and knee osteoarthritis complaints (Janke, Collins, & Kozak, 2007). Research by Thorp et al. (2007) has shown that, for subjects with mild knee osteoarthritis, radiography plays an important role in calculating the increased burden on the knee compartment from the knee adduction moment, which is significantly related to the increase in pain complaints. Metabolic factors that are thought to play a role in the relationship between obesity and pain intensity are changes in glucose homeostasis. Glucose homeostasis may also be an important factor related to pain (Janke, Collins, & Kozak, 2007). Pain experienced by obese sufferers with knee osteoarthritis will make the subject reduce his physical activity so that there is an increase in body weight and deconditioning including the quadriceps muscle which in turn can further increase the pain (Janke et al., 2007). Significant decreases in muscle strength decreased between groups with a BMI >30 kg/m^2 (obesity II) and groups with a BMI below it. Although there were no significant differences, quadriceps strength tended to decrease between groups of normal weight, overweight, and obesity I. The results of this study are in accordance with the research of Amin et al. (2009) who found that there was a strong significant negative correlation between body weight and knee extensor strength. The relationship between quadriceps muscle weakness and obesity is thought to be due to an increase in body weight, which increases the axial load that passes through the knee joint, resulting in higher pain intensity. This finding is supported by the research of Roos et al. (2011), states that obese individuals have quadriceps muscles with lower resistance to fatigue than individuals without obesity.

Furthermore, quadriceps muscle weakness can also be caused and aggravated by the lifestyle of individuals with obesity, who tend to be sedentary. The strength of the concentric

contraction, as well as the eccentric muscles of the quadriceps, are weaker in transient women (Lim et al., 2009). Research subjects in the obese group with average knee osteoarthritis experienced severe functional impairment (median Lequesne index 8). Although not statistically significant, subjects in that group had a more severe disability compared to subjects in the normal group with knee osteoarthritis, who on average experienced moderate functional impairment (median Lequsne index 6). The results of this study did not show significant differences in the knee function between obese and normal sufferers with knee osteoarthritis, which is in contrast to the study of Teichtahl et al. (2008), which found that there is a linear correlation between BMI and the incidence of disability in patients with knee osteoarthritis. According to Creamer et al. (2000), the intensity of pain, obesity and feeling of helplessness are the factors most related to disability. The subjects in this study had a mean pain intensity that was not significantly different in the two groups, and the mean BMI in the normal group was near the upper limit of weight classification more in line with the Asia Pacific classification. The two factors that are almost the same might cause the level of knee function ability, which is not significantly different between the obese group and without obesity with knee osteoarthritis.

Based on the results of previous studies, a decrease in muscle strength is also believed to be a factor that affects the reduced knee function in patients with knee osteoarthritis (Dekker, Van Dijk & Veenhof, 2009; Sharma, Lou, Cahue & Dunlop, 2000). Decreased quadriceps strength, is a risk factor for the progression of knee osteoarthritis, due to reduced muscle ability to accurately control joint movement (Roos et al., 2011).

In the present study, the quadriceps strength of the subjects in the obese group was significantly lower compared to the normal group with knee osteoarthritis. However, this did not seem to affect the Lequesne index reported by the study subjects in the two groups, so there was no significant difference in knee function in the two groups. This can occur because, in addition to muscle strength factors, there are still many other risk factors that cause a decrease in the ability of knee function that were not examined in this study.

In this study, the presence of comorbidity is only sought based on history and simple physical examination on the subject of research, so that there may still be other undetectable comorbidity factors that could affect the results. Other than the existence of the aforementioned factors, psychological and social disorders can also be a confounding factor, especially in the analysis of differences in the functional ability of the knee between the obese and non-obese groups with knee osteoarthritis.

Obesity, especially obesity II, has been shown to have a large influence on the level of pain intensity and decreasing quadriceps strength. Given significant decreases in muscle strength in obese people with knee osteoarthritis, it is necessary to strengthen the muscle with exercise, especially quadriceps and hamstring, which will be very beneficial in maintaining knee stability and reducing the burden that passes through the knee joint.

Acknowledgements
The research was funded by Khon Kaen University. The author thanks the research investigator and study participants.

Conflict of Interest
The authors declare that there is no conflict of interest.

Received: 04 May 2020 | **Accepted:** 28 June 2020 | **Published:** 01 February 2021

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