Original Research

The Relationship Between Quadriceps Muscle Atrophy and Proprioception Function in Knee Osteoarthritis Patients

Ayu Susanti[1], Rr. Indrayuni Lukitra Wardhani[1], I Putu Alit Pawana[1]
[1]*Physical Medicine and Rehabilitation Department, Airlangga University, Surabaya, Indonesia.*

Abstract

Background: Osteoarthritis of the knee (OA) patients can experience impaired proprioceptive function which causes instability, balance disorder and limited activity. Further analysis is needed to detect changes that occur. There are two methods to evaluate the speed and angle of a particular motion as an analysis of the function of proprioception, Time to Detect Passive Movements (TTDPM) and Joint Position Sense (JPS).
Aim: To analyze the relationship between quadriceps muscle atrophy with proprioception in knee osteoarthritis patients.
Methods: The design of this research is cross sectional analysis done in Dr. Soetomo General Hospital Surabaya, Indonesia. There were 25 knee OA patients (2 men and 23 women) with each subject had proprioception (JPS and TTDPM) function measured using isokinetics dynamometer on both sides of the knee.
Results: This study shows the atrophic side had greater pain intensity and greater disturbance of proprioception. In addition, there were significant differences in JPS measurements at angle of 30^0, and 60^0 and TTDPM ($p < 0.05$). No difference obtained at 45^0 measurements angle.
Conclusion: In this study, there was no association between quadriceps atrophy and function of proprioception in knee osteoarthritis patients. This was due to a number of confounding factors that cannot be controlled such as duration, difference in pain intensity, OA severity, physical activity before measurement, and fatigue which can affect proprioception function and bring misinterpretation on measurements.

Keywords: *knee osteoarthritis, proprioception, muscle atrophy, Time to Detect Passive movement test, Joint Position Sense test*.

Introduction

Osteoarthritis is a degenerative disorder of the joint causing changes in the joint cartilage and new bone formation on the joint surface. The underlying processes is complex, including degradation and repair of subchondral cartilage, and synovial inflammatory processes influenced by mechanical stress, biochemical and genetic factors. The proportion of patients with symptomatic knee OA tends to increase because of the increasing number of elderly and obese in general population. The prevalence of knee OA in Asia is very high. A study reported that there was an increasing

incidence of this disorder in Southeast Asia reaching 53% in rural area. In the Chinese population, prevalence of knee OA for people over 60 years is 22% of men and 43% of women. In 2016 knee OA was the second most treated case in the outpatient clinic in Dr. Soetomo General Hospital Surabaya, Indonesia (9.11 % of total cases). Those data tell that knee OA needs serious attention due to the impact to the population.

Older adults with symptomatic knee OA are reported to experience proprioception disturbance, quadriceps muscle weakness, imbalance, and higher risk of falling than those without symptomatic knee OA. Proprioception plays an important role in maintaining joint stability through the sensorimotor system utilizing various sensory systems of muscles, ligaments, tendons, joints, skin, organs and muscle spindles. The main sensory receptor of the joint position sensation is the muscle spindle along with the sensory receptors on the skin. Any proprioception impairment will affect the joint stability and will decrease the functional ability of patients with knee OA.[1-4]

Impaired proprioceptive accuracy in patients with knee OA causes an imbalance of pressure in the weight bearing knee joint, which will further worsen joint damage. This condition will also impair posture control resulting in imbalance, and is the cause of falls in the elderly.[5]

Muscle weakness is caused by a decrease in the number or size of extrafusal muscle fibers or due to failure of muscle fiber activation (reduced activation). Joint damage, immobilization, decreased activity, and muscle weakness will cause muscle fibers to become atrophic. Another cause of muscle atrophy is the failure to fully activate the quadriceps muscle. Impaired proprioception could be compensated by increasing muscle strength. Examinations to measure proprioception function in the knee joint are Time To Detect Passive movement (TTDPM) test to assess motion sensations and Joint Position Sense (JPS) test for reproduction of positions at certain angles. These examinations are valid and reliable measurement tools of knee joint proprioception. Good examination will help the process of rehabilitation people with knee OA.[6-8]

This study aims to analyze the correlation between quadriceps muscle atrophy with proprioception function in knee osteoarthritis patients.

Material and Methods

Participants

The study had ethical approval from Dr. Soetomo General Hospital ethical committee number 071/KEPK/II/2018. There were 25 patients (2 males and 23 females) who met inclusion criteria and willing to voluntarily participate as a subject by signing informed consent and medical procedure agreement after getting clear information. The inclusion criteria were positive diagnosis of knee OA based on ACR criteria, 50-70 years old of age, had pain level of visual analog scale between 2-5, never had proprioception training, and the involved thigh circumference at least 2 cm smaller than the contralateral side.

Examination Protocol

Quadriceps muscles' circumference

Quadriceps muscles' circumference was measured using measurement tape in centimeter (cm). Patient in seated position, then examiner identify the medial tibial plateu (MTP), and the measurement area was on 3 inches proximal to MTP.

Joint position sense (JPS)

JPS was measured by Cybex isokinetic dynamometer. Patient seated in examination chair with knee flexed 90^o. Patient was instructed to close their eyes, and patient's knee was moved passively by the examiner to the 30^o position, this position was held for 20 seconds, and then the examiner return the patient's knee to 90^o position. Patient was instructed to reproduce the 30^o position actively, and the examiner records the results (the difference between reproduced angle and the initial set angle). The protocol was repeated for 45^o and 60^o position. Patient had trial conducted before patient underwent the real examination, and the measurement was taken three times for each position, the result was the mean of those three.

Time to Detect Passive Movement (TTDPM)

TTDPM was measured using Cybex isokinetic dynamometer. Patient seated in examination chair with knee flexed 90^o and held a stop button. The patient's knee then extended passively by the machine with the speed set to 1^o/second. With the eyes and ears closed patient was instructed to push the stop button whenever they feel their joint is moved. The examiner record the time and the knee's angle when protocol starts and when the button was pushed. Trial was conducted before patient underwent the examination, and the measurement was taken three time, the result was the mean of those three.

Statistical analysis

Statistical analysis was performed using IBM™ SPSS v.23 software. *Shapiro-Wilk* was used to determine normality of the data in each group. *Pearson correlation coefficient* was used for normally distributed data and *Spearman* was used for not normally distributed data. The significance level was set at $p \leq 0.05$.

Result

The characteristics of the subjects were shown in Table 1. and Figure1. Quadriceps muscles' circumference difference was shown in Figure 2. Pain intensity was measured using visual analogue scale (VAS), the pain intensity of the subject was shown in Figure 3 and Figure 4, 24% subject experienced pain for less than 6 months and 76% more than 6 months. Training session attendance was 100% for all subjects, and no dropouts. All the data were normally distributed.

Table 1. Baseline characteristics of the subjects

	n	Min	Max	Mean	SD
Age (years)	25	50	68	59.2	5.4
Body height (cm)	25	146	175	154.96	5.56
Body weight (kg)	25	50	85	68.92	7.86
BMI (kg/cm^2)	25	21.36	32.9	27.05	3.16

*BMI: Body Mass Index; SD: Standard Deviation

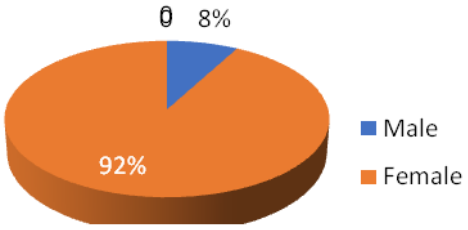

Figure1. Sex characteristic of the samples

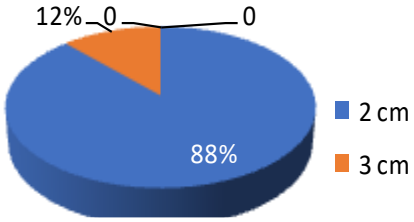

Figure2. Quadriceps muscles' circumference difference

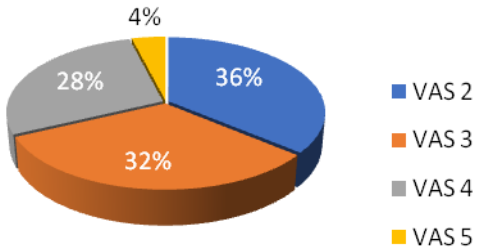

Figure3. Pain Scale on non atrophy side

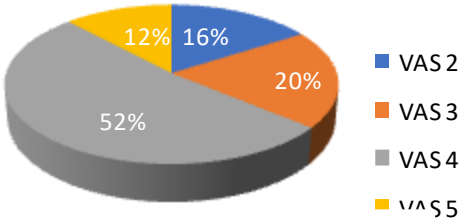

Figure4. Pain Scale on atrophy side

Table 2. Results of TTDPM and JPS examination for both side

	Atrophy side	Non-atrophy side	*p-value*
JPS 30	7.95±3.77	4.75 ± 2.40	0.001*
JPS 45	7.05±3.75	6.08 ± 2.82	0.174
JPS 60	7.13±3.18	5.15 ± 2.69	0.006*
TTDPM	7.25±3.86	5.84 ± 3.14	0.032*

*$p<0.05$

Table 2. showed significant difference for TTDPM and JPS examination results at 30^o and 60^o angle, but there was no significant difference for JPS examination at 45^o angle on both side. Table 3. showed no significant correlation between the results of JPS and TTDPM examination and quadriceps muscle atrophy.

Table3. Correlation between parameters and quadriceps muscle atrophy

	Correlation	
	r	***p-value****
JPS 30	0.371	0.068
JPS 45	- 0.26	0.209
JPS 60	- 0.122	0.562
TTDPM	- 0.044	0.863

* *Pearson* correlation test

Discussion

In this study, prevalence of OA is greater in female (92%) than male (8%), with mean age of subjects is 59.2±5.4 years. The results of this data in accordance with the data published by the American College of Rheumatology (ACR), saying OA can affect two-thirds of people over 65 years of age, with a prevalence of 60.5% in men and 70.5% in women. Data from the CDC (Center for Disease Control and Prevention) in the United States showed that there were around 30.3% of the population aged 45-64 years diagnosed with arthritis, whereas at the age over 65 years is around 49.7%.[1-4]

In our study, we found that on atrophic side pain intensity was greater than on the non-atrophic side. This is in accordance with Van der Esch's study which found that quadriceps muscle atrophy and weakness were often present in knee joint arthritis. This is due to the presence of a neural activation deficit in quadriceps. This process is known as arthrogenic muscle inhibition (AMI).[7,9]

This study found that there was significant difference of JPS (at angle of 30^{o}and 60^o) and TTDPM result between atrophic and non-atrophic side. This is due to atrophic muscles have less mass and decrease in mechanoreceptors impulses that in turn will decrease the function of proprioception. Patients with weak quadriceps muscles will get tired quickly and has proprioception imparment.[4,7,10]

In this study, JPS measurement at 45^o or middle angle was not significant, this is due to proprioception receptors in the joints of patients with OA not sufficiently activated. Li *et al.* states that the proprioception receptor joints only play a small role in the middle angle.[11] Joint proprioception receptors play an active role only in extreme range of joint motion. In contrast to muscle spindles that actively provides information on the entire range of joint motion. Different results were showed by Guney *et al.* who measured patients with patellofemoral syndrome at an angle of 20^o and 60^o. There was significant difference from JPS examination at these angles on both sides of the knee ($p < 0.001$).[8]

This study result shows no significant correlation between the parameters and the atrophy of quadriceps muscles. This is probably due to the fact that the subjects of this study had received therapeutic exercise. The data taken from the medical record showed that all patients had muscle strengthening training in PMR department of Dr. Soetomo General Hospital Surabaya. Shakoor *et al.* reported that there was a weak relationship between pain and muscle strength ($r=-0.39$, $p=0.01$) and between proprioception accuracy and muscle strength ($r= -0.35$, $p=0.03$). This relationship became strong after the subject had muscle strengthening exercises to reduce pain ($r=0.45$, $p=0.005$) and there was an increase in proprioception accuracy ($r=0.41$, $p=0.01$).[12] This means that muscle strengthening exercises can improve the proprioception function with knee OA.[12-16]

Other possible causes are the differences of pain intensity between both knee, and there was no grouping of subject based on severity. There were two studies which reported the correlation between proprioception function and OA severity. The relationship between quadricep muscle strength and the progression of knee OA is still unclear and very complex, various studies with human subjects failed to find a clear relationship between the two.[17,18]

The results of the study showed that there was no correlation between muscle atrophy and proprioception because researchers did not exclude the physical activity of the patients in the beginning of the study. People with regular physical activity and exercises

have better proprioception function than sedentary people. This is due to regular physical activity and exercise effect of increasing the sensitivity of the muscle spindle.[13,19]

Conclusion

There was no significant correlation between quadriceps muscle atrophy and the proprioception function of knee osteoarthritis patients.

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