Correlation of Quadriceps and Hamstring Muscles Strength with Knee Osteoarthritis Stages and Pain Levels in Elderly Female Subjects

Mohammad Fathul Qorib [1], Hening Laswati[1]

[1]Department of Physical Medicine and Rehabilitation, Dr. Soetomo Teaching Hospital, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia

Abstract

Background: Osteoarthritis (OA) is one of the most common disease occur in elderly. It is commonly occurs in knee, hips and interphalangeal joints Pain caused by knee OA may result in functional disorders that affect patient's life quality.

Objective: To analyze correlation of quadriceps and hamstring muscles strength with knee OA stages and pain levels in elderly female subjects.

Methods: 38 elderly female subjects (average age of 67.18 ± 4.91) were assessed for pain scale using numeric rating scale (NRS). We used 1RM protocol (EN-Tree) to measure quadriceps and hamstring muscles strength. We performed anterior-posterior and lateral knee X-rays to determine OA stage. The process of data analysis was conducted using several tests, including Kolmogorov-Smirnov test, Pearson's correlation test, Spearman's correlation test and Mann-Whitney test to measure difference between knee OA level using 1RM quadriceps muscle and quadriceps/hamstring (Q/H) ratio.

Results: The average NRS was 3.68 ± 1.19, 1RM quadriceps and hamstring muscles strength were 2.68 ± 1.23 and 1.11 ± 0.44, respectively, quadricep/hamstring ratio (Q/H) was 2.53 ± 0.95. A total of 30 subjects had OA stage 2, while 8 subjects had OA stage 3.

Conclusion: The 1RM quadriceps and hamstring muscles was not correlated with NRS. There was no difference in 1RM quadriceps and hamstring muscles between subjects with OA stage 2 and 3. We found a positive correlation between Q/H ratio and the NRS. The Q/H ratio in subjects with OA level 2and 3 was different.

Keywords: *1RM Quadriceps and Hamstring, NRS, osteoarthritis level, Q/H ratio*

Introduction

Osteoarthritis (OA) is the most common joint disorder and a major cause of disability in elderly people [1,2]. Pain caused by knee OA may result in functional disorders that affect patient's life quality [3]. Prevalence increases with age. Ten percent of total population will have symptomatic osteoarthritis in their 70s [2]. The number and percentage of elderly in Indonesia continues to increase each year with an average increase of 0.5% per year. Such increases will potentially lead to an increased OA prevalence. Osteoarthritis may cause socio-economic problems in family and social environment[4].

Osteoarthritis is a common progressive joint disorder. It is commonly occurs in knee, hips and interphalangeal joints [5]. Even though OA is not commonly found in

Corresponding Author:
Hening Laswati Purba
Departrment of Physical Medicine and Rehabilitation, Dr. Soetomo Teaching Hospital, Faculty of Medicine, Universitas Airlangga, Jalan Mayjen Prof. Dr. Moestopo 47, Surabaya 60285, Indonesia
Email: heninglaswati1@gmail.com

knee joint, it is the most common cause of disability. Patients with knee osteoarthritis often experience disruption in their daily activities because of the arising pain [1]. Female subjects have a greater risk of knee OA than male. The number of new patients with knee OA visiting Medical Rehabilitation Unit of Dr. Soetomo Teaching Hospital, Surabaya, Indonesia, from October 11- December 28, 2011 were 61 patients (51 females and 10 males). The osteoarthritis pathology is damages in joint cartilage and new subchondral bone formation (osteophyte) [5]. Osteoarthritis occurs due to disruption of the balance between cartilage catabolism and anabolism. Some factors affecting the balance are types of work, weight, trauma, abnormal growth process, collagen gene mutations, muscle weakness, changes in proprioceptive function, joint neurological disorders and metabolic abnormalities [1].

Muscle strength decreases with age particularly after 60 years old. Muscle strength will be reduced by 45% at age 65 due to a complex process including biological and functional causes. Quadriceps and hamstring muscles are the most common muscle types suffering from strength and size reduction [5]. Muscles around the knee act as chondro-protective. A study conducted in178 female and 164 male elderly found that quadriceps muscle weakness became a risk factor for knee OA occurrence in the female patients [6].

Other studies in elderly subjects found that quadriceps muscle weakness was not the result of knee immobilization due to pain, but rather a trigger factor of knee OA [2,6]. Quadriceps muscle weakness eliminates one of knee stabilizer functions. Several studies have shown that quadriceps receptor failure when performing voluntary contractions is one of the causes of decreased muscle strength occurring in old age [7].

Hamstring muscles have a role as knee joint stabilizer [8]. To date, there has been no study confirming correlation of quadriceps and hamstring muscle strength with pain level and knee OA, therefore is still no form of early prevention and a more measurable muscle strengthening program for pain management due to knee OA. Several previous studies have examined the relationship between quadriceps muscle weakness and OA. Those studied did not radiologically examine correlation of hamstring muscle strength with pain OA levels radiologically [6,9–12].

Muscle strength assessment can be easily conducted with simple and inexpensive methods. One method used to assess muscle strength is 1RM (repetition maximum), a maximum load that can be lifted with the movement of the full joint motion, or calculated according to the Oddvar Holten diagram. Previous studies conducted in healthy women subjects found no significant difference of quadriceps bench after being assessed with 1RM using EN-tree tools. Disability in elderly subjects due to knee OA pain complaint should be prevented by an early 1RM assessment and an immediate reinforcement program if it is proven that quadriceps and hamstring muscle strength is correlated with pain level and knee OA. Quadriceps bench can be made by yourself or modified easily and at very cheap cost. Muscle strength is easily assessed and enhanced by exercise using quadriceps bench. In this study, we used the EN-tree tool because the process of collecting 1RM data of quadriceps and hamstring muscles was more objective and more efficient. This study aims to analyze correlation of quadriceps and hamstring muscles strength with knee osteoarthritis (OA) stages and pain levels in elderly female subjects.

Methods

This observational analytic study using cross sectional approach was carried out from March to April 2012 at Medical Rehabilitation Unit of Dr. Soetomo Teaching Hospital, Surabaya, Indonesia. We used 38 elderly female subjects with knee OA who visited Medical Rehabilitation Unit of Dr. Soetomo Teaching Hospital, Surabaya, Indonesia. The inclusion criteria were as follows: (1) Women aged 60 years and over; (2) Willing to participate in this study by signing informed consent. On the other hand, the exclusion criteria were: (1) Obese subject with a Body Mass Index (BMI) of more than 30; (2) Having experienced lower extremity fracture; (3) Having impaired neurological function and cardiorespiratory disorders. The study protocol was approved by the ethics committees of Dr. Soetomo Teaching Hospital (Surabaya, Indonesia).

This study used EN-Tree protocol with NRS to assess pain level at Medical Rehabilitation Unit and X-ray machine at Radiology Unit of Dr. Soetomo Teaching Hospital, Surabaya, Indonesia. We assessed if subjects had not experienced any lower extremity fractures and/or neurological disorder. Pain level was assessed using NRS, while 1RM was calculated using EN-Tree protocol. Knee was evaluated using X-ray.

All data were processed using SPSS software (SPSS., Inc., Chicago., IL). The process of data analysis was conducted using several tests, including Kolmogorov-Smirnov test, Pearson's correlation test (for normal data distribution), Spearman's correlation test (for non-normal data distribution) and Mann-Whitney test to measure difference between knee OA level using 1RM quadriceps muscle and quadriceps/hamstring (Q/H) ratio.

Results

We took 1RM quadriceps and hamstring muscle data from 38 eligible subjects using EN-Tree protocol at Medical Rehabilitation Unit of Dr. Soetomo Teaching Hospital, Surabaya, Indonesia. Radiographic data of knee OA was taken after 1RM examination. All subjects had bilateral knee OA, but we only assessed the right side. The X-ray results showed 30 subjects had stage 2 OA, and 8 subjects had stage 3 OA. The subjects' basic characteristics were presented in Table 1. The data for age, BMI, NRS and 1RM hamstring muscle parameters were normally distributed, while data for 1RM quadriceps muscle and Q/H ratio were non-normally distributed. Pearson's correlation test showed no significant correlation between pain level with age, BMI and 1RM hamstring muscles.

Table 1. Subject's Characteristics

Variable		N	Mean ± SD	Minimum	Maximum
Age (year)		38	67.18 ± 4.91	62.27	72.09
BMI (Kg/m2)		38	24.47 ± 3.09	21.38	27.56
NRS		38	3.68 ± 1.19	2.49	4.87
1RM Quadriceps (Kg)		38	2.68 ± 1.23	1.45	3.91
1RM Hamstring (Kg)		38	1.11 ± 0.44	0.67	1.55
Q/H Ratio (Kg)		38	2.53 ± 0.95	1.58	3.48
OA Stage	1	0			
	2	30			
	3	8			
	4	0			

In Table 2. Shown the data for normality test for variables.

Table 2. Normality Test for Age, BMI, NRS, 1RM Quadriceps Muscle, 1RM Hamstring Muscle and Q/H Ratio Parameters

Variable	N	p
Age (year)	38	0.465
BMI (Kg/m2)	38	0.934
NRS	38	0.150
1RM Quadriceps (Kg)	38	0.029
1RM Hamstring (Kg)	38	0.101
Q/H Ratio (Kg)	38	0.046

Spearman's rho showed a weak negative correlation between 1RM quadriceps muscle and pain level. The Q/H ratio had a weak positive correlation with pain level (r = 0.365).

Table 3. Correlation between 1RM Hamstring Muscle, 1RM Quadriceps Muscle and Q/H Ratio with Pain Level

Variable	NRS
Age	r = -0.076 p = 0.642
BMI	r = -0.198
	p = 0.234
1RM Hamstring	r = -0.297
	p = 0.070
1RM Quadriceps	r = -0.960
	p = 0.567
Q/H Ratio	r = 0.365
	p = 0.024

Table 4. Differential Test of Age, BMI and 1RM Hamstring in Both Groups

Variable	Stage OA	N	Mean±SD	p
Age	2	30	67.033±4.91	0.719
	3	8	67.75±5.20	
BMI	2	30	23.97±3.22	0.056
	3	8	26.31±1.69	
1RM Hamstring	2	30	1.073±0.45	0.352
	3	8	1.24±0.38	

T-test showed that age, BMI and hamstring muscle strength between subjects with stage 2 and 3 knee OA were not different, with p >0.05 (Table 4.).

Table 5. Differential Test of 1RM Quadriceps and Q/H Ratio in Both Groups

Variable	Stage OA	N	Mean	Median	Minimum	Maximum	p
1RM Quadriceps	2	30	2.7733	2.7000	0.60	6.20	0.425
	3	8	2.3375	2.7000	1.20	2.70	
Q/H Ratio	2	30	2.6821	2.2404	1.00	4.43	0.047
	3	8	1.9692	2.0385	1.20	2.70	

On the other hand, Mann-Whitney test showed that the Q/H ration between two groups was significantly different, with p = 0.047. The average value of the Q/H ratio in the group with stage 3 knee OA was 1.969 (Table 5.).

Discussion

Pain is an uncomfortable sensory and emotional experience associated with existing tissue damage or potentially causing tissue damage. Uncomfortable feelings include all emotional processes such as fear, sadness, anxiety, or even suicidal attempts. Pain assessment is influenced by various factors including sensory, motoric, emotional and even cultural factors. In this study, we found that subject's pain was positively correlated and statistically significant with the Q/H ration. This result indicated that the greater the Q/H ratio, the greater the pain level. Increased Q/H ratio in this study correlated with the increase of 1RM quadriceps muscle value and the decrease in value of 1RM hamstring muscle. These findings were consistent the results of previous studies, where the value of Q/H ratio in OA subject was greater than healthy subject, even though it was not significantly different. On the other hand, some studies found the opposite result that the Q/H ration in OA subject was lower than healthy subject [13,14]. Differences in the results of Q/H ratio in some of studies might be due to differences in strength assessment procedures, instruction given to subjects, subject's position during examination (prone, supine, or sitting), subject's stabilization during examination [15].1RM quadriceps and hamstring muscles negatively correlated with pain level, even though it was statistically insignificant with a weak correlation coefficient (<0.5).

This negative correlation might be due to knee joint stability towards mechanical stress ismore determined by the balance between quadriceps and hamstring muscle strength, suggesting that the Q/H ratio in healthy subject is 3:2 [13,14].Another assessment of thigh muscle strength ratio is the ratio of concentric strength of hamstring-quadriceps muscles (Hcon/Qcon). The reported Hcon/Qcon ratio value is 0.43-0.90. Previous study suggested that knee injuries could be predicted by detecting the strength balance of both muscles by assessing the Hcon / Qcon ratio of at least 0.6 [16]. The athlete's and tennis player's normal H/Q ratio is 60% to 80%. This indicates that the increased strength of quadriceps muscle that is not compensated with the increased strength of hamstring muscle of at least 60% makes the knee will be prone to injury. Quadriceps and hamstring muscles play an important role as structural stabilizers of patellofemoral joints. Quadriceps muscle strength that is not compensated with hamstring muscle strength will cause an excessive tibia translation to anterior and an excessive attraction of the ligaments around the knee joint, particularly ACL [17].

We found no difference in quadriceps and hamstring muscle strength between group of subjects with stage 2 and 3 knee OA (p = 0.352). This might be due to the knee joint stability towards mechanical stress is more determined by the balance between two muscle strength. These imbalances lead to changes in knee joint stability, exaggerated anterior tibial translation and changes in path patellar movement (Patellar tracking), that subsequently result in increased mechanical stress. Excessive mechanical loads and mechanical stresses cause various changes in chondrocytes environment that subsequently result in decreased tissue pH and lead to decreased matrix syntheses and immature proteoglycan synthesis.

Such process causes joint cartilage damage [18]. Previous study stated that the value of Q/H ratio did not affect the OA progress [19]. Nevertheless, we found a significant difference in the Q/H ratio between both groups (p = 0.047).

The average value of Q/H ratio in the group with stage 3 knee OA was smaller (1.969) than the group with stage 2 OA (2.68). This might be due to osteoarthritis in the early stages will cause pain, but it can reduce the patient's mobility at a later stage [20]. Decreased mobility can lead to decreased muscle strength, including quadriceps muscle. This simultaneous decline in quadriceps and hamstring muscle strength is believed to be the basis for the decrease in Q/H ratio in the group with stage 3 OA.

Conclusion

We found no correlation between quadriceps and hamstring muscle strength with pain level. There was no difference in quadriceps and hamstring muscle strength between groups with stage 2 and 3 OA. On the othet hand, there was a positive correlation between Q/H ratio and pain level. There was a difference in Q/H ratio between groups with stage 2 and 3 OA, with average Q/H ratioin stage 3 OA was lower than stage 2 OA.

Ethical Clearance: The study protocol was

approved by the Ethical Commission to conduct basic science/clinical research in Dr. Soetomo Teaching Hospital Surabaya, Indonesia. The present study was carried out in accordance with the research principles. This study implemented the basic principle ethics of respect, beneficence, non-maleficence, and justice.

Conflict of Interest: The author reports no conflict of interest of this work.

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References

1. Fernandez H, Cassel CK, Leipzig R. Fundamentals of geriatric medicine: a case-based approach. Springer Science & Business Media; 2007.
2. Shakoor N, Furmanov S, Nelson DE, Li Y, Block JA. Pain and its relationship with muscle strength and proprioception in knee OA: results of an 8-week home exercise pilot study. J Musculoskelet Neuronal Interact. 2008;8(1):35–42.
3. McDougall JJ. Pain and OA. J Musculoskelet Neuronal Interact. 2006;6(4):385.
4. Neogi T. The epidemiology and impact of pain in osteoarthritis. Osteoarthr Cartil. 2013;21(9):1145–53.
5. Lewis CB. Aging: The health-care challenge. FA Davis; 2002.
6. Slemenda C, Heilman DK, Brandt KD, Katz BP, Mazzuca SA, Braunstein EM, et al. Reduced quadriceps strength relative to body weight: a risk factor for knee osteoarthritis in women? Arthritis Rheum Off J Am Coll Rheumatol. 1998;41(11):1951–9.
7. Kean CO, Birmingham TB, Garland SJ, Bryant DM, Giffin JR. Minimal detectable change in quadriceps strength and voluntary muscle activation in patients with knee osteoarthritis. Arch Phys Med Rehabil. 2010;91(9):1447–51.
8. Neumann DA. Kinesiology of the musculoskeletal system-e-book: foundations for rehabilitation. Elsevier Health Sciences; 2013.
9. Schipplein OD, Andriacchi TP. Interaction between active and passive knee stabilizers during level walking. J Orthop Res. 1991;9(1):113–9.
10. Ikeda S, Tsumura H, Torisu T. Age-related quadriceps-dominant muscle atrophy and incident radiographic knee osteoarthritis. J Orthop Sci. 2005;10(2):121–6.
11. Amaro A, Amado F, Duarte JA, Appell H-J. Gluteus medius muscle atrophy is related to contralateral and ipsilateral hip joint osteoarthritis. Int J Sports Med. 2007;28(12):1035–9.
12. Grimaldi A, Richardson C, Durbridge G, Donnelly W, Darnell R, Hides J. The association between degenerative hip joint pathology and size of the gluteus maximus and tensor fascia lata muscles. Man Ther. 2009;14(6):611–7.
13. Adegoke B, Mordi E, Akinpelu O, Jaiyesimi A. Isotonic quadriceps-hamstring strength ratios of patients with knee osteoarthritis and apparently healthy controls. African J Biomed Res. 2007;10(3).
14. Hayes KW, Falconer J. Differential muscle strength decline in osteoarthritis of the knee. A developing hypothesis. Arthritis Rheum Off J Am Coll Rheumatol. 1992;5(1):24–8.
15. Kannus P. Ratio of hamstring to quadriceps femoris muscles' strength in the anterior cruciate ligament insufficient knee: relationship to long-term recovery. Phys Ther. 1988;68(6):961–5.
16. Greco CC, Da Silva WL, Camarda SRA, Denadai BS. Rapid hamstrings/quadriceps strength capacity in professional soccer players with different conventional isokinetic muscle strength ratios. J Sports Sci Med. 2012;11(3):418.
17. Lyons ME. Isokinetic hamstring: quadriceps strength ratio in males and females: implications for ACL injury. 2006;
18. Lee RB, Wilkins RJ, Razaq S, Urban JPG. The effect of mechanical stress on cartilage energy metabolism. Biorheology. 2002;39(1, 2):133–43.
19. Brandt KD, Heilman DK, Slemenda C, Katz BP, Mazzuca SA, Braunstein EM, et al. Quadriceps strength in women with radiographically progressive osteoarthritis of the knee and those with stable radiographic changes. J Rheumatol. 1999;26(11):2431–7.
20. Kaur N, Verma SK. Quadriceps strength of patients of osteoarthritis knee: Relationships to pain and disability. J Exerc Sci Physiother. 2005;1:38.