Factor Associated with Quadriceps Muscle Strength in Elderly People with Knee Osteoarthritis Pain in Northern of Thailand: A Pilot Study

Sinthuporn Maharan[1,2*], Suphannika Ladawan[1,2], Pacharee Manoy[2], Sirinthip Kumfu[2], Patcharin Prompao[3], Sudarat Sungkamanee[1,2]

[1]Department of Physical Therapy, School of Allied Health Sciences, University of Phayao, Phayao, Thailand 56000

[2]Unit of Excellence of Human Potential Development and Herbs, University of Phayao, Phayao province, Thailand 56000

[*]Corresponding author : sinthuporn.ma@up.ac.th

Abstract

Aims: The primary aim of this study was set up to determine the factors that influenced quadriceps muscle strength in elderly people with symptomatic knee osteoarthritis (OA). The secondary aim was to set up to predictive equation of quadriceps muscle strength in OA knee.

Materials and Methods The subjects (n = 45) were out-patients of Phayao hospital who lived in Mae ka sub-district, Phayao province in January-September 2020 and diagnosed with OA of knee. They were interviewed the demographic data (sex, age, weight, high, BMI) and other data (level of pain, WOMAC), and evaluated the quadriceps muscle strength via Handheld dynamometer (N). The function of knee joint in daily living was measured by WOMAC questionnaires. Pearson correlation and multiple regression stepwise analysis was applied and the significant was reported when p value less than 0.05.

Results: Main finding reveals that the factors related quadriceps muscle strength in symptomatic elderly people with OA knee are the level of pain (VAS score), BMI and WOMAC function. The equation have a high correlation (r=0.796) and 60.6% estimate power. The equation; quadriceps muscle strength (N) = 161.258 – 19.671 (Level of pain) + 3.869 (BMI) - 0.516 (WOMAC function).

Conclusion: The level of pain, WOMAC function and BMI are the factors that indicated quadriceps muscle strength which can be predicted the strength of quadriceps muscle in elderly people who had symptomatic OA knee in Phayao province, the Northern of Thailand.

Keyword; Elderly, Knee osteoarthritis, Pain, Quadriceps

Introduction:

Knee osteoarthritis (OA) with symptomatic of pain is a common condition worldwide which represents a major contribution to the burden of physical disability[1, 2]. In Thailand, the prevalence of OA knee is quite high especially in rural area. The reported of health status of the Thai elderly association was found that the prevalence of knee pain around 43.9% and OA is the cause of present pain[3] and limit function. Moreover, the dramatic pathology of OA knee is also worse correlated with age-increases. Therefore, the rate of symptomatic of pain in OA knee commonly found in people who aged

รับต้นฉบับ 1 กุมภาพันธ์ 2567, ปรับปรุงต้นฉบับ 21 กุมภาพันธ์ 2567, ตอบรับต้นฉบับตีพิมพ์ 22 กุมภาพันธ์ 2567

over 60 years[4-6]. Previous report found that the function of quadriceps muscle was slowed down after OA knee that related to the risk of fall and their daily living. Unfortunately, a pile of evidence unfocused directly to the factors that influenced quadriceps muscle strength that relate with the function of the knee in quality of life in the pain condition.

Therefore, this study was set up to determine the factors that influenced to quadriceps muscle strength in patients with symptomatic pain of knee OA as a primary aspect parallel with set up to investigate the predict equation of quadriceps muscle strength in patient with OA knee who aged more than 60 and lived in Phayao province.

Materials and Methods:

Participants

This cross-sectional study was conducted the participants from Primary Care Units of Mae-ka sub-districted, Maung district, Phayao province, Thailand from January-September 2020. They were announced and recruitment via care giver, 45 people of the pilot were included in this study (total number of 127 was calculated from the study of Tapanya et al. via G power 3.1.5 program)[7]. The inclusion criteria are the patient who had been diagnosed with OA by the physician and lived in Phayao, aged more than 60 years, unilateral or bi-lateral knee pain (dominant pain was selected) and willing to enrollment. Excluded criteria are the participants with serious health problems such as knee fracture, cancer, a history of knee joint surgeries such as prosthetic knee replacement, tendon tear and orthopedic fixation, severe respiratory and circulatory problems and who had neurological problems that were not understood or unable to communicate.[8]

Research protocol

All participants were questioned their demographic about the personal data (such as age, sex, weight, height, BMI) were collected. Moreover, level of pain, the modified WOMAC questionnaire also interviews the quality of life within 3 dimensions (pain, stiffness, function). Then, the strength of quadriceps muscle in dominant side was measured. Before starting the study, the research protocol (No. 1.3/010/63) was submitted to and approved by the University of Phayao Ethics Committee in Human Research based on the Declaration of Helsinki's ethical principles.

1. Quadriceps muscle strength by using Hand-Held Dynamometer (HHD)

The well-train physical therapy was evaluated peak force of quadriceps isometric contraction via Handheld Dynamometer (Lafayette Handheld Dynamometer, Model 01165; England) in 90 degree of knee flexion (intraclass correlation r>.90). Briefly, the participant sitting the chair without footrest, arm crossed with both hand position, gained maximum effort of isometric extend knee hold 5 seconds, the reference of HHD was pasted between the medial and lateral malleolus 9-10. The best value was calculated in N of IS unit.

2. Quality of life by using modified WOMAC questionnaire

The QoL of participants who had a symptomatic OA knee were interviewed by modified WOMAC questionnaires which divided into 3 dimensions (pain, stiffness, function). Each dimension was recorded as a score which ranged from 0 (no

symptomatic) -10 (severe). The first dimension is the level of knee pain during activities in 5 activities in daily living such as standing, walking, up-down stairs, etc. The second dimension was set up to evaluate the stiffness of the knee during morning and throughout day and the last dimension is related to the function of the knee joint within 15 choices[11] .

Statistical analysis

All data were corrected as mean (SE) in SPSS version 23 (@License of University of Phayao). The Shapiro–Wilk test was used to test the distribution of all variables. Pearson product moment correlation coefficient statistics were used to determine the relationship between knee extensor strength and subject's demographic data. Multiple regression stepwise analysis was applied to detect the factors that influenced quadriceps muscle strength. Moreover, in this study also predicted the strength of quadriceps muscle as the equation regression model. The p-value less than .05 was reported as significant.

Results:

Participant's enrollment

7 Primary Care Units of Mae-Ka sub-districted of Phayao were invited to encounter the Head executive project for review the objective of this research and announcement the participants who interested to enroll as following the inclusion criteria during January-September 2020. Only 45 participants reached the criteria. Table 1 shows the characteristics of all participants.

Table 1 Demographics of all participants (n=45)

Variables	Frequency	Percent
Sex		
Female/Male (N)	36/9	80/20
Variables	Mean±SD	
Age (years)	69.02±8.31	
Weight (kg)	53.93±9.92	
Height (m)	1.52±0.69	
BMI (kg/m2)	23.18±3.83	

In this time, the eligible of participants consisted of 36 females and 9 males as shown in Table 1. The demographics of symptomatic OA knee people show the mean age 69.02±8.31 years, weight 53.93±9.92 kg, height 1.52±0.69 m. and BMI 23.18±3.83 kg/m^2.

Table 2 Correlation between demographic information of the participants (n=45), level of pain, WOMAC score with quadriceps strength variable

	Quadriceps strength variable	p-value
Demographic variables		
Gender	-0.082	0.297
Age	-0.407	0.003**
Weight	0.546	0.000***
Height	0.377	0.005**
BMI	0.472	0.001**
Other variables		
VAS	-0.854	0.000***
WOMAC pain	-0.172	0.129
WOMAC stiffness	-0.153	0.157
WOMAC function	-0.273	0.035*

Note; * Significant correlation at $p < 0.05$; ** Significant correlation at $p < 0.005$; *** Significant correlation at $p < 0.001$

Table 2 shows the correlation of quadriceps muscle strength in elderly people who had an OA knee with demographic data (gender, age, weight, height, BMI) and other variables data (VAS, WOMAC).

Detail, the demographic data (gender, age, weight, height, BMI), all variables reveal the low to moderate correlation (r = -0.08-0.55) while the others variable shows the low to high correlation (r = -0.15-(-0.85)). The significant level of positive correlation was found in weight, height, and BMI ($p<0.05$ all) while age variables show the significant negative correlation ($p=0.003$) with the peak force contraction of quadriceps muscle. Moreover, all the other variables show the negative correlation with the dependent variable but only VAS and WOMAC function rising to the significant level ($p<0.05$ both).

The Pearson correlation measures the strength of the linear relationship between quadriceps strength and once variable that interested (both demographic and other variables) in elderly people who had an OA knee in this study. Summarized that, all of the viables that reach the significant level ($p<0.05$) (age, weight, height, BMI, level of pain, and WOMAC function) will be included to the statistics with factors associated quadriceps muscle strength phase.

Factor related to quadriceps muscle strength.

Table 3 shows BMI, level of pain (VAS) and WOMAC function are the key factors that influence the peak force performance of quadriceps muscle. The factors could be created into the 3 different models as follows in the table then the most proper model was selected to set the equation.

In detail, the most powerful predicted equation for quadriceps muscle strength for this study is model 3 which included level of pain, BMI and WOMAC function variables into the regression analysis resulted in $r=0.796$ and $p<0.05$ all. ($R^2=60.6\%$; SEE=35.013). Model 2 demonstrated

that the predicted variable come from level of pain and BMI variables which r=0.765 and p<0.05 all (R^2=56.5%; SEE=36.808) while only detected in level of pain for created model 3 that presented r=0.729 and p<0.001 (R^2=52.0%; SEE=38.648). However, only the age variable was excluded in all models of predicted equation for quadriceps muscle strength caused the significant level more than 0.05.

Table 3 Model of regression analysis of quadriceps muscle strength and variables (n=45)

Model	Included variables	β	*p*-value	*r*	Adjusted r^2	SEE
1	Constant	247.021	0.000***	0.729	0.520	38.648
	VAS	-22.930	0.000***			
2	Constant	151.825	0.002**	0.765	0.565	36.808
	VAS	-20.630	0.000***			
	BMI	3.536	0.025*			
3	Constant	161.258	0.001**	0.796	0.606	35.013
	VAS	-19.671	0.000***			
	BMI	3.869	0.011*			
	W function	-0.516	0.025*			

Note; * Significant correlation at $p < 0.05$; ** Significant correlation at $p < 0.005$; *** Significant correlation at $p < 0.001$; SEE=Standard Error of the Estimate; VAS= Visual Analog Score; BMI=Body Mass Index; W function=WOMAC function

Equation

Quadriceps muscle strength (N) = 161.258 – 19.671 (Level of pain) + 3.869 (BMI) - 0.516 (WOMAC function)

Discussion:

This study investigated the pilot correlation of quadriceps muscle strength with demographics and other variable factors in elderly symptomatic knee OA people who lived in Phayao, Thailand. The main finding concluded that level of pain, WOMAC function score and demographic variables (BMI) could be used to predict the relationship with quadriceps muscle strength (r=0.796).

Past reports found that the strength of muscle in people with osteoarthritis. It consists of three main factors: 1.) Basic properties of muscles (cross section, muscle composition, muscle activation) 2.) General properties (physical activity and exercise, endocrine and metabolic factors, nutrition and vitamins, demographic) 3.) OA specific factors (joint degeneration, biomechanical factors, knee pain and inflammation).[12-14] Therefore, there are many factors that affect the force of muscle contraction. This study wants to focus on pain, BMI and knee function while the other factors will be consumed for the next time.

Recently, it was found that pain in people with OA results in decreased muscle function (negative correlation) and the overall function of the knee joint related with this study. Pain in OA, may be rising from the complex peripheral and central mechanisms, comes from the synovium, subchondral bone, and periosteum, which are innervated by small-diameter nociceptive neurons. It had been associated with many structural factors, including bone marrow lesions, synovial thickening (synovitis), and knee effusion. The inflammatory mediators produced by the synovium and chondrocytes increase the excitation of the

nociceptive neurons, creating an amplified painful response. Moreover, the alterations of physiological cross-talk between subchondral bone and cartilage are considered the primary trigger of the OA pathological process.[15-17] Therefore, higher body weight and body composition that directly put the interfaces force of the joint are associated directly with muscle strength in the lower extremities. Previous report found that the peak force contraction of knee extensor has been correlated with worsening of knee pain in individuals with or at risk of developing knee OA[18]. During gait and knee function, the strength of muscle around the knee has also been associated with cartilage loss in individuals with knee pain[15]. In detail, the adequate knee extensor and flexor muscle strength is the key for the knee joint working since it serves as a stabilizing and shock-absorbing function that may protect the cartilage from microtrauma and high peak loads during activity. Moreover, pain maybe come from several factors such as duration of OA pain, grade of OA knee pathology, inflammatory markers (IL, BDNF level) etc. In this study, the level of pain was only one of all three factors that was fit within 3 models, and it had the highest significant level. Therefore, level of pain in very powerful parameter which selected to evaluate to the association factor of knee extensor, the future study could be conducting the overall factors of pain to include in the multiple regression analysis.

Specifically, after pain occurring in people with OA knee resulting in the decrease of function and physical activity in daily living. Previous finding of found that the WOMAC function of K/L grade < 2 was correlated with knee extension 180 peak torque (r=-0.453;p<0.001) while the WOMAC function of K/L grade<2 was correlated with knee extension 60 peak torque (r=-0.366;p<0.001)[19] related with our study it show the strong negative correlation of knee extensor strength and knee function (r=-769; p=0.025). However, the difference in measurement of knee extensor (isokinetic dynamometer vs HHD) and number of subjects will be focused more for the further study.

Muscle strength in the lower extremities is associated with body weight and body composition. The studied of Ericsson et al. found the women with knee pain tended to have lower muscle strength, at both knee extensors and flexors, but a slightly higher hamstrings-to-quadriceps strength ratio (mean (SD) 0.53 (0.11) and 0.51(0.08), p=0.04). Moreover, overweight women generally have higher muscle strength in the lower extremity than their normal weight counterparts.[20] Lean mass is highly correlated with muscle strength, and with age, decreases more slowly than strength.[21] Related to our study, it shows the strong positive correlation between knee extensor and BMI (r=769; p=0.011).

The limitations of this study are the number of volunteers quite small, and the previous period of collect data was over in during the COVID-19 situation, it quite be difficult and vulnerable for finding area, however, the next study should be a comparative study with asymptomatic people, and separating the data into the equal periods of year, number of gender to reduce data bias with the larger number of volunteers, and other factors that may affect the force of muscle contraction. Moreover, the next time will be completed with the error prediction

equations.

Conclusion:

Elderly people with OA of the knee living in Phayao province, the north of Thailand. There was a strong positive correlation of BMI and a strong negative correlation of pain level, the function of knee joint when correlated with the ability to contract muscles of knee extensor. The equation; Quadriceps muscle strength (N) = 161.258 – 19.671 (level of pain) + 3.869 (BMI) - 0.516 (WOMAC function). Therefore, future studies should be conducted and focused on the others factor that cause pain and the severity of joint deterioration.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgement

This study was supported by Research Funding of Thailand science research and innovation fund and the University of Phayao, Unit of Excellent of Human Potential Development and Herbs (Grant No. FF66-UoE025), University of Phayao. Thank you for all researchers, participants, officer and care giver who help to follow up the patients in this study.

References

1. Badley EM, Thompson RP, Wood PHN. The prevalence and severity of major disabling conditions. Int J Epidemiol 1978; 7: 145–51.

2. Guccione AA, Felson DT, Anderson JJ. Defining arthritis and measuring functional status in elders: methodological issues in the study of disease and physical disability. Am J Public Health 1990; 80: 945–9.

3. Roopsawang I, Aree-Ue S. Knee osteoarthritis in adult and older Thais living in rural and urban areas: A comparative study. Pacific Rim Int J Nurs Res 2015; 19: 187-201.

4. Felson DT, Naimark A, Anderson J, Kazis L, Castelli W, Meenan RF. The prevalence of knee osteoarthritis in the elderly: The Framingham Osteoarthritis Study. Arthritis Rheum 1987; 30: 914–8.

5. Lethbridge-Cejku M, Tobin JD, Scott WW Jr, Reichle R, Plato CC, Hochberg MC. The relationship of age and gender to prevalence and pattern of radiographic changes of osteoarthritis of the knee: data from Caucasian participants in the Baltimore Longitudinal Study of Aging. Aging 1994; 6: 353–7.

6. Cunningham LS, Kelsey JL. Epidemiology of musculoskeletal impairments and associated disability. Am J Public Health 1984; 74: 574–9.

7. Tapanya A, Sangkarit N, Amput P, Konsanit S. Lower extremity strength equation of pler adults assessed by Five Time Sit to Stand Test (FTSST). Hong Kong Physiotherapy Journal 2023; 43: 1-10.

8. Anwer S, Alghadir A. Effect of isometric quadriceps exercise on muscle strength, pain, and function in patients with knee osteoarthritis: A randomized controlled study. J Phys Ther Sci 2014; 26: 745-8.

9. Hirano M, Katoh M, Gomi M, Arai S. Validity and reliability of isometric knee extension muscle strength measurements using a belt-stabilized hand-held dynamometer: a comparison with the measurement using an isokinetic dynamometer in a sitting posture. J Phys Ther Sci 2020; 32: 120–4.

10. Arnold CM, Warkentin KD, Chilibeck PD, Magnus CRA. The reliability and validity of handheld dynamometry for the measurement of lower-extremity muscle strength in older adults. J

Strength Cond Res 2010; 24: 815-24.

11. Khuman RP, Chavda D, Surbala L, Bhatt U. Reliability and validity of modified western ontario and mcmaster universities osteoarthritis index gujarati version in participants with knee osteoarthritis. The Journal of Indian Association of Physical Therapists 2018; 12: 8-15.

12. Grazio S, Balen D. Obesity: risk factor and predictors of osteoarthritis. Lijec Vjesn 2009; 131: 22–6.

13. Heidari B. Knee osteoarthritis prevalence, risk factors, pathogenesis and features: Part I. Caspian J Intern Med 2011; 2: 205–12.

14. Creamer P, Lethbridge-Cejku, Hochberg MC. Factors associated with functional impairment in symptomatic knee osteoarthritis. Rheumotology 2000; 39: 490-6.

15. Adatia A, Rainsford KD, Kean WF. Osteoarthritis of the knee and hip. Part I: Aetiology and pathogenesis as a basis for pharmacotherapy. J Pharm Pharmacol 2012; 64: 617–25.

16. Neogi T. Clinical significance of bone changes in Osteoarthritis. Ther Adv Musculoskelet 2012; 4: 259–67.

17. Goldring M, Goldring SR. Articular cartilage and subchondral bone in the pathogenesis of Osteoarthritis: Articular cartilage and subchondral bone. Ann N Y Acad Sci 2010; 1192: 230–37.

18. Glass NA, Torner JC, Frey Law LA, Wang K, Yang T, Nevitt MC, et al. The relationship between quadriceps muscle weakness and worsening of knee pain in the MOST cohort: a 5-year longitudinal study. Osteoarthr Cartilage 2013; 21: 1154–9.

19. Kim MJ, Kang BH, Park SH, Kim B, Lee G-Y, Seo YM, et al., Association of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) with muscle strength in community-dwelling elderly with knee osteoarthritis. Int J Environ Res Public Health 2020; 17: 2260-70.

20. Ericsson YB, McGuigan FE, Akesson KE. Knee pain in young adult women- associations with muscle strength, body composition and physical activity. BMC Musculoskelet Disord 2021; 22: 715-25.

21. Madsen OR, Lauridsen UB, Hartkopp A, Sørensen OH. Muscle strength and soft tissue composition as measured by dual energy x-ray absorptiometry in women aged 18–87 years. Eur J Appl Physiol Occupational Physiol 1997; 75: 239–45.