Clinical Research

Anthropometric measurements associated with intertrochanteric fractures in the elderly: a case-control study

Andy Ardiansyah, Sugeng Yuwana

pISSN: 0853-1773 • eISSN: 2252-8083
https://doi.org/10.13181/mji.v28i4.2680
Med J Indones. 2019;28:365–9

Received: August 8, 2018
Accepted: August 6, 2019

Authors' affiliations:
Department of Orthopaedics and Traumatology, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada, Dr. Sardjito Hospital, Yogyakarta, Indonesia

Corresponding author:
Sugeng Yuwana
Department of Orthopaedics and Traumatology, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada, Dr. Sardjito Hospital, Jl. Farmako Sekip Utara, Yogyakarta 55281, Indonesia
Tel/Fax: +62-274-558183/ +62-274-515054
E-mail: sugengyuwana@yahoo.com

ABSTRACT

BACKGROUND Femoral intertrochanteric fracture is an important cause of disability in the elderly. Low muscle mass, especially those of the lower limbs, has been associated with osteoporosis and higher fall incidents. This study was aimed to assess the association between the anthropometric indices and intertrochanteric fractures.

METHODS This case-control study was performed from September 2013 to July 2015. The criteria of case group were elderly patients with intertrochanteric fractures admitted in Dr. Sardjito Hospital within 72 hours after a low energy injury without multiple fractures or pathological fracture. For control group, the subjects were matched according to age and gender without any fracture. Thigh and calf circumferences were done on healthy limbs. Body mass index (BMI) was calculated. History of steroid use was obtained. Adjusted odds ratio (aOR) was calculated using logistic regression after analyzed with student's *t*-test or chi-square test.

RESULTS There were 82 subjects on each group. Smaller thigh and calf circumferences and also lower BMI were risk factors of intertrochanteric fractures. Thigh circumference <39 cm (aOR 5.12; 95% CI 2.30–11.43; $p < 0.001$) and calf circumference <29 cm (aOR 9.42; 95% CI 4.14–21.40; $p < 0.001$) were independently associated with intertrochanteric fracture after adjustment of BMI and steroid use.

CONCLUSIONS Calf and thigh circumferences were independently associated with femoral intertrochanteric fractures in Indonesian elderly.

KEYWORDS calf circumference, femoral fractures, intertrochanteric fractures, thigh circumference

Proximal femoral fractures are an important health problem for the elderly around the world. As longer life expectancy is associated with more elderlies in the population, the highest prevalence of proximal femoral fractures is in the European countries where life expectancy is longer. However, in Asia and in many other developing countries where life expectancy is rapidly increasing, the prevalence of proximal femoral fractures has also increased. It has been estimated that, by 2050, more than half of proximal femoral fracture cases will occur from Asia.[1]

About 45% of all proximal femoral fractures are fractures in the intertrochanter region, which is the area between the major and minor trochanter. Intertrochanteric fractures cause severe physical impairments, a major decrease in the quality of life, and prolonged hospital stays or even deaths. Although age-related osteoporosis is an important risk factor for fractures, osteoporosis is not the only risk factor.[2] As most of the fractures were associated with low-energy fall, the risk for fall was also most likely associated with the risk for fractures.[3]

Obesity, due to the abundance of estrogen producing fat tissue, was always regarded as protective for osteoporosis in women.[4] However, obese individuals tended to have poorer balance, i.e., higher risk for fall, especially those who had less muscle mass. As almost half of the human's body muscle mass was in the lower limbs, circumferences of the lower limbs, including the thighs and calves, were a good proxy of muscle mass.[5]

The impact of the circumferences of the thigh or calf as a risk for fractures has not been established. Higher thigh circumference was, perhaps, associated with higher soft tissue mass around the femur that may reduce the impact of fall.[6] Higher calf circumference, however, was more likely associated with higher overall muscle mass.[7] The understanding of risk factors for fractures were necessary to form a recommendation for prevention. This study was aimed to assess the association of the body's anthropometric indices (height and weight), body mass index (BMI), and thigh and calf circumferences with the intertrochanteric fracture risk.

METHODS

This case-control study used data of elderly patients admitted in the Orthopedic Wards of Dr. Sardjito Hospital because of femoral intertrochanteric fracture and healthy elderly patients in the general population. For the cases group, the inclusion criteria were patients of Javanese descents aged >60 years; had femoral intertrochanteric fracture due to a simple fall or any low-energy injury within 72 hours of admission. Subjects were excluded when they had multiple fractures or pathologic fracture due to metastatic cancer. The control group were Javanese elderly subjects who had never had any type of femoral fractures selected from the neighborhood of the patients' residence and matched with age and gender. This study recruited only Javanese subjects to reduce variability. The study was performed from September 2013 to July 2015.

The sample size was estimated using OpenEpi (www.openepi.com) with an estimated proportion of exposure of cases of 33%, an estimated odds ratio (OR) of 2.0, a significance level of 95%, and a power of 80%, the recommended minimum subject size was 77 in each group.[6] Anthropometric measurements of thigh and calf circumferences were performed on the healthy limb using a nonstretchable tape, rounded to the nearest 0.1 cm. Thigh and calf circumferences were then categorized using cut-off of each median of all subjects (case and control groups). Body height was measured in a supine position to the nearest 0.1 cm, whereas weight was measured with a body weight scale to the nearest 0.1 kg. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. BMI was classified using quartiles.

The questionnaires were used to obtain data on age, sex, and steroid use history. Steroid use was regarded as positive when subjects used any corticosteroid routinely in the last 6 months. The corticosteroid use included those prescribed by a medical doctor for any indication, such as allergy or asthma, or those obtained over the counter.

This study had obtained ethical approval from the Medical and Health Research Ethics Committee, Faculty of Medicine, Universitas Gadjah Mada, Dr. Sardjito Hospital (No: KE/FK/499/EC/2015). Odds ratio (OR) (95% confidence interval [CI]) was calculated for BMI, thigh circumference, calf circumference, and steroid use. Statistical significance was set at $p < 0.05$. Student's *t*-test, chi-square tests, and logistic regression models were used. Statistical analyses were performed using SPSS version 17 (SPSS Inc, USA).

RESULTS

There were 90 patients diagnosed with femoral intertrochanteric fractures between September 2013 and July 2015 in Dr. Sardjito Hospital. Eight patients were excluded in this study; five patients were not admitted within 72 hours and three patients had oncological pathological fractures as suggested by their X-rays. Of 82 patients, 61 (74%) were women. The gender has the same frequency since case and control were matched for gender and age. The mean (standard deviation [SD]) of ages were 75.3 (5.8) years in the case group and 74.9 (4.8) years in the control group. Anthropometric measurements of the cases and controls are presented in Table 1. The cases had significantly less weight, BMI, and thigh and calf circumferences.

Higher BMI and larger thigh or calf circumference had protective effects on the risk of fractures (Table 2). It also showed that the protective effect of BMI was dose-related. The higher the BMI quartile, the lower the risk is.

Table 1. Anthropometric indices between the cases and the controls

Anthropometric indices	Cases, mean (SD) (N = 82)	Controls, mean (SD) (N = 82)	Mean difference (95% CI)	*p*
Height (cm)	154.2 (6.7)	154.1 (6.9)	0.00 (−0.02–0.02)	0.95
Weight (kg)	49.2 (10.2)	53.7 (8.7)	4.52 (1.59–7.46)	**0.003**
BMI (kg/m²)	20.6 (3.4)	22.6 (3.2)	1.98 (0.96–3.01)	**<0.001**
Thigh circumference (cm)	37.7 (3.4)	41.8 (4.1)	4.12 (2.97–5.27)	**<0.001**
Calf circumference (cm)	27.2 (3.1)	32.1 (3.7)	4.85 (3.80–5.91)	**<0.001**

SD=standard deviation; CI=confidence interval; BMI=body mass index
Case: patients with femoral intertrochanteric fracture

Table 2. Univariate and multivariate logistic regression models for predictors of femoral intertrochanteric fractures

Variables	Fracture, n (%) (N = 82)	Control, n (%) (N = 82)	Univariate model		Multivariate model*			
					Thigh circumference		Calf circumference	
			OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
BMI quartile								
Quartile 1	27 (32.9)	14 (17.1)	1.00					
Quartile 2	32 (39.0)	12 (14.6)	1.38 (0.58–3.49)	0.49				
Quartile 3	12 (14.6)	26 (31.7)	0.24 (0.09–0.61)	**0.003**				
Quartile 4	11 (13.4)	30 (36.6)	0.19 (0.07–0.49)	**0.001**	0.93 (0.81–1.05)*	0.24	0.91 (0.93–2.13)*	0.33
Thigh circumference (cm)								
≤39†	58 (70.7)	23 (28.0)	6.20 (3.15–12.20)	**<0.001**	5.12 (2.30–11.43)	**<0.001**	-	
>39	24 (29.3)	59 (72.0)	1.00		1.00		-	
Calf circumference (cm)								
≤29‡	64 (78.0)	21 (25.6)	10.33 (5.02–21.23)	**<0.001**			9.42 (4.14–21.40)	**<0.001**
>29	18 (22.0)	61 (74.4)	1.00				1.00	
Steroid use	16 (19.5)	3 (3.7)	6.38 (1.8–22.8)	**0.004**	8.51 (2.05–35.40)	**0.003**	9.20 (2.09–40.56)	**0.003**

OR=odds ratio; CI=confidence interval; BMI=body mass index
Quartile 1 = <19.15, quartile 2 = 19.15 to <20.81, quartile 3 = 20.82 to <20.81, quartile 4 = >23.55
*Both multivariate models were adjusted for gender and age; †In the logistic regression, BMI is analyzed as a continuous variable; ‡The median thigh circumference was 39 cm and calf circumference was 29 cm

Table 2 shows the protective effect of larger thigh and calf circumferences persisted after controlling for BMI, steroid use, age, and gender. The mean (SD) thigh and calf circumferences were 39.9 (4.2) and 29.8 (4.1) cm in non-steroid users and 38.4 (4.6) and 28.2 (4.6) cm in steroid users, respectively. Their mean differences were 1.5 (−0.5–3.6) cm (p = 0.15) and 1.6 (−0.4–3.6) cm (p = 0.11), respectively.

Multiple logistic regression models were also analyzed using continuous data of thigh and calf circumferences as the independent variables (Table 3). The models showed that, after adjustment for BMI, age, and sex, every centimeter increase in thigh circumference was associated with a 28% decrease in odds. Similarly, every centimeter increase in calf circumference was associated with a 38% decrease in odds.

DISCUSSION

This study observed that higher BMI and larger calf or thigh circumferences were associated with less risk for femoral intertrochanteric fractures. The

Table 3. Univariate and multivariate logistic regression models for predicting femoral intertrochanteric fractures using continuous data of thigh and calf circumferences

Variables	Univariate model		Multivariate model			
			Thigh circumference		Calf circumference	
	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
BMI (kg/m^2)	0.83 (0.74–0.92)	**0.001**	1.05 (0.90–1.21)	0.56	1.08 (0.93–1.26)	0.32
Thigh circumference (cm)	0.74 (0.67–0.83)	**<0.001**	0.72 (0.63–0.83)	**<0.001**	-	-
Calf circumference (cm)	0.66 (0.57–0.75)	**<0.001**	-	-	0.62 (0.52–0.73)	**<0.001**
Steroid use (1 = yes; 0 = no)	6.38 (1.78–22.86)	**0.004**	7.13 (1.62–31.3)	**0.009**	9.18 (1.72–49.1)	**0.01**

OR=odds ratio; CI=confidence interval; BMI=body mass index
Both multivariate models were adjusted for gender and age

protective effect of BMI was dose-related: the higher the BMI, the lower the risk. The protective effect of larger thigh and calf circumferences persisted after controlling for BMI, steroid use, age, and sex, which means larger thigh or calf circumferences were independently associated with less risk for fractures. Previous studies had also reported that larger body size, as indicated by higher BMI or body weight, had less risk for hip fracture. BMI was usually used as a proxy for body fat, which was often regarded as the source of estrogen, a protector of osteoporosis.[8] However, higher BMI might also be the proxy of larger muscle mass, an indication of active lifestyles. Larger muscle mass, especially muscle mass of the lower limbs, was significantly associated with higher femoral neck bone mineral density.[9]

The impact of abdominal obesity, as shown by higher waist circumference, with the risk for fractures had recently become an important issue in the elderly. As higher BMI, which was usually associated with higher waist circumference, was known to have a protective effect for hip fractures, a recent meta-analysis showed that higher waist circumference was associated with a higher risk for hip fractures, independent of BMI.[8,10,11] As abdominal obesity, compared with BMI, was known to be a better proxy of body fat,[12] this observation seemed to reject the associations between higher fat mass, higher estrogen level, and lower fracture risks. The other hypothesis was, more likely, the lean component of the body mass was the more important protector of hip fractures.

Parker et al[6] observed that thigh circumference was an important protector for hip fracture because of its role in absorbing the direct impact. Their prospective study on a cohort of postmenopausal women found an inverse association between hip circumference and hip fracture incidents. This association persisted after controlling for waist circumferences. As thigh consisted primarily of bone and muscle mass, this observation also emphasized the importance of adequate lean body mass on the risk of hip fractures.

Calf circumference was considered as a good muscle-measuring approach because the lower limbs contained almost half of the body's muscle mass and had been recognized as related to physical activity and active lifestyle.[5] Calf circumference was also a good predictor for sarcopenia, i.e., insufficient lean body mass.[13] Beside associated with lower femoral neck bone density, Diaz-Villegas et al[3] also reported a higher risk of falls in the elderly who had lower calf circumferences. Our study, consistent with other previous studies, emphasized the importance of adequate lean body mass to prevent fractures in elderly.[9]

The median thigh and calf circumferences observed in this study were 39 and 29 cm, respectively, and they were used as the cut-off values of this study. Diaz-Villegas et al[3] used 31 cm as the cut-off value for calf circumference, as its mean (SD) in their population was 31.3 (5.3) cm. It seemed that the cut-off might differ between population. Our study also observed that, for every centimeter increase in thigh or calf circumferences, the odds for fractures were lowered, i.e., OR 0.72 (95% CI 0.63–0.83) for thigh circumference and OR 0.62 (95% CI 0.52–0.73) for calf circumference. To the best of our knowledge, we have not been able to find any other studies reporting the inverse dose relationships between thigh and calf circumferences with the risk of fractures. To be able to assess the dose relationship

of the circumferences with the risk of fractures, a study involving more subjects with larger ranges of thigh or calf circumferences is needed.

Age, sex, and corticosteroid use history were regarded as important confounders. Age and sex were strongly associated with risk for osteoporosis. Steroid use history was known to be associated with both osteoporosis risk and smaller limb circumferences, as it was well known that routine steroid use was associated with truncal obesity and smaller limbs' circumferences.[14] Although not statistically significant, this study also observed smaller thigh and calf circumferences in steroid users.

Sedentary lifestyle did not increase the prevalence of obesity in the elderly, as problems of sarcopenia, i.e., inadequate lean body mass, were also increasing. Sarcopenia had been recognized to be associated with a less active life and a risk factor for many diseases in the elderly.[15] Sarcopenic subjects were more likely to have osteoporotic bones that were regarded as the most important risk for fractures.[7,16] The result of this study, in line with other previous studies, emphasizes the importance of sustaining lean body mass in the elderly through maintaining an active lifestyle. Unfortunately, we had no information on the subjects' lifestyle. This is considered as one of the limitations of the study.

The other limitation of the study was that the waist circumferences were not measured because a previous study had observed a higher risk for fracture in those who had larger waist circumferences.[15] In conclusion, this study observed that after adjustment for BMI and steroid use, calf and thigh circumferences were independently associated with the risk for intertrochanteric fractures in Indonesian elderly. As thigh and calf circumferences are most likely representing the adequacy of the lean body mass, i.e., musculature and bony components of the body, this study emphasized the importance of maintaining the adequacy of lean body mass in elderly.

Conflict of Interest

The authors affirm no conflict of interest in this study.

Acknowledgment

The authors would like to acknowledge dr. Yudha Nur Patria, who has helped with the statistical analyses, and also to fellow residents, nurses and administrative staffs who have helped during the data collection.

Funding Sources

None.

REFERENCES

1. Dhanwal DK, Dennison EM, Harvey NC, Cooper C. Epidemiology of hip fracture: worldwide geographic variation. Indian J Orthop. 2011;45(1):15–22.
2. Nasiri M, Luo Y. Study of sex differences in the association between hip fracture risk and body parameters by DXA-based biomechanical modeling. Bone. 2016;90:90–8.
3. Díaz-Villegas G, Parodi JF, Merino-Taboada A, Perez-Agüero C, Castro-Viacava G, Runzer-Colmenares FM. Calf circumference and risk of falls among Peruvian older adults. Eur Geriatr Med. 2016;7(6):543–6.
4. Määttä M, Terho E, Jokinen H, Pulkkinen P, Korpelainen J, Heikkinen J. Lifestyle factors and site-specific risk of hip fracture in community dwelling older women – a 13-year prospective population-based cohort study. BMC Musculoskelet. 2012;13:173.
5. Landi F, Onder G, Russo A, Liperoti R, Tosato M, Martone AM, et al. Calf circumference, frailty and physical performance among older adults living in the community. Clin Nutr. 2014;33(3):539–44.
6. Parker ED, Pereira MA, Virnig B, Folsom AR. The association of hip circumference with incident of hip fracture in a cohort of postmenopausal women: the Iowa Women's Health Study. Ann Epidemiol. 2008;18(11):836–41.
7. Sjöblom S, Suuronen J, Rikkonen T, Honkanen R, Kröger H, Sirola J. Relationship between postmenopausal osteoporosis and the components of clinical sarcopenia. Maturitas. 2013;75:175–80.
8. Moayyeri A, Luben RN, Wareham NJ, Khaw K. Body fat mass is a predictor of risk of osteoporotic fractures in women but not in men: a prospective population study. J Intern Med. 2012;271(5):472–80.
9. Blain H, Jaussent A, Thomas E, Micallef JP, Dupuy AM, Bernard PL, et al. Appendicular skeletal muscle mass is the strongest independent factor associated with femoral neck bone mineral density in adult and older men. Exp Gerontol. 2010;45(9):679–84.
10. Søgaard AJ, Holvik K, Omsland TK, Tell GS, Dahl C, Schei B, et al. Abdominal obesity increases the risk of hip fracture. A population-based study of 43,000 women and men aged 60–79 years followed for 8 years. Cohort of Norway. J Intern Med. 2015;277(3):306–17.
11. Sadeghi O, Saneei P, Nasiri M, Larijani B, Esmaillzadeh A. Abdominal obesity and risk of hip fracture: a systematic review and meta-analysis of prospective studies. Adv Nutr. 2017;8(5):728–38.
12. Matsushita Y, Nakagawa T, Shinohara M, Yamamoto S, Takahashi Y, Mizoue T, et al. How can waist circumference predict the body composition? Diabetol Metab Syndr. 2014;6:11.
13. Vaez ID, Bufato HF, de Aguilar-Nascimento JE, Dock DD. SUN-P175: risk of sarcopenia by screening tool Sarc-F and presarcopenia by the calf circumference. Clin Nutr. 2017;36(Suppl 1):S118.
14. Kanis JA, Johansson H, Oden A, Johnell O, de Laet C, Melton III LJ, et al. A meta-analysis of prior corticosteroid use and fracture risk. J Bone Miner Res. 2004;19(6):893–9.
15. Bruyère O, Beaudart C, Locquet M, Buckinx F, Petermans J, Reginster JY. Sarcopenia as a public health problem. Eur Geriatr Med. 2016;7(3):272–5.
16. Di Monaco M, Vallero F, Di Monaco R, Tappero R. Prevalence of sarcopenia and its association with osteoporosis in 313 older women following a hip fracture. Arch Gerontol Geriatr. 2011;52(1):71–4.