Correlation Between Serum Vitamin D (25 (OH)D) Concentration and Quadriceps Femoris Muscle Strength in Indonesian Elderly Women Living in Three Nursing Homes

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ABSTRACT

Aim: *to investigate the correlation between serum vitamin D (25(OH)D) concentration and quadriceps femoris muscle strength.*

Methods: *this was a cross-sectional correlative study, conducted at three nursing homes in Jakarta and one nursing home in Bekasi in January 2005. The subjects were women aged 60 years or above. Those selected study subjects underwent quadriceps femoris muscle strength examination with Cybex dynamometer with 150^0/second speed, twice (three repetitions with 30 second rest time). The 25 (OH)D concentration was measured by ELISA.*

Results: *out of 67 subjects who met the required criteria for this study, five subjects withdrew from the study during muscle strength examination. The mean age was 71.1 (SD 7.2) years old while the mean serum vitamin D concentration was 68.2 (SD 21.6) nmol/l. Vitamin D deficiency (≤ 50 nmol/l) was found in 22.6% of subjects. It was also found that the median (minimum-maximum) quadriceps femoris muscle strength was 40.00 (11-116) N.m. Approximately 82.3% of the subjects were of generalized muscle weakness. Correlation was found between serum 25 (OH)D concentration and quadriceps femoris muscle strength (r = 0.327; P = 0.009).*

Conclusion: *this study reveals that serum 25 (OH) D concentrations in Indonesian elderly women is correlated with quadriceps femoris muscle strength. The proportion of elderly women with muscle weakness is higher than the normal ones. The group with older age shows higher proportion of muscle weakness. Most subjects have normal serum vitamin D concentration.*

Key words: *elderly women, quadriceps femoris muscle weakness, vitamin D deficiency, correlation.*

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INTRODUCTION

Advances in health sector have increased the life expectancy of Indonesians. Consequently, the proportion of elderly people in Indonesia also increases.[1] On the other hand, the proportion of elderly women exceeds men. As a result, incidence of health problems of elderly women associated with decreased organ function in aging process also increases.[1]

The muscle is an organ that deteriorates in function due to aging process. The muscle consists of contractile proteins actin and myosin which have roles in muscle contraction and have influence in muscle strength. During the aging process, reduced muscle mass will also reduces actin, myosin, and consequently decreases muscle strength. The decreased muscle strength along with reduced muscle mass (sarcopenia) as a part of the aging process is one of the important intrinsic factors of fall.[2-16] Fall is one of the health problems in the elderly.[2]

Sarcopenia is often found together with vitamin D deficiency. Other than its role in calcium and bone metabolism, vitamin D also contributes in muscle protein synthesis with or through its receptor on the cell membrane. Therefore, vitamin D deficiency causes disturbance of muscle protein synthesis and furthermore could reduce muscle mass and finally reduce muscle strength.[2-16] Glerup found the positive correlation between 25 hydroxycholecal cipherol (25(OH)D) with lower extremity muscle strength in elderly people, although Pfeifer and colleagues did not find similar relation.[17-18]

The purpose of the study was to find correlation between serum vitamin D concentration with quadriceps femoris muscle strength in Indonesian elderly women living in nursery home, as an addition to the existing studies using muscle strength measurement tool (*Cybex* isokinetic dynamometer) with confirmed validity and reliability.

METHODS

Subject

The target of the population study were Indonesian elderly women living in nursery homes, while accessible population was Indonesian elderly women living in three nursery homes in Jakarta and one nursery home in Bekasi in January 2005 and fulfilled the inclusion criteria: aged 60 years or above, female, independent (Barthel ADL index for mobilization/walking: 3), full comprehension to the instructions (scale 8-10 in Abbreviated Mental Test/AMT), and willing to participate in the study. The exclusion criteria: were in the state of depression according to geriatric depression scale, malunion of fracture in lower extremity, epilepsy, severe peripheral vascular disease, uncontrolled third to fourth degree heart failure according to the New York Heart Association (NYHA), acute exacerbation of COPD/third degree according to NHLBI (National Heart Lung Blood Institute) and WHO in 1998, using anticoagulant, long-term use of steroid (>3 months), neurologic diseases (acute stroke, parkinson), acute muscle/ligament disorder (7 days), knee/leg pain prior to muscle strength examination using Cybex dynamometer, knee joint effusion, deformity on the knee joint (genu varus or genu vagus with Q angle $>15^0$).

Sampling was done using stratified sampling method followed by simple proportional random sampling from a list. We found 62 subjects that fulfilled the inclusion criteria and did not have any of the exclusion criteria. The number of samples was in accordance with the formula:

$$n = \frac{Z\alpha + Z\beta}{5 \ln [(1+r)(1-r)]}^2 + 3$$

Legends:
n = sample size
$Z\alpha$ = type-1 error, α = 5% was used → $Z\alpha$ = 1.96
$Z\beta$ = type-2 error, β = 20% was used → $Z\beta$ = 0.846
r = correlation coefficient (from the literature) = 0.35

Required sample size according to the above formula was 61.8 (rounded to 62).

From the 62 subjects we obtained informed consent and we collected information on age, education level, serum vitamin D concentration (25(OH)D), height, weight, body mass index (BMI), serum calcium ion concentration, and the presence of chronic diseases as a comorbid state (COPD, heart failure, renal failure, hyperthyroidism, diabetes mellitus, malnutrition) through anamnesis, physical examination, and or laboratory examinations (when needed) according to each chronic disease diagnostic on criterion, and also quadriceps femoris muscle strength examination.

Quadriceps Femoris Muscle Strength

Because the working forces on the muscles work as a lever, Mac Dougall and colleagues (1991) defined muscle strength as a peak of torque force formed at maximum voluntary contraction with certain pre-arranged condition (such as contraction type and velocity).[19]

Subject sat on Cybex chair with 80^0 hip flexion. Both hips were fixated with belt for stabilization, while the trunk was in full contact with the back support of the chair, fixated with a double shoulder belt. The leg not being examined was fixated using a lever in Cybex chair. The examined leg was adjusted to the Cybex dynamometer rotation axis. Then the Pad was placed slightly above the medial maleolus with full dorsoflexion position, knee in 90^0 flexed position. The Cybex was set according to the set protocol, i.e. 150^0/second velocity, with concentric contraction type. The subject underwent three times familiarization with the device prior to the test. Subject performed 2 sets of concentric and eccentric contractions (3 times of repetition, 30 seconds for each set). The produced muscle strength could be seen in the monitor.

Vitamin D Concentration

Venous blood was collected between 8.00 and 9.30 a.m. after fasting for at least 8 hours. Serum 25 (OH)D was examined using ELISA method.

Confounding Factors

The confounding factors were also investigated in this study including age, body mass index, and calcium ion concentration. The age of subject was calculated from birth date to the time of measurement, through interview, Indonesian citizen identity card, or other personal identity. The body mass index was calculated using the formula: weight (kg) / height (meter)^2.[20] Serum calcium ion concentration was measured by calorimetry. Anabolic and catabolic confounding factor and comorbid diseases affecting muscle strength were not included in the study.

Statistical Analysis

Data were analyzed using SPSS 12 program. Mean and standard deviation were calculated when the data fulfill criteria for normality, and calculation of median and range when it did not meet the criteria for normality, were done for quantitative variables. Relationship between two quantitative variables was assessed using Pearson correlation method. Relationship between qualitative and quantitative variables was not statistically examined, only descriptively presented. Cut off for significancy being used in this study was 5%.

Ethical Consideration

The study obtained ethical clearance from the Faculty of Medicine University of Indonesia, Standing Committee for Medical Research Ethics, Jakarta.

RESULTS

There were 36 out of 62 (58,1%) subjects aged ≥ 70 years, 14 out of 62 (22,6%) subjects had vitamin D deficiency, more than half (82,3%) of the subjects had quadriceps femoris muscle weakness, 22 of 62 (35,5%) subjects were obese, and more than half of the subjects had serum calcium ion concentration of 1,1-1,3 mmol/liter.

Table 1. Characteristics of Subject

Characteristics	n	%
Age		
60-70 years	26	41,9
≥ 70 years	36	58,1
Vitamin D (25(OH)D) Concentration		
Normal (> 50 nmol/litre)	48	77,4
Vitamin D deficiency (≤ 50 nmol/litre)	14	22,6
Quadriceps Femoris Muscle Strength in Elderly Women		
Normal	11	17,7
Weak	51	82,3
Body Mass Index (BMI)		
≥ 25 kg/m^2 (obese)	22	35,5
23-24.9 kg/m^2 (overweight)	5	8,1
18,5-22.9 kg/m^2 (normal)	25	40,3
< 18.5 kg/m^2 (low)	10	15,1
Serum Calcium Ion Concentration		
< 1.1 mmol/litre	28	46,2
1.1-1.3 mmol/litre	34	54,8

In statistical analysis (Table 2), all variables had normal distribution except quadriceps femoris muscle strength. Mean (SD) age was 71,1 (SD 7,2) years old, BMI 24,7 (SD 4,9) kg/m^2, serum vitamin D was 68,2 (SB 21,6) nmol/l, while median value (minimum-maximum) of quadriceps femoris muscle strength in elderly women was 40,00 (11-116) N.m., serum calcium ion concentration 1,1 (SB 0,24).

Based on vitamin D concentration classification, 14 out of 62 (22,6%) subjects had vitamin D deficiency. (Table 3).

Reference for normal quadriceps femoris muscle strength was only present for age 20 to 70 years. Because there were subjects aged over 80 years, subjects were divided into only two age groups, 60-69 and ≥ 70 years in order to determine the proportion of muscle strength degree. Overall we found 51 of 62 (82,3%) subjects with quadriceps femoris muscle weakness. Thirty out of 36 (83,3%) subjects aged ≥ 70 years and 21 out of 26 (80,8%) subjects aged 60-69 years had quadriceps femoris muscle weakness. (Table 4)

This study found correlation between 25(OH) vitamin D concentration with quadriceps femoris muscle strength in Indonesian elderly women living in nursery home (r = 0,327; *P*=0,009). (Figure 1)

Age, BMI, and calcium ion concentration do not correlate with quadriceps femoris muscle strength in Indonesian elderly women living in nursery home. (Table 5)

DISCUSSION

Vitamin D becomes important because it has been lately found that vitamin D influences not only bone metabolism but also muscle strength.[21] Based on this fact, there has been a vitamin D classification status. Based on the classification used by Lips,[21] we found 14 of 62 (22,6%) subjects had vitamin D deficiency in this study. This is contrary to Lips study report in several European, American, and also South East Asian countries. In Singapore, South East Asia, no elderly women were found to have vitamin D deficiency.[22]

Table 2. Characteristics of Subjects Based on Variable Mean and Median

Variable	Mean	SD**	Range		Median
			Min	Max	
Age (year)	71.1	7.2	60.00	87.00	
BMI (kg/m^2)	24.7	4.9	16.17	44.39	
Vitamin D Concentration (25(OH)D Serum (nmol/l)	68.2	21.6	29.1	117.9	
Quadriceps Femoris Muscle Strength (N.m)*			11	116	40.00
Serum Calcium Ion Concentration (mmol/l)	1.1	0.24	1.03	1.15	

* Abnormal distribution ** Standard Deviation

Table 3. Distribution of Subject s Based on Serum Vitamin D (25(OH)D) Concentration Group [25]

Serum Vitamin D Concentration Group (25(OH)D)	n	%
Normal (> 50 nmol/)	48	77.4
Vitamin D deficiency (≤ 50 nmol/l)	14	22.6
Total	62	100

Table 4. Distribution of Subject s Based on Age Group and Quadriceps Femoris Muscle Strength

Age Group	Quadriceps Femoris Muscle Strength			
	Weak		Normal	
	n	%	n	%
≥ 70 years	30	83.3	6	16.7
60-69 years	21	80.8	5	19.2

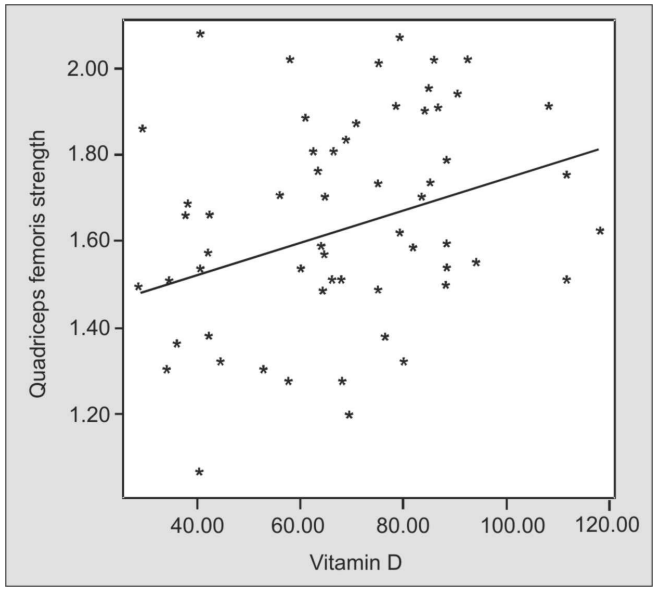

Figure 1. Scattered Diagram of Correlation Between Serum Vitamin D (25(OH)D) Concentration and Quadriceps Femoris Muscle Strength in Indonesian Elderly Women living in Nursery Home.

* Result of logarithmic transformation from quadriceps femoris strength data in elderly women living in nursery home with abnormal distribution

In Northern Europe there were 11,2 %. In Southern Europe there were 31%. In Northern America, there were 24,6%.[22]

The difference in prevalence in various countries could be due to differences in geographical difference that causes differences in duration of sun exposure and vitamin D synthesis.[22] In contrast with, our study found higher prevalence of vitamin D deficiency compared to North European Countries. This may be caused by vitamin D fortification program through dairy products in North European Countries (400 IU/quart), which resulted in the low prevalence of vitamin D deficiency in those countries, although relatively far from the equator.[22]

Overall most subjects in this study were categorized as having weak muscle strength (82,3%). Further analysis using age group showed that the proportion of subject categorized as having weak muscle strength in older age group was larger compared to younger age group (83,3% vs 80,8%). This indicates that muscle strength tends to decrease as the age advances. Although it differs in age group with this study, Frontera and colleagues (1991) also found that muscle strength in male and female aged 65-78 years was lower (15,5%-26,7%) compared to the muscle strength in people aged 45-54 years.

Although not using quadriceps femoris muscle strength as a parameter, the relationship between vitamin D concentration and muscle strength has been shown by many previous studies. For example, Mowe and colleagues found the correlation between serum 25 (OH)D concentration with grip strength.[23] Similar to the above studies, ours found correlation between serum 25 (OH)D concentration with quadriceps femoris muscle strength in Indonesian elderly women living in nursery home although it was not too strong. It was probably due to a number of other factors that also contribute to quadriceps femoris muscle strength formation.

Because this is a correlational cross-sectional study, we did not include confounding factor that could affect vitamin D concentration and the relationship with

Table 5. Correlation Between Age, Body Mass Index (BMI), Serum Calcium Ion Concentration, Thigh Circle, Upper Arm Circumference (UAC), and Upper Arm Muscle Circumference (UAMC) with Quadriceps Femoris Muscle Strength in Indonesian Elderly Women Living i n Nursery Home

	Quadriceps Femoris Muscle Strength			
	Correlation Coefficient	Correlation Test	*P*	r^2
Age	-0.083	Pearson (r)	0.519	0.007
Body Mass Index (BMI)	-0.004	Pearson (r)	0.974	0.000
Serum calcium ion concentration	-0.128	Pearson (r)	0.391	0.016

muscle strength in data analysis. However, in correlation analysis, we did not find it between age, BMI, and serum calcium ion concentration with quadriceps femoris muscle strength. In the context of these confounding factors a study by Visser et al. might be used as a reference. Visser and colleagues found that subjects with 25 (OH) vitamin D concentration less than 25 nmol/L showed more loss in grip strength compared to the subjects with higher 25 (OH) vitamin D concentration, even after potential confounding factor were corrected, such as height, body mass index, degree of physical activity, serum creatinine concentration, season, the presence of chronic disease, and smoking, all has been known to contribute to parathyroid hormone (PTH) and/or 25(OH)D concentration.[24]

This is a cross-sectional study to find the correlation between serum vitamin D concentration (25 (OH) D) with quadriceps femoris muscle strength in Indonesian elderly women living in nursery home without including other factors, such as anabolic, catabolic, and comorbid disease factors, in calculating the study sample size. Referring to this, it is not impossible that if those factors were included in statistical calculation, the correlation between insignificant factors will become more significant.

CONCLUSION

As a conclusion, there is a correlation between serum 25(OH)D concentration in Indonesian elderly women with quadriceps femoris muscle strength.

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