Journal of Aging Research & Clinical Practice©
Volume 1, Number 3, 2012

DIETARY VITAMIN D INTAKE IS ASSOCIATED WITH SKELETAL MUSCLE MASS IN COMMUNITY-DWELLING OLDER JAPANESE WOMEN

M. Yamada[1], K. Terai, S. Nishiguchi, K. Yoshimura, Y. Kajiwara, T. Sonoda, T. Aoyama[1]

Abstract: *Background & purpose:* Recently, several studies have suggested that low serum 25-hydroxyvitamin D levels are associated with sarcopenia (age-related loss of skeletal muscle mass). However, the relationship between dietary vitamin D intake and skeletal muscle mass in older adults remains unclear. The purpose of this cross-sectional study was therefore to determine whether dietary vitamin D intake is associated with muscle mass in community-dwelling older Japanese women. *Methods:* Ninety-one older Japanese women (mean age, 73.0 ± 5.5 years) participated in this cross-sectional study. We measured the skeletal muscle mass index(SMI) of the participants using bioelectrical impedance, the intake of several dietary nutritional factors using a food-frequency questionnaire, and physical activity. *Results:* The SMI correlated with level of vitamin D intake(r=0.208, p=0.037) and body mass index (r=0.330, p=0.001). Regression analysis revealed that vitamin D (β=0.308; 95% confidence interval, 0.022–0.303) was a significant and independent determinant of the SMI (p<0.001). *Conclusion:* Dietary vitamin D intake is associated with the SMI in older, community-dwelling Japanese women.

Key words: Sarcopenia, vitamin D, nutrition, muscle mass, older adults.

Introduction

Sarcopenia, the age-related loss of skeletal muscle mass, is prevalent in older adults (1) and results in increased risk of falls and fractures, physical disability, mobility disorders, and mortality (2-4).The physiopathological causes of sarcopenia include increasing age, muscle disuse, endocrine function, neurodegenerative diseases, and malnutrition (5).Therefore, resistance training, as well as better nutrition, such as sufficient protein intake, is important for the prevention of sarcopenia (6).

Dietary protein intake is important for the maintenance of muscle mass and strength in community-dwelling older adults (7-8). In fact, a protein or amino acid supplement has been shown to increase muscle mass (9-11). However, vitamin D is also important in preventing sarcopenia.

Vitamin D levels are measured clinically using serum 25-hydroxyvitamin D (25(OH)D). Recently, several studies suggested that a low 25(OH) D level is associated with muscle mass, lower muscle strength, declined physical performance, and activity of daily living (ADL) disability (7, 12-14). Thus, patients with low 25(OH) D levels may require vitamin D replacement (15). Older adults are at risk for low vitamin D levels because the vitamin D production capacity of the skin at the age of 70 is reduced to only 30% of that of a 20-year-old person (16, 17) Thus, dietary vitamin D intake should be recommended in older adults. However, the relationship between dietary vitamin D intake and skeletal muscle mass in older adults remains unclear.

The purpose of this cross-sectional study was to determine whether dietary vitamin D intake is associated with muscle mass in community-dwelling older Japanese women.

Methods

Participants

Participants were recruited through a local press requesting healthy community-dwelling volunteers. A total of 91Japanese participants, aged 65 years and older (mean age, 73.0 ± 5.5 years), living in Kyoto city enrolled in this study in September 2011. The interview was then used to exclude participants based on the following

1. Department of Human Health Sciences, Kyoto University Graduate School of Medicine, 53 Kawahara-cho, Shogoin, Sakyo-ku, Kyoto 606-8507, Japan

Corresponding Author: Minoru Yamada, PT, PhD, Tel.: +81-75-751-3964, Fax: +81-75-751-3909, E-mail address: yamada@hs.med.kyoto-u.ac.jp

Received February 28, 2012
Accepted for publication May 16, 2012

exclusion criteria: severe cognitive impairment (Rapid Dementia Screening Test score of 4 or less) (18); severe cardiac, pulmonary, or musculoskeletal disorders; and comorbidities associated with greater risk of falls, such as Parkinson disease and stroke. Written informed consent was obtained from each participant in accordance with the guidelines approved by the Kyoto University Graduate School of Medicine and the Declaration of Human Rights, Helsinki, 1995.

Skeletal muscle mass index (SMI)

A bioelectrical impedance data acquisition system (Inbody 720; Biospace Co, Ltd, Seoul, Korea) was used to determine bioelectrical impedance (19). This system also uses electrical current at multi-frequencies (5, 50, 250, 500, and 1000 kHz) to directly measure the amount of extracellular and intracellular water. Participants stood on 2metallic electrodes and held metallic grip electrodes. Using segmental body composition and muscle mass, a value for the appendicular skeletal muscle mass was determined and used for further analysis. Muscle mass was converted to the skeletal muscle mass index (SMI) by dividing by height squared (kg/m^2). This index has been used in several epidemiological studies (4, 20).

Assessment of dietary nutrient intake

Dietary nutrient intake was assessed using the food frequency questionnaire (FFQ) (21). However, there is possibility of recall bias in the FFQ by older adults. Therefore, in the current study, participants were asked to record the intake of dietary foods on a calendar at 7 consecutive days. The intake of dietary foods was converted to the FFQ by one of the authors (K.T.). The output included averaged daily estimates for total energy intake and for 29 dietary nutrients including protein and vitamin D. In present study, we defined sarcopenia as coexistence of low muscle mass. Japanese women criteria for sarcopenia by SMI were less than 5.46kg/m^2 (22).

Measurement of physical activities

Measurement of step counts was conducted by pedometer, YamaxPowerwalker EX-510 (Yamasa Co, Ltd, Tokyo, Japan) which measures free-living step counts (23), and has a 30-day data storage capacity. Participants were instructed to wear the pedometer in the pocket of their dominant leg for 7 consecutive days, except when bathing, sleeping, and performing water-based activities. We calculated the average of the daily step count per week for each subject.

Statistical analyses

The relationship between the SMI and demographic data, physical activity, and nutritional factors (total energy, protein, and vitamin D) was assessed by Pearson's correlation coefficient. A multivariate analysis by means of multiple regressions was performed to investigate whether age, physical activity, total energy, protein, and vitamin D were independently associated with the SMI of the subjects. A p value <0.05 was considered statistically significant for all analyses. Differences in the data of nutritional factors variables between the Sarcopenia and non-Sarcopenia groups were analyzed by the Student's t–test. The utility of the nutritional factors for distinguishing between Sarcopenia and non-Sarcopenia was tested using receiver operating characteristic (ROC) curves for cut-off points on dietary nutrient intake. Data were analysed using the Statistical Package for Social Science (Windows version 18.0, SPSS, Inc., Chicago, IL).

Results

The characteristics of the study population are shown in Table 1. We used Pearson's correlation coefficients to determine the association of the SMI with subject demography, physical activity, and nutritional factors. The SMI was correlated with vitamin D (r=0.208,p=0.037) and body mass index(r=0.330,p=0.001;Table 2). Regression analysis revealed that vitamin D (β=0.308, 95% confidence interval,0.022–0.303) was a significant and independent determinant of the SMI (p<0.001). The Sarcopenia group had significantly worse scores than the non-Sarcopenia group in the dietary intake of vitamin D (Sarcopenia=5.66±1.74μg/day, non-Sarcopenia= 6.70±2.06μg/day, p=0.018). In the ROC curve, the area under the curve was 0.655 and the Sarcopenia-related cut-off value for dietary intake of vitamin D was determined to be 5.93μg/day (sensitivity = 62.5%, specificity = 66.7%).

Table 1
Demographic characteristics of the participants

	Mean	SD	(Min - Max)
Age (y)	73.0	5.5	(65 - 90)
Height (cm)	151.0	5.1	(139 - 164)
Weight (kg)	50.8	7.0	(35.2 - 71.8)
BMI	22.3	2.8	(16.5 - 30.9)
PA (steps/d)	6581.8	3675.6	(1865 - 26167)
SMI (kg/m^2)	6.44	1.01	(4.57 - 9.63)
Total energy (kcal/d)	1630.6	300.6	904.5 - 2366)
Protein (g/d)	57.0	11.3	(24.2 - 84.5)
Vitamin D (μg/d)	6.35	1.91	(1.0 - 10.5)

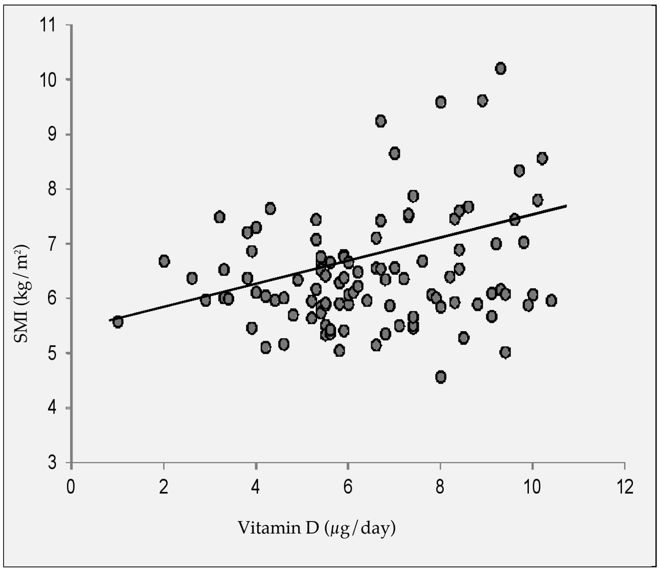
BMI: body mass index; PA: physical activity; SMI: skeletal mass

Table 2
Pearson's correlation coefficients between SMI and demographic data, physical activity, and nutritional factors

	age	BMI	PA	SMI	Total energy	Protein	Vitamin D
SMI	-.060	.330**	.034		.068	.074	.208*
Total energy	.207*	-.077	.176	.068		.877**	.404**
Protein	.202*	-.038	.184	.074	.877**		.607**
Vitamin D	.013	.013	.050	.208*	.44**	.607	

BMI: body mass index; PA: physical activity; SMI: skeletal mass; *: p<0.005; **: p<0.01

Figure 1
Dietary vitamin D intake is associated with the SMI in older Japanese women



Discussion

This study showed that dietary vitamin D intake may be related to the SMI in community-dwelling older Japanese women. Regression analysis revealed that dietary intake of vitamin D was a significant and independent determinant of the SMI. Furthermore, the Sarcopenia-related cut-off value for dietary intake of vitamin D was determined to be 5.93μg/day. Taken together, these findings led us to conclude that measuring dietary vitamin D intake is potentially important to assess the SMI in community-dwelling older women.

Vitamin D can be obtained from dietary intake and can be produced by the skin. In serum, bound to a vitamin D-binding protein, vitamin D3 is transported to the liver. In the kidneys, 25(OH) D 3 is further metabolised into the biologically active form of vitamin D (24, 25). However, vitamin D nuclear receptors were identified on muscle cells, and their abundance decreases with increasing age (26). Vitamin D deficiency may lead to loss of type 2 muscle fibres and thus to atrophy of proximal muscles (27). In addition, older adults have various risk factors for vitamin D deficiency, such as decreased sunlight exposure, reduced skin thickness, decreased dietary intake, impaired intestinal absorption, and impaired hydroxylation in the liver and kidneys (28). Specifically, older adults are at risk for low vitamin D levels because the vitamin D production capacity of the skin at the age of 70 is reduced to only 30% of that of a 20-year-old person (16, 17). Therefore, dietary vitamin D intake is very important for maintenance of muscle mass in community-dwelling older adults.

However, the current study suggests that dietary protein intake is not related to the SMI in community-dwelling older adults. Previous studies reported that dietary protein intake is important for maintenance of muscle mass in community-dwelling older men and women (7, 8). The reasons for this discrepancy remain unclear; however, the previous studies were not performed on Japanese subjects (7, 8). Differences in the ethnic origin of the study population could therefore be a reason for the disagreement of data.

There were several limitations of this study. First, our limited sample size may introduce some error of inference, reduce the power of the analysis, and limit generalization. Second, dietary vitamin D intake may not be predictive of sarcopenia in older adults as this study had a cross-sectional design. Third, the serum 25 (OH) D was not measured. Therefore, the relationship between SMI and 25 (OH) D is unclear. Fourth, the measurement of SMI estimated using BIA. The validation study of the BIA that is referred to was performed in not Japanese older women, and the validation study in Japanese older women is needed.

In conclusion, to the best of our knowledge this is the first study to indicate that dietary vitamin D intake is associated with the SMI in community-dwelling older Japanese women. A larger survey is needed to confirm and extend the present study.

Acknowledgments: The authors thank Ms. Toshiko Saito, Ms. Kazue Hatakeyama, Mr. Tetsuo Nagai, Mr. Kazuo Onishi, and Mr. Tetsuro Ichida for their significant contributions to data collection. None of the authors have conflicts of interest or financial disclosures.

Conflict of Interest: None

Sponsor's Role: None

References

1. Chien MY, Huang TY, Wu YT (2008). Prevalence of sarcopenia estimated using a bioelectrical impedance analysis prediction equation in community-dwelling elderly people in Taiwan. J Am GeriatrSoc 56: 1710–1715.
2. Rolland Y, Czerwinski S, Abellan Van Kan G et al (2008). Sarcopenia: its assessment, etiology, pathogenesis, consequences and future perspectives. J Nutr Health Aging 12: 433–450.
3. Topinkova E (2008). Aging, disability and frailty. Ann NutrMetab 52: 6-11.
4. Janssen I, Baumgartner RN, Ross R et al (2004). Skeletal muscle cutpoints associated with elevated physical disability risk in older men and women. Am J Epidemiol 159:413-421.
5. Cruz-Jentoft AJ, Baeyens JP, Bauer JM et al (2010). European Working Group on Sarcopenia in Older People. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age Ageing 39:412-423.
6. Boirie Y (2009). Physiopathological mechanism of sarcopenia. J Nutr Health Aging. 13: 717-723
7. Houston DK, Nicklas BJ, Ding Jet al (2008). Health ABC Study. Dietary protein intake is associated with lean mass change in older, community-dwelling adults: the Health, Aging, and Body Composition (Health ABC) Study. Am J ClinNutr 87:150-155.
8. Meng X, Zhu K, Devine A et al (2009). A 5-year cohort study of the effects of high protein intake on lean mass and BMC in elderly postmenopausal women. J Bone Miner Res 24:1827-1834.
9. Meredith CN, Frontera WR, O'Reilly KP et al (1992). Body composition in elderly men: effect of dietary modification during strength training. J Am Geriatr Soc 40: 155-162.
10. Kim HK, Suzuki T, Saito K et al (2012). Effects of exercise and amino acid supplementation on body composition and physical function in community-dwelling elderly Japanese sarcopenic women: a randomized controlled trial. J Am Geriatr Soc 60: 16-23.
11. Solerte SB, Gazzaruso C, Bonacasa R et al (2008). Nutritional supplements with oral amino acid mixtures increases whole-body lean mass and insulin sensitivity in elderly subjects with sarcopenia. Am J Cardiol 101:69E-77E.
12. Visser M, Deeg DJ, Lips P (2003). Longitudinal Aging Study Amsterdam. Low vitamin D and high parathyroid hormone levels as determinants of loss of muscle strength and muscle mass (sarcopenia): the Longitudinal Aging Study Amsterdam. J Clin Endocrinol Metab 88: 5766-5772.
13. Hirani V, Primatesta P (2005). Vitamin D concentrations among people aged 65 years and over living in private households and institutions in England: population survey. Age Ageing 34:485-491.
14. Houston DK, Cesari M, Ferrucci L et al (2007). Association between vitamin D status and physical performance: the InCHIANTI study. J Gerontol A BiolSci Med Sci 62:440-446.
15. Morley JE, Argiles JM, Evans WJ et al (2011).Nutritional recommendations for the management ofsarcopenia. J Am Med DirAssoc 11:391-396.
16. Holick MF, Matsuoka LY, Wortsman J (1989). Age, vitamin D, and solar ultraviolet. Lancet 2:1104-1105.
17. MacLaughlin J, Holick MF (1985). Aging decreases the capacity of human skin to produce vitamin D3. J Clin Invest 76:1536-8.
18. Kalbe E, Calabrese P, Schwalen S et al (2003). The Rapid Dementia Screening Test (RDST): a new economical tool for detecting possible patients with dementia. Dement GeriatrCognDisord 16: 193-199.
19. Gibson AL, Holmes JC, Desautels RL, et al (2008). Ability of new octapolarbioimpedance spectroscopy analyzers to predict 4-component-model percentage body fat in Hispanic, black, and white adults. Am J ClinNutr 87:332-338.
20. Janssen I (2006). Influence of sarcopenia on the development of physical disability: the Cardiovascular Health Study. J Am GeriatrSoc 54:56-62.
21. Sone H, Yoshimura Y, Tanaka S et al (2007). Japan Diabetes Complications Study (JDCS) Group. Cross-sectional association between BMI, glycemic control and energy intake in Japanese patients with type 2 diabetes. Analysis from the Japan Diabetes Complications Study. Diabetes Res ClinPract 77: 23-29.
22. Sanada K, Miyachi M, Tanimoto M et al (2010). A cross-sectional study of sarcopenia in Japanese men and women: reference values andassociation with cardiovascular risk factors. Eur J Appl Physiol 110: 57-65.
23. Crouter SE, Schneider PL, Karabulut Met al (2003). Validity of 10 electronic pedometers for measuring steps, distance, and energy cost. Med Sci Sports Exerc 35: 1455-1460.
24. Omdahl JL, Garry PJ, Hunsaker LA et al (1982). Nutritional status in a healthy elderly population: vitamin D. Am J ClinNutr 36:1225-1233.
25. Holick MF (1995). Environmental factors that influence the cutaneous production of vitamin D. Am J ClinNutr 61:638-645.
26. Bischoff-Ferrari HA, Borchers M, Gudat F et al (2004). Vitamin D receptor expression in human muscle tissue decreases with age. J Bone Miner Res 19:265-269.
27. Sato Y, Inose M, Higuchi I et al (2002). Changes in the supporting muscles of the fractured hip in elderly women. Bone 30:325-330.
28. Janssen HC, Samson MM, Verhaar HJ (2002). Vitamin D deficiency, muscle function, and falls in elderly people. Am J ClinNutr 75:611-615.