Original Article

Serum 25-hydroxyvitamin D and elderly skeletal muscle mass and function in urban north China

Liping Meng PhD[1], Qingqing Man Bsc[1], Linhong Yuan PhD[2], Lingxia Shen BSc[3], Weimin Li MD[4], Guiyuan Guo BSc[4], Lixiang Li BSc[1], Shanshan Jia MD[1], Yixiong Gao PhD[1], Pengkun Song MD[1], Jian Zhang PhD[1]

[1]*Institute for Nutrition and Health, National Center for Disease Control and Prevention, China*
[2]*School of Public Health, Capital Medical University, Beijing, P. R. China*
[3]*Wulituo Community Health Center, Shijingshan District, Beijing, China*
[4]*Lugu Community Health Center, Shijingshan District, Beijing, China*

Background and Objectives: To investigate the association of serum 25-hydroxyvitamin D (25(OH)D) with skeletal muscle mass (SMM) and function among the elderly in an urban area in northern China. **Methods and Study Design:** A total of 912 participants (316 men, 596 women) aged more than 60 years from 4 communities in Beijing were enrolled. Serum concentrations of 25(OH)D were measured through radioimmunoassay. SMM was assessed through bioelectrical impendence analysis, whereas skeletal muscle function was assessed through grip strength and 4-m regular gait speed measurements. On the basis of expert consensus of the Asian Working Group for Sarcopenia, low muscle mass was defined as relative skeletal mass index (RSMI) <7.0 kg/m^2 for men and <5.7 kg/m^2 for women. A noncondition logistical regression model was employed to explore the association between vitamin D and both muscle mass and function. **Results:** Serum 25(OH)D was positively associated with grip strength (β=0.16, SE=0.05). The upper quartile of 25(OH)D was negatively associated with loss of grip strength (OR=0.05, 95% CI: 0.01–0.48) in men but not in women. No significant associations were noted between 25(OH)D and appendicular skeletal muscle mass, RSMI, and gait speed (p>0.05). **Conclusions:** The present study demonstrated a positive association between vitamin D and skeletal muscle strength in elderly Chinese men but not women.

Key Words: vitamin D, skeletal muscle mass, grip strength, gait speed, elderly

INTRODUCTION

China has gradually changed into an aging society, with approximately 202 million elderly people in 2013; this number is expected to double by 2050.[1] Aging is accompanied by significant changes in body composition that are often linked to sarcopenia, a syndrome characterized by progressive and generalized low skeletal muscle mass (SMM) and function (muscle strength and performance), which carries a risk of adverse outcomes such as physical disability, poor quality of life, and death.[2,3] Sarcopenia has been estimated to cost $18.4 billion per year in the USA.[4]

Multiple mechanisms and risk factors, such as physical inactivity, poor nutrition, genes, hormones, and metabolism, contribute to the development of sarcopenia.[5,6] With associations between low vitamin D and various extraskeletal conditions reported in various epidemiological and prospective cohort studies over the past several years,[7] the potential effect of vitamin D on SMM and muscle function (including physical performance) has been receiving increased attention in recent years.[8-14] A few recent reports have indicated that muscle mass, strength, and performance are reduced in older individuals with low serum 25-hydroxyvitamin D, whereas the risk of falls is increased.[8-10] A recent population-based study reported that after adjustment for confounders and in terms of grip strength, people with low baseline serum 25(OH)D (<25 nmol/L) were 2.57 times (95% CI 1.40–4.70) more likely to experience sarcopenia compared with those having high serum 25(OH)D (>50 nmol/L).[9] However, there is limited knowledge regarding the effects of vitamin D on muscle mass and function in the Chinese population; furthermore, results in the literature are inconsistent.[13,14] A deeper understanding of the relationship between vitamin D and muscle mass and function in the elderly may help in developing a novel way to slow the loss of muscle mass and maintain muscle function. Therefore, in the present study, we investigated the association between serum 25(OH)D and SMM, grip strength, and gait speed in elderly persons in urban north China.

Corresponding Author: Dr Jian Zhang, Institute for Nutrition and Health, National Center for Disease Control and Prevention, China. 29 Nanwei Road, Xicheng District, Beijing, China.
Tel: 8610-83132560, 8610-13611309379; Fax: 010-67791292
Email: zhjian6708@126.com; zhjian6708@aliyun.com.
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MATERIALS AND METHODS

Participants

A total of 912 senior adults, aged more than 60 years, from 4 communities in Shijingshan district, Beijing, were invited to participate in this survey, which was conducted from November to December 2013. The exclusion criteria were as follows: 1) individuals with severe illnesses such as obesity (body mass index (BMI) ≥30 kg/m^2), diabetes (with serious complications), severe liver, kidney, or neural diseases, or progressive cancer; 2) individuals with a history of stroke or myocardial infarction in the past one year; 3) individuals with conditions such as joint disease with restricted activity and hyperthyroidism and those receiving estrogen therapy; 4) individuals with metal in the body (who therefore cannot undergo bioelectrical impendence analysis (BIA)); and 5) individuals who were heavy smokers or alcoholics.

The study protocol was approved by the Ethical Review Committee of the National Institute for Nutrition and Health, Chinese Center for Disease Control and Prevention, Beijing(INFS 20120301). Written informed consent was obtained from all participants.

General information

A questionnaire was used to collect information about demography (sex, age, previous occupation, and education), lifestyle (smoking, alcohol drinking, breakfast frequency per week, and frequency of eating out), and physical activity (instances of moderate-to-vigorous exercise or housework per week and the duration of each such instance) from the participants through face to face interviews. Additional information regarding socioeconomic status, duration of sun exposure during summer and winter, duration of sleep, and intake of nutrition supplements was also collected using the same questionnaire.

Dietary survey

A semi-quantified Food Frequency Questionnaire (FFQ; validated as a reliable method to assess dietary energy and protein in Chinese adults)[15] containing 45 food items was used to assess dietary energy and protein intake. The habitual diet of the participants during the past 1 year was ascertained through face-to-face interviews. Photos of foods with measured portion sizes were used to help participants in estimating the amount of foods they have consumed. Energy and protein intake were assessed on the basis of food intake and the Chinese food composition table (2004).

Anthropometry measurement

The height of the participant was measured to the nearest 0.1 cm by using a freestanding stadiometer mounted on a rigid tripod (GMCS-I, Xindong Huateng Sports Equipment Co. Ltd., Beijing, China). Fasting body weight was measured to the nearest 0.1 kg by using a balance beam scale (RGT-140, Weighing Apparatus Co. Ltd., Changzhou Wujin, China) with the participants wearing only underwear. BMI (kg/m^2) was calculated as weight (kg) divided by the square of the height (m).

Measurement of muscle mass and function

Muscle mass was assessed using a segmental multifrequency BIA (SMF-BIA) device (InBody720, Biospace, Korea) that measured the voltage drop in the upper and lower body. The accuracy of lean body mass measured through the SMF-BIA method has been verified in previous studies.[16,17] The InBody720 uses eight tactile electrodes (at the hands and feet) and six frequencies (1, 5, 50, 250, 500 kHz and 1M kHz) to detect segmental body composition, including body water, fat, muscle, and mineral content. The participants were asked to fast for over two hours, remove their shoes and socks, wear only their underwear, and stand over the electrodes on the machine for 3–5 min. From the InBody720 output, we measured SMM and appendicular skeletal muscle mass (ASM) and subsequently calculated the relative skeletal mass index (RSMI) by dividing the ASM (kg) by the square of height (m).

A handgrip dynamometer (EH101, Camry, Guangdong Xiangshan Weighing Apparatus Group Ltd., Zhongshan, China) was used to measure grip strength. Participants were instructed to hold the dynamometer in the dominant hand while standing and use maximum isometric effort for about 5 s. Maximum strength was measured twice and the highest recorded value was considered the maximal grip strength. A minimum rest period of 5 min was ensured between each measurement.

The 4-m regular gait speed was measured to assess muscle performance. Participants, wearing ordinary shoes, were asked to walk for 4 m at their regular speed, and the time taken was recorded in seconds (s). The gait speed test was performed only once.

Vitamin D measurement

Fasting venous blood samples (4.5 mL) were obtained and the serum samples were stored at –70℃ until further analysis. Serum concentration of 25(OH)D, measured using an immunoradiometric assay (DIAsource ImmunoAssays S.A., Louvain-la-Neuve, Belgium), was used as an indicator of the vitamin D status. All samples were analyzed simultaneously. The reference range for 25(OH)D was 6.6–24.5 ng/mL, and the intra- and inter-coefficients of variation for 25(OH)D were 4.7% and 9.1%, respectively, according to the manufacturer's notes.

Definition of variables and outcomes

Sarcopenia was defined on the basis of expert consensus of the Asian Working Group for Sarcopenia.[18] Participants who had low muscle mass simultaneously with either low grip strength or low gait speed were defined as having sarcopenia. Low muscle mass was defined as RSMI <7.0 kg/m^2 in men and <5.7 kg/m^2 in women. Low grip strength was defined as handgrip strength <26 kg in men and <18 kg in women. Low gait speed was defined as walking speed < 0.8 m/s in both men and women.

According to the widely used criteria,[19] the following ranges were used for classifying the 25(OH)D status: deficiency, <20 ng/mL; insufficiency, 20–29.9 ng/mL; and sufficiency, ≥30 ng/mL.

Statistical analysis

SAS package version 9.1 (SAS Institute Inc, Cary, NC) was used for statistical analyses in the present study. General linear model was used to calculate the mean and

Table 1. Basic characteristics of the study population (%)[†]

Descriptive variables	Men		Women		Total	
	n	%	n	%	n	%
Age group						
60-69	203	64.2	399	67.0	602	66.0
70-79	90	28.5	173	29.0	263	28.8
≥80	23	7.3	24	4.0	47	5.2
Education						
Primary school and below	57	18.0	180	30.2	237	26.0
Middle/technical secondary school	240	76.0	402	67.5	642	70.4
College and above	19	6.0	14	2.4	33	3.6
Previous occupation						
Manual worker	194	61.4	317	53.2	511	56.0
Peasant	16	5.1	80	13.4	96	10.5
Mental worker	85	26.9	139	23.3	224	24.6
Others	21	6.7	60	10.1	81	8.9
Smoking						
No	217	68.7	570	95.6	787	86.3
Yes, every day	85	26.9	24	4.0	109	12.0
Yes, but not everyday	14	4.4	2	0.3	16	1.8
Alcohol drinking						
Yes, everyday	81	25.6	10	1.7	91	10.0
Yes, 1-6 times per week	36	11.4	10	1.7	46	5.0
Yes, <1 times per week	42	13.3	18	3.0	60	6.6
No	157	49.7	558	93.6	715	78.4
Vitamin D category						
Deficiency	236	74.7	468	78.5	704	77.2
Insufficiency	49	15.5	82	13.8	131	14.4
Sufficiency	31	9.8	46	7.7	77	8.4
Physical exercise at least once a week						
No	220	69.6	442	74.2	662	72.6
Yes	96	30.4	154	25.8	250	27.4
	Mean	SE	Mean	SE	Mean	SE
Serum 25(OH)D (ng/mL)[‡]	15.1	0.6	14.6	0.4	14.8	0.4
BMI (Kg/m^2)	25.3	0.2	25.2	0.2	25.2	0.1
Sun exposure in Winter (hr)	2.3	0.1	2.0	0.1	2.1	0.1
Sun exposure in Summer (hr)	2.0	0.1	1.6	0.1	1.8	0.0
Sleep duration per day	7.2	0.1	6.7	0.1	6.9	0.1
Energy intake (Kcal/d)	1719	35.8	1399	24.7	1512	21.0
Protein intake (g/d)	72.4	1.6	55.0	1.1	61.1	0.9

BMI: body mass index.
[†]Continuous variables were expressed as mean and standard error and categorical variables were expressed as cases and prevalence.
[‡]Median serum 25(OH)D was 12.6 ng/mL, 12.7 ng/mL, and 12.7 ng/mL for men, women, and all participants, respectively.

95% CI of gait speed, grip strength, SMM, ASM, and RSMI by vitamin D quartiles after adjustment for covariates such as sex, age, sun exposure, and physical activity. The prevalence of sarcopenia and its components were presented as prevalence and 95% CI. Wald chi-square test was used to compare the differences in prevalence among the vitamin D quartiles. Noncondition logistic regression model was employed to explore the association of vitamin D with muscle mass and function. Four models were explored with low SMM, low grip, low gait speed, and sarcopenia as the lone dependent variable. No variable except serum 25(OH)D was included as the independent variable in the unadjusted model. We included eleven potential confounders (sex, age, occupation, sun exposure, physical activity, education, body fat percentage, smoking, drinking, dietary protein, and energy intake) as independent variables in model I. In model II, we further adjusted for grip strength and gait speed for low SMM, for gait speed and SMM for low grip strength, for grip strength and SMM for low gait speed. $p<0.05$ was considered statistically significant.

RESULTS

General information

A total of 912 elderly participants (316 men and 596 women) aged sixty years and older participated in the survey. The mean age of the participants was 67.9 years, and the majority (94.8%) belonged to the 60–79 age group. The percentage of participants educated at the level of middle school, or lower was 96.4%, and 80.6% of the participants had previous occupational histories of manual and mental work. In addition, 13.8% and 21.6% of the participants reported smoking and drinking habits, respectively.

Serum 25(OH)D in the elderly were found to be 14.8±0.4 ng/mL (median: 12.7 ng/mL): 15.1±0.6 ng/mL (median: 12.6 ng/mL) in men and 14.6±0.4 ng/mL (median: 12.7 ng/mL) in women. The prevalence of vitamin D deficiency was 74.7% in men and 78.5% in women. Mean dietary energy and protein intake were 1512 Kcal/d and 61.1 g/d, respectively (Table 1).

Vitamin D–based distribution of skeletal muscle mass and function levels

The mean grip strength among the vitamin D quartiles differed significantly, whereas no significant differences were observed in mean gait speed, SMM, ASM, and RSMI (Table 2). Furthermore, no significant differences were noted in the rates of low SMM, low gait speed, and sarcopenia among the vitamin D quartiles (p>0.05).

Association of vitamin D with skeletal muscle mass and function

As shown in Table 3, serum 25(OH)D was positively associated with grip strength in men (β=0.160, p=0.001) but not in women (β=0.013, p=0.493). No significant associations were seen between 25(OH)D and ASM, RSMI, and gait speed in both men and women (p>0.05) .

The prevalence of sarcopenia, low SMM, and low gait speed were not significantly associated with serum vitamin D in both men and women, irrespective of whether the model was adjusted (p>0.05). However, a significant negative association was found between low grip strength and serum vitamin D in men but not in women, with or without adjustment (Table 4). As listed in Table 4, OR ranged from 0.05 in model II to 0.13 in the unadjusted model (highest quartile vs. lowest quartile of 25(OH)D).

DISCUSSION

Association of vitamin D with muscle mass

Though a 3-year follow-up longitudinal study in the Netherlands found that low serum 25(OH)D (<25 nmol/l) was a risk factor (OR, 2.14; 95% CI, 0.73-6.33) for loss of muscle mass,[9] a recent review summarized the impact of nutrition on muscle mass, strength, and performance in older adults and reported a moderate association between vitamin D status and muscle strength but not muscle mass.[14] To the best of our knowledge, the present study is the first to report an association between vitamin D status and both skeletal muscle mass and function in the elderly in China, showing consistent results with previous studies.[13,14] Few studies have investigated the association between vitamin D and SMM, for which the possible reasons include: 1) SMM has not been widely detected in population-based studies mainly because it is complex, time intensive, and expensive to measure. 2) Compared with muscle function, ameliorating SMM by vitamin D supplements is more difficult. 3) Scholars tend to report positive results for easier publication, thereby leading to bias. Considering the inconsistency in the results in the present literature, additional longitudinal studies are needed to clarify the presence and strength of an association between vitamin D and muscle mass.

Association of vitamin D with skeletal muscle function

Unlike SMM, the association of vitamin D with skeletal muscle function (grip strength, gait speed, and balance) has been studied more frequently in the past, and a positive association has been reported between the two.[8,10,13,20] An early study showed that lower serum 25(OH)D_3 concentrations (<40 nmol/L) were associated with lower handgrip strength and shorter walking distance in community-dwelling elders.[8] A similar result was found in a cross-sectional study in older healthy Chilean adults.[10] A recent study reported that serum 25(OH)D_3 was associated with handgrip strength in older (mean age, 80 years) hip-fracture patients.[13] A prospective study by Visser et al. highlighted that low vitamin D was one of the risk factors

Table 2. Muscle mass and function stratified by serum vitamin D quartiles[†]

	Vitamin D quartile[‡]				F	p
	Q1	Q2	Q3	Q4		
Gait speed (m/s)	1.01 (0.95, 1.06)	0.94 (0.90, 0.98)	0.94 (0.89, 0.98)	0.95 (0.89, 1.00)	2.20	0.09
Grip strength (kg)	26.4 (25.3, 27.6)	27.1 (26.2, 27.9)	28.0 (27.1, 28.9)	28.1 (26.9, 29.2)	2.90	0.03
SMM (kg)	24.2 (23.5, 24.9)	23.7 (23.2, 24.2)	23.5 (23.0, 24.1)	23.5 (22.8, 24.2)	1.20	0.31
ASM (kg)	17.8 (16.8, 18.8)	18.1 (17.5, 18.7)	17.9 (17.4, 18.5)	17.7 (17.0, 18.4)	0.41	0.75
RSMI (kg/m^2)	6.9 (6.8, 7.1)	6.8 (6.7, 7.0)	6.8 (6.7, 6.9)	6.8 (6.7, 7.0)	0.85	0.47
Low SMM (%)	12.0 (11.8, 12.2)	16.0 (15.9, 16.1)	12.3 (12.2, 12.4)	7.3 (7.2, 7.5)	5.45	0.14
Low grip strength (%)	20.0 (19.8, 20.2)	23.89 (23.8, 24.0)	18.1 (18.0, 18.2)	15.5 (15.3, 15.6)	6.46	0.09
Low gait speed (%)	15.2 (5.4, 5.8)	20.5 (20.4, 20.6)	23.2 (23.1, 23.3)	17.1 (16.9, 17.2)	4.35	0.23
Sarcopenia (%)	5.6 (15.0, 15.4)	8.5 (8.4, 8.6)	8.5 (8.4, 8.6)	4.9 (4.7, 5.1)	5.93	0.12

SMM: skeletal muscle mass; ASM: appendicular skeletal muscle mass; RSMI: relative skeletal mass index.
[†]Continuous variables were described as mean and 95% CI. Covariant analysis adjusted for sex, age, sun explore and physical activity was used to test the difference among vitamin D quartiles. Categorical variables were described as prevalence and 95% CI. Chi-square test for the difference of the prevalence among vitamin D quartiles was used.
[‡]Mean and standard error of 25(OH) D in Q1, Q2, Q3, Q4 was 3.5±0.1 ng/mL, 9.0±0.1 ng/mL, 17.0±0.2 ng/mL, and 33.4±0.8 ng/mL, respectively.

Table 3. Multiple linear regression results

	Men			Women		
	B	SE	p	B	SE	p
Gait speed (m/s)	-0.002	0.002	0.267	-0.001	0.001	0.343
Grip strength (kg)	0.160	0.046	0.001	0.013	0.019	0.493
ASM (kg)	-0.010	0.026	0.696	-0.007	0.007	0.341
RSMI (kg/m^2)	-0.005	0.006	0.414	-0.005	0.003	0.120

ASM: appendicular skeletal muscle mass; RSMI: relative skeletal mass index.

Table 4. Multiple logistic regression results[†]

	Men			Women		
	Unadjusted	Model I	Model II	Unadjusted	Model I	Model II
Low gait speed						
Q1	1.00	1.00	1.00	1.00	1.00	1.00
Q2	0.87(0.37, 2.07)	0.61 (0.22, 1.65)	0.64 (0.23, 1.74)	1.72 (0.92, 3.21)	1.82 (0.87, 3.79)	1.63 (0.78, 3.44)
Q3	0.39 (0.15, 1.02)	0.44 (0.15, 1.28)	0.47 (0.16, 1.37)	1.29 (0.69, 2.41)	1.47 (0.70, 3.08)	1.35 (0.64, 2.86)
Q4	0.37 (0.12, 1.16)	0.24 (0.06, 0.99)	0.31 (0.07, 1.29)	1.36 (0.64, 2.88)	1.61 (0.67, 3.90)	1.52 (0.63, 3.71)
Low grip strength						
Q1	1.00	1.00	1.00	1.00	1.00	1.00
Q2	0.78 (0.31, 1.94)	0.73 (0.26, 2.08)	0.58 (0.20, 1.65)	2.37 (1.00, 5.59)	2.22 (0.88, 5.64)	1.98 (0.77, 5.08)
Q3	0.36 (0.13, 1.01)	0.56 (0.18, 1.73)	0.43 (0.14, 1.33)	1.94 (0.82, 4.58)	1.74 (0.68, 4.44)	1.57 (0.61, 4.05)
Q4	0.13 (0.03, 0.67)	0.07 (0.01, 0.66)	0.05 (0.01, 0.48)	1.71 (0.62,4 .72)	1.73 (0.57, 5.31)	1.65 (0.53, 5.08)
Low SMM						
Q1	1.00	1.00	1.00	1.00	1.00	1.00
Q2	1.10 (0.45, 2.69)	1.37 (0.53, 3.52)	1.47 (0.56, 3.87)	1.62 (0.78, 3.37)	1.84 (0.86, 3.95)	1.84 (0.86, 3.95)
Q3	1.05 (0.42, 2.66)	1.12 (0.43, 2.95)	1.25 (0.46, 3.36)	2.15 (0.96, 4.38)	2.43 (0.97, 5.12)	2.43 (0.97, 5.12)
Q4	1.08 (0.38, 3.03)	1.59 (0.52, 4.80)	1.98 (0.63, 6.18)	1.08 (0.43, 2.70)	1.34 (0.52, 3.46)	1.34 (0.52, 3.46)
Sarcopenia						
Q1	1.00	1.00	1.00	1.00	1.00	1.00
Q2	0.46 (0.13, 1.67)	0.63 (0.15, 2.69)	0.90 (0.17, 4.72)	0.57 (0.25, 1.31)	0.49 (0.15, 1.66)	0.89 (0.22, 3.44)
Q3	0.46 (0.13, 1.69)	1.22 (0.26, 5.80)	1.05 (0.16, 6.77)	0.43 (0.19, 0.95)	0.32 (0.10, 1.02)	0.43 (0.12, 1.57)
Q4	0.36 (0.10, 1.40)	0.64 (0.11, 3.77)	0.25 (0.03, 2.12)	0.76 (0.28, 2.08)	1.05 (0.22, 5.14)	1.23 (0.22, 6.78)

SMM: skeletal muscle mass.
[†]Presented as odds ratio and 95% CI for skeletal muscle mass and function with serum vitamin D percentiles. There was no any adjustment in the "Unadjusted" model. Model I was adjusted for sex, age, occupation, sun exposure, physical activities, education, body fat percentage, smoke, alcohol drinking, dietary protein and energy intake. In model II, low grip strength, low gait speed and low SMM, were additionally adjusted for.

for loss of grip strength in the elderly.[9]

The present study revealed sex heterogeneity in the association between vitamin D and muscle strength. Serum 25(OH)D was positively associated with grip strength, and the upper quartile of 25(OH)D was negatively associated with loss of grip strength in men but not in women. These inconsistent findings might be partly attributed to vitamin D receptor (VDR) gene polymorphism. VDRs have been characterized as members of the steroid hormone super-family, acting as a hormone-inducible transcription factor.[21] Vitamin D plays a direct role in skeletal muscle formation via VDRs, most likely through both genomic and nongenomic mechanisms.[22,23] VDRs have been shown to possess various genetic polymorphisms, which may affect the function of the skeletal muscle.[24] A 23% difference in quadriceps strength and a 7% difference in grip strength between the two homozygote types of a restriction site have been reported.[25] Therefore, the genetic polymorphisms of VDR may explain the sex heterogeneity in the association between vitamin D and grip strength; however, this need to be confirmed in future investigations.

Vitamin D was not associated with gait speed in the present study. This may be attributed to some participants not walking at their usual speed during the 4-m gait speed test. Although those with restricted activity were excluded in this study, a few participants had slight activity restriction and could not perform the test at their usual speed. Similar inconsistent conclusions have been observed in randomized clinical trials (RCTs);[11,12,26-28] although some RCTs have demonstrated positive effects,[11,26] Latham et al have reported the lack of significant impact of 25(OH)D on any of the functional outcome parameters in 25(OH)D treated participants.[27,28] In addition to physical activity and nutritional factors, genetic and biological factors such as genotype, hormones, and metabolism are also related to muscle mass and function.[6] Heterogeneity in basic serum vitamin D, nationality, and culture characteristics might also be potential confounders for the association; these factors are difficult to control for in a regional study. The inconsistent results from RCTs might be due to heterogeneity in study design, methodology, and dosage of vitamin D supplement.

Strengths and limitations

It should be noted that this study has some limitations. Firstly, the cross-sectional study design precludes causal inferences regarding the relationship between vitamin D and sarcopenia. Hence, additional experimental and longitudinal studies are warranted. Secondly, blood samples for vitamin D detection were obtained in winter, when the participants may have presented with lower vitamin D concentrations than normal, which might have led to an underestimation of the average vitamin D and might bring a bias in the association. Finally, we used only grip strength and regular gait speed to assess skeletal muscle function. More indicators for muscle strength and physical performance (e.g., isometric knee extensor strength test, timed up and go test, and timed chair stand test) should be included in future studies.

Nevertheless, this study has some strength: this is the first study to investigate the association between vitamin D and both skeletal muscle mass and function in China, and the findings are expected to spur future studies in this field in China. Moreover, nearly 1000 participants from the community were involved in this study, and the response rate was as high as 92.4%.

Conclusions

The present study indicates the role of vitamin D on skel-

etal muscle strength in men, which highlights a new potential way for improving skeletal muscle function in older people.

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AUTHOR DISCLOSURES

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