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Impact of Low 25-Hydroxyvitamin D on Handgrip Strength in Adult Chinese Population

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Abstract

Decreased grip strength is a predictor of adverse outcomes such as disability, immobility, falls, or mortality in the elderly population. Low serum 25-Hydroxyvitamin D has been linked to grip strength. However, its relationship in the adult Chinese population remains unclear. This cross-sectional study involves 4,720 participants in Tianjin, China. Handgrip strength was calculated by a dynamometer (EH101. CAMRY, Guangdong, China). Serum 25(OH)D was assessed by enzyme immunoassay method. The analysis of covariance was used to assess the relation between serum 25-Hydroxyvitamin D and handgrip strength. Among total participants, 36.25% were aged over 50 years and 63.75% under 50 years. For participants over 50 years, the results of handgrip strength per body weight (kg/kg) across serum 25-Hydroxyvitamin D were 0.46, (0.40, 0.52); 0.47, (0.41, 0.53); 0.47, (0.42, 0.53); 0.47, (0.42, 0.53) (Ptrend=0.01), and the results of handgrip strength were 31.7, (27.9, 36.0); 32.5, (28.6, 36.9); 32.6, (28.7, 37.1); 32.8, (28.9, 37.3) (Ptrend=0.02) after adjusting all confounders. However, this relation was not found in subjects under 50 years. Our study showed that low vitamin D was significantly linked to low handgrip strength in subjects aged over 50 years.

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Keywords

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Serum 25(OH)D,
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Vitamin D.

Introduction

Sarcopenia is considered a muscle attenuation syndrome with diminished muscle strength associated with increased risk of falls,[1] disability,[2] hospitalization[3] and mortality.[4] It has become an important global public health issue and has attracted interest over recent decades. The European Working Group on Sarcopenia in Older People emphasizes an essential role of evaluation of muscle attenuation syndrome, including sarcopenia when assessing muscle strength. Since muscle strength is a major determinant of physical function and health status,

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its maintenance will help against diseases over an individual's lifespan.[5]

Vitamin D plays a direct role in skeletal muscle formation via vitamin D receptors found in muscle cells[6,7] and neural cells.[8] Hence, vitamin D inadequacy not only causes cardiovascular diseases, cancer or infections linked to the immune system but also influences hyperparathyroidism to reduce muscle strength.[9] Several studies in the past have investigated the association of vitamin D and muscle strength in elderly population. Moreover, longitudinal studies have demonstrated that older people with lower serum 25-Hydroxyvitamin D suffer from restricted mobility and disability.[10] Muscle strength peaks at around 30 years and attenuates after 50 years, and so does the vitamin D status that is largely dependent on factors such as age and gender. However, the results of previous reports are inconsistent, and this relation in adult Chinese population remains unknown.[11] Therefore, our research investigated impact of ageing on low serum 25-Hydroxyvitamin D and handgrip strength.

Methods

Study Participants

The study population consisted of Tianjin Chronic Low-grade Systemic Inflammation and Health (TCLSIHealth) Cohort, details of which has been reported elsewhere.[12] The protocol of this study was approved by the Institutional Review Board of the Tianjin Medical University and participants signed written informed consent to the study. A total of 4,720 participants underwent a comprehensive health examination including both serum 25-Hydroxyvitamin D examination and handgrip strength assessment.

Measurement of Handgrip Strength

Handgrip strength was calculated by a dynamometer (EH101, CAMRY, Guangdong, China). The dynamometer was adjusted to fit individual hand size, and participants were required to make maximal effort under the same conditions. Participants performed one maximum force trial for each hand. The maximum value of the strength of both sides relative to body weight were the indices best associated with the physical function.[13] In this study, both absolute handgrip strength (kg) and handgrip strength per weight (kg/kg) were analyzed.

Measurement of 25-Hydroxyvitamin D

Serum 25-Hydroxyvitamin D was assessed by an enzyme immunoassay method, (IDS 25-hydroxy Vitamin D EIA kit). The value ranged between 47.7 – 144 nmol/L as per the manufacturer.

Relevant Covariates

The anthropometric variables such as height, weight and waist circumference were assessed by standardized protocols. Body mass index (BMI) was the weight (kg) divided by square of the height (m^2).

The socio-demographic variables, lifestyle and health status were collected by a standardized survey form.

Physical activity (PA) was assessed by the International Physical Activity Questionnaire (IPAQ), well suited for the Chinese population.[14] Metabolic equivalent (MET) were calculated by the formula : MET coefficient of activity (3.3; 4.0 and 8.0, respectively) x duration (hours) x frequency (days). Total PA levels were calculated by combining separate scores for different activities. Depression was determined by Chinese form,[15] and the cut-point was 40 scores.

Total energy intake was collected by survey form and the Chinese food composition tables. The detailed information has been described elsewhere.[16]

All blood tests were performed on empty stomach. Enzymatic method measured serum creatinine. Serum albumin was assessed by the bromocresol green method with the Cobas 8000 analyzer. Metabolic syndrome was explained by the American Heart Association Scientific Statement.[17] The seasons were divided into four categories for blood extraction (Spring, Summer, Autumn and Winter).

Statistical Analysis

Data was analysed by SAS version 9.3 (Statistical Analysis System). Baseline characteristics were tested using ANOVA and logistic regression analysis for continuous and categorical variables respectively. The handgrip strength was considered as a dependent variable. Analysis of covariance was used to assess the relation. Model 1 was the crude, model 2 was adjusted for age, gender, and BMI while model 3 was adjusted for all confounders. P<0.05 considered to be statistically significant.

Results

The characteristics participants according to serum 25-Hydroxyvitamin D are presented in Table 1. Participants over 50 years with a high serum 25-Hydroxyvitamin D evel were more likely Ex-smoker (Ptrend = 0.03); professional (Ptrend < 0.01), and have lower managers (Ptrend < 0.001). Participants under 50 years with a higher serum 25-Hydroxyvitamin D level were more likely physical activity (Ptrend < 0.001); marital status (Ptrend = 0.02) and have lower Ex-Drinker(Ptrend = 0.02); have lower percentage of family history of disease (Ptrend = 0.01). For the moment of taking blood, compared proportion of participants in the highest serum 25-Hydroxyvitamin D level with the other levels tended to a low in spring (Ptrend < 0.0001) and a high proportion of summer (Ptrend < 0.0001) and autumn (Ptrend < 0.0001).

Table 1: Baseline characteristics of participants according to serum 25-Hydroxyvitamin D quartiles stratified (n=4,720)[a]

Basic characteristics	Quartiles of serum 25-Hydroxyvitamin D level				p for trend [a]
	Level 1	Level 2	Level 3	Level 4	
Age ≥ 50 years	428	429	425	429	-
Age (y)	58.2, (57.6, 58.8)b	57.7, (57.1, 58.2)	57.2, (56.6, 57.7)	58.2, (57.6, 58.8)	0.01
BMI (kg/m^2)	25.4, (25.1, 25.7)	25.3, (25.0, 25.6)	25.7, (25.4, 26.0)	25.0, (24.7, 25.3)	0.17
WC (cm)	87.4, (86.5, 88.3)	87.3, (86.4, 88.3)	88.0, (87.1, 89.0)	86.8, (85.9, 87.7)	0.32
Physical activity (Mets ×) hour/week	12.3, (10.8, 14.0)	12.6, (11.0, 14.3)	13.8, (12.1, 15.8)	15.4, (13.5, 17.5)	0.22
Total energy (kcal)	2005.1, (1950.6, 2061.1)	2007.4, (1952.9, 2063.4)	2032.9, (1977.5, 2089.9)	2034.7, (1979.5, 2091.5)	0.49
Serum Albumin (g/dl)	45.5, (45.3, 45.7)	45.7, (45.4, 45.9)	45.8, (45.6, 46.0)	45.6, (45.3, 45.8)	0.07
Serum creatinine (mg/dl)	68.1, (66.8,) 69.4	68.4, (67.1, 69.7)	68.5, (67.2, 69.8)	70.1, (68.8,) 71.4	0.64
Self-rating depression scale (SDS) score	34.5, (33.7, 35.3)	34.9, (34.1, 35.7)	33.9, (33.1, 34.7)	34.5, (33.8, 35.3)	0.28
Metabolic syndromes (yes, %)	41.4	41.0	43.5	39.2	0.70
Smoking status (%)					
Smoker	25.2	23.1	23.1	20.8	0.14
Ex-smoker	9.35	8.86	13.7	12.8	0.03
Drinking status (%)					
Everyday	9.67	10.1	12.8	10.1	0.54
Sometime	53.1	51.8	53.0	56.2	0.32
Ex-drinker	8.49	8.43	8.08	8.00	0.76
Educational level (≥college grade, %) Occupation (%)	44.9	41.1	40.3	40.1	0.15
Managers	44.0	34.7	31.8	28.7	<0.001
Professionals	9.60	14.1	17.7	15.9	<0.01
Income (≥10,000 Yuan, %)	33.1	39.7	32.9	37.3	0.58
Marital status (married, %)	98.4	99.3	99.8	99.1	0.21
Sleep duration (6.5-7.5h, %)	41.8	37.1	41.7	35.2	0.15
Family history of diseases (%)					
Diabetes	25.9	29.1	25.4	29.1	0.54
Hyperlipidemia	0.00	0.23	0.47	0.23	0.38

Hypertension	54.4	57.3	57.9	53.6	0.85
Cardiovascular disease	42.3	39.2	41.2	36.6	0.15
Season of measurement (%)					
Spring	60.1	44.8	29.9	23.7	<0.0001
Summer	21.6	26.6	31.4	41.1	<0.0001
Autumn	9.55	20.3	30.2	26.9	<0.0001
Winter	8.71	8.36	8.43	8.28	0.85
	Level 1	**Level 2**	**Level 3**	**Level 4**	
Age < 50 years	753	752	750	754	-
Age (y)	40.3, (39.8, 40.8)	40.7, (40.2, 41.2)	39.9, (39.4, 40.4)	40.0, (39.5, 40.5)	0.25
BMI (kg/m^2)	24.3, (24.1, 24.6)	24.5, (24.2, 24.7)	24.4, (24.2, 24.7)	24.3, (24.0, 24.6)	0.47
WC (cm)	82.3, (81.6, 83.1)	83.4, (82.6, 84.2)	82.8, (82.0, 83.6)	82.3, (81.5, 83.1)	0.41
Physical activity (Mets × hour/week)	8.76, (8.00, 9.60)	9.62, (8.77, 10.5)	11.4, (10.4,) 12.4	9.88, (9.02, 10.8)	<0,001
Total energy (kcal)	2020.8, (1980.3, 2062.2)	1995.9, (1955.8, 2036.8)	1996.5, (1956.3, 2037.4)	2012.8, (1972.4, 2053.9)	0.41
Serum Albumin (g/dl)	46.3, (46.1, 46.5)	46.4, (46.2, 46.6)	46.4, (46.2, 46.6)	46.3, (46.1, 46.5)	0.44
Serum creatinine (mg/dl)	67.4, (66.5, 68.4)	67.6, (66.6, 68.6)	67.9, (66.9, 68.9)	68.7, (67.7,) 69.7	0.54
SDS score	35.3, (34.8, 35.9)	35.5, (35.0, 36.1)	35.1, (34.6, 35.7)	35.7, (35.1, 36.3)	0.65
Metabolic syndromes (yes, %)	26.2	25.3	24.7	23.5	0.22
Smoking status (%)					
Smoker	24.7	21.8	22.7	20.7	0.10
Ex-smoker	4.38	6.25	6.93	6.50	0.07
Drinking status (%)					
Everyday	4.92	5.60	4.32	7.30	0.11
Sometime	63.4	63.6	62.8	65.3	0.53
Ex-drinker	10.1	9.60	9.72	6.51	0.02
Educational level (≥college grade, %) Occupation (%)	69.6	67.1	65.5	67.6	0.32
Managers	43.8	38.6	37.7	40.9	0.22
Professionals	13.2	15.1	15.7	14.5	0.42
Income (≥10,000 Yuan, %)	54.1	57.4	53.3	55.7	0.91
Marital status (married, %)	91.9	94.1	94.3	95.0	0.02
Sleep duration (6.5-7.5h, %)	36.5	37.5	32.3	34.8	0.18
History of diseases (%)					
Diabetes	29.6	27.5	26.8	26.8	0.21
Hyperlipidemia	0.53	0.27	0.53	0.27	0.60
Hypertension	57.4	56.3	56.3	53.6	0.16
Cardiovascular disease	35.2	33.5	33.3	28.8	0.01
Season of measurement (%)					
Spring	51.8	41.6	25.4	16.3	<0.0001
Summer	30.3	27.5	41.2	47.7	<0.0001
Autumn	9.25	19.4	26.7	28.9	<0.0001
Winter	8.66	11.5	6.65	7.14	0.06

a Analysis of variance.

b Geometric mean (95% confidence interval) (all such values).

Table 2 summarizes the association between quartiles of serum 25-Hydroxyvitamin D and handgrip strength. For participants over 50 years, after adjustment confounder, the results of handgrip strength per weight (kg/kg) across serum 25-Hydroxyvitamin D quartiles were 0.46, (0.40, 0.52); 0.47, (0.41, 0.53); 0.47, (0.42, 0.53); 0.47, (0.42, 0.53) (Ptrend = 0.01), and the means (95%CI) of absolute handgrip strength were 31.7, (27.9, 36.0); 32.5, (28.6, 36.9); 32.6, (28.7, 37.1); 32.8, (28.9, 37.3) (Ptrend = 0.02). There were significant differences in serum 25-Hydroxyvitamin D quartiles both handgrip strength per body weight and absolute handgrip strength, and especially the mean values of the higher serum 25-Hydroxyvitamin D level tended to increase. However, for participants below 50 years, there was no significant relation between handgrip strength per weight and absolute handgrip strength with serum 25-Hydroxyvitamin D levels.

Table 2: Adjusted associations of serum 25-Hydroxyvitamin D with handgrip strength (n=4,720)[a]

	Quartiles of serum 25-Hydroxyvitamin D				p for trend[a]
	Level 1	Level 2	Level 3	Level 4	
Subjects aged ≥ 50 years	428	429	425	429	-
Hand grip strength per body weight (kg/kg)					
Model 1[b]	0.45, (0.44, 0.46)	0.47, (0.46, 0.48)	0.47, (0.46, 0.48)	0.47, (0.46, 0.48)	0.07
Model 2[c]	0.44, (0.44, 0.45)	0.45, (0.45, 0.46)	0.46, (0.45, 0.46)	0.46, (0.45, 0.46)	<0.01
Model 3[d]	0.46, (0.40, 0.52)	0.47, (0.41, 0.53)	0.47, (0.42, 0.53)	0.47, (0.42, 0.53)	0.01
Hand grip strength (kg)					
Model 1	31.7, (30.7, 32.7)	32.6, (31.6, 33.6)	33.0, (32.0, 34.1)	32.7, (31.7, 33.7)	0.06
Model 2	30.5, (30.0, 31.0)	31.2, (30.7, 31.7)	31.4, (30.9, 31.9)	31.6, (31.0, 32.1)	0.01
Model 3	31.7, (27.9, 36.0)	32.5, (28.6, 36.9)	32.6, (28.7, 37.1)	32.8, (28.9, 37.3)	0.02
	Level 1	**Level 2**	**Level 3**	**Level 4**	
Subjects aged < 50 years	753	752	750	754	-
Hand grip strength per body weight (kg/kg)					
Model 1	0.50, (0.49, 0.51)	0.50, (0.49, 0.51)	0.50, (0.49, 0.51)	0.50, (0.49, 0.51)	0.60
Model 2	0.49, (0.49, 0.5)	0.49, (0.48, 0.49)	0.49, (0.48, 0.5)	0.49, (0.48, 0.49)	0.89
Model 3	0.49, (0.40, 0.60)	0.49, (0.40, 0.60)	0.49, (0.40, 0.60)	0.49, (0.40, 0.60)	0.81
Hand grip strength (kg)					
Model 1	34.7, (33.9, 35.5)	34.7, (33.9, 35.4)	34.5, (33.8, 35.3)	34.3, (33.6, 35.1)	0.78
Model 2	33.7, (33.3, 34.1)	33.6, (33.2, 34.0)	33.5, (33.1, 33.9)	33.3, (32.9, 33.7)	0.57
Model 3	33.6, (27.5, 41.0)	33.6, (27.5, 40.9)	33.5, (27.4, 40.9)	33.4, (27.3, 40.7)	0.75

[a]Analysis of covariance.
[b]Model 1 was the crude.
[c]Model 2 was adjusted for age and body mass index.
[d]Model 3 was adjusted for variables in model 2 plus other confounder factors
[e]Geometric mean (95% confidence interval) (all such values).

Discussion

The data in the cross-sectional study were derived from the TCLSI Health Cohort – This cohort collected data on the living status of participants, physical examination, disease history. Additionally, the cohort explored disease incidence based on chronic low-level inflammation system. Our study revealed a significant association between low serum 25-Hydroxyvitamin D and handgrip strength with subjects above 50 years. However, this relation was not significant in subjects under 50 years.

Previous studies have shown a significant relation between serum 25-Hydroxyvitamin D and handgrip strength in the elderly population.[18,19,20] These studies mainly focused on subjects aged over 65 years. Grimaldi *et al.,* have shown a similar association in subjects ranging from 20 to 76 years of age.[21] In another study, subjects displaying positive association were aged between 30-79 years.[22] In humans, skeletal muscle mass declines by around 50% and muscle strength that peaks at 30 years, declines at a rate of 15% from 50 years onwards and further declines by 30% by 70 years of age.[23] Another study demonstrated that muscle strength peaks at 25 to 35 years, moderately maintains between 40 and 49 years, and then starts declining after 50 years.[24] Besides, all age-related changes associated with vitamin D metabolism in 394 worldwide studies along with the meta-analysis 33,266 subjects showed that the decrease in serum 25-Hydroxyvitamin D in participants aged over 75 years (serum 25-Hydroxyvitamin D of subjects aged over 75 years was moderately lower than subjects aged 65 – 75 years [p =0.04].[25] Moreover, a study on vitamin and ageing in nursing homes showed that women aged between 80 and 95 years had normal 25-Hydroxyvitamin D levels while the serum 1,25(OH)2D3 levels were much lower than in women aged 65 to 75 years.[26] Our study stated that handgrip strength starts to decline at around 50 years.[27] Consequently, our study considered that subjects aged over 50 years with lower serum 25-Hydroxyvitamin D levels had significantly weaker handgrip strength than the subjects with high levels. The major contributor of handgrip strength is 1, $25(OH)_2D_3$, which is an active metabolite of 25-Hydroxyvitamin D. Moreover, Vitamin D receptor also functions in several musculoskeletal phenotypes. In many cases, vitamin D receptor polymorphisms have been demonstrated to relate to bone mineral density and multiple fracture risks.[28] Therefore, vitamin D receptor polymorphisms have also been studied with varying muscle strength. Bischoff-Ferrari HA found that vitamin D receptor in skeletal muscle declined significantly with age.[29] Similarly, Simpson also indicated more vitamin D receptor in young skeletal myocytes than old myocytes.[6] A decline in muscle strength occupied by type II fibers caused by ageing that maybe be linked to vitamin D receptor expression decreases the functional the muscle cells to 1,25 $(OH)_2D_3$. During the ageing process, the muscle cells reduced protein synthesis, as well as decline in type II fibers eventually increase the risk of sarcopenia.

Our study has some advantages. The study assessed effect of serum 25-Hydroxyvitamin D on handgrip strength with adjusting all confounders, such as demographics, socioeconomic status, disease history. Secondly, our study emphasize that the low serum 25-Hydroxyvitamin D is linked to handgrip strength in subjects 50 years, which was turning point of this relation. However, the major limitation is its cross-sectional study design due to which results cannot form a basis for the cause of the relation between 25-Hydroxyvitamin D and handgrip strength. Hence, further longitudinal studies are needed to confirm our research.

Conclusion

The present study showed a significant relation between the low serum 25-Hydroxyvitamin D and grip strength in subjects over 50 years, but this relationship doesnot occurs in subjects under 50 years. These findings will form a solid basis for larger future prospective epidemiologic studies to support the view that vitamin D supplementation will possibly reduce the risk of functional limitation, fractures, and disability, including sarcopenia.

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Conflicts of interest

The author(s) do not have any conflict of interest.

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