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Relationship of serum vitamin D level on geriatric syndromes and physical performance impairment in elderly hypertensive patients

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Abstract

Objective To investigate the relationship among serum vitamin D levels, physical performance impairment, and geriatric syndromes in elders with hypertension. **Methods** According to the concentration of vitamin D levels, a total of 143 elderly patients with hypertension were classified into vitamin D deficient group (vitamin D ≤ 20 ng/mL, n = 94) and vitamin D appropriate group (vitamin D > 20 ng/mL, n = 49). Geriatric syndromes and physical performance were assessed by using comprehensive geriatric assessment (CGA). Correlation among vitamin D levels, geriatric syndromes and physical performance was analyzed. **Results** No statistical differences were found in various aspects of geriatric syndromes between the two groups ($P > 0.05$). While correlation analysis indicated that vitamin D levels had a positive association with ADL score ($r = 0.235$, $P < 0.01$) and a negative association with Morse fall scale score ($r = –0.238$, $P < 0.01$). Patients with deficient vitamin D level had longer time both in the Five Time Sit to Stand Test (5tSTS), (15.765 ± 5.593) and the four-meter walk test [7.440 (5.620, 9.200)], a weaker hand-grip in the grip strength test (28.049 ± 9.522), and a lower Tinetti performance-oriented mobility assessment (Tinetti POMA) [26 (22, 27)] and Balance subscale of the Tinetti performance-oriented mobility assessment (B-POMA) score [14 (12, 16)], compared with appropriate vitamin D level [(13.275 ± 3.692); 5.810 (4.728, 7.325)]; (31.989 ± 10.217); [26.5 (25, 28)]; [15 (14, 16), respectively, all $P < 0.05$]. Furthermore, results of logistic regression indicated that vitamin D was significantly associated with 5tSTS (OR = 1.2, 95% CI = 1.050–1.331, $P < 0.01$), Tinetti POMA (OR = 3.7, 95% CI:1.284–10.830, $P < 0.05$) and B-POMA (OR = 0.8, 95% CI:0.643–0.973, $P < 0.05$). **Conclusions** In elderly hypertensive patients, serum vitamin D deficient level is associated with physical performance impairment. However, no statistical significance was found between vitamin D and geriatric syndromes. Further study is required to investigate possible mechanisms for the association between vitamin D and physical performance.

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1 Introduction

Geriatric syndromes and physical performance impairment are commonly considered as multidimensional clinical conditions in older persons. Geriatric syndromes are characterized by the declines of functional, cognitive status and capacities of an elderly person suffering from exogenous and endogenous stressors.[1,2] As previously reported, physical performance impairment is an important contributor to increase risk of geriatric syndromes, and thereby results in frailty, loss of independence and mortality.[3,4]

Vitamin D is known to be important for mineral bone metabolism and muscle tissue.[5] As recently reported, low vitamin D levels in serum are a common health problem for elders,[6] which are associated with a decrease in physical performance and increase in fall incidence as well as risk of fractures.[7–9] Furthermore, it has been demonstrated that those with vitamin D deficiency have more risk of cognitive impairment,[10] depression[11] and anxiety.[12] Hypertension was widely present as a chronic disease in the elderly, meanwhile, in recent years, some studies have shown that low serum vitamin D levels are associated with increased risk of hypertension.[13,14] However, all the results are not very clear.[15–17] Previous experimental studies demonstrated that vitamin D has a function of cellular regulation, and association with the renin-angiotensin system and vascular muscle function by vitamin D receptors (VDRs).[18,19] In clinical studies, vitamin D displays biological effects through its receptors which are located on several tissues, including bones, muscles, and brain neurons.[20,21] Most of

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the studies showed that the lower physical performance associated with vitamin D concentration in blood,[9,22] and vitamin D deficiency could increase the incidence of hypertension incidence.[13] However, there were few researches that focus on the association among geriatric syndromes assessed by comprehensive geriatric assessment (CGA),[23,24] physical performance impairment, and vitamin D in the elderly hypertensive patients.

This study hypothesized that low serum vitamin D level was associated with the increased risk of physical performance impairment in elderly patients with hypertension, including functional decline of gait and balance, muscle strength and stability, which could directly or indirectly affected the presence of various geriatric syndromes.

2 Methods

2.1 Data collection

A total of 143 elderly hypertensive patients admitted to the geriatric ward of the Zhejiang Hospital were recruited in the study from October 2013 to October 2015. All patients were diagnosed with hypertension by clinical cardiovascular physicians according to the 2010 Chinese guidelines for the management of hypertension.[25]

Inclusion criteria for the study included participants aged 65 and older who were able to walk independently, were in-hospital with stable medical status, and ability to write informed consent. Patients who had severe psychiatric diseases [for example: mini-mental state examination (MMSE) score ≤ 10, delirium]; or severe visual and acoustical impairment; or with acute medical conditions (e.g., acute cardiovascular and cerebrovascular diseases), Parkinson's disease, malignant tumor, terminal illness were not included in this study. All patients were informed about the content, aim, and application of the study. The all study protocols have been approved by the medical ethics committee of the Zhejiang Hospital.

Baseline data was collected from a comprehensive geriatric assessment (CGA), including name-surname, sex, age, height and weight, lifestyle factors (e.g., smoking, alcohol intake), medical history, prescription drug use, and history of falling in the recent year were documented. Body mass index (BMI) was calculated using body weight divided by height squared (kg/m^2). Meanwhile, geriatric syndromes and physical performance were assessed by using CGA.

2.2 Geriatric syndromes

In our study, we observed some common geriatric syndromes in elderly hypertensive patients during hospitalization, including functional status, cognitive function, depressive symptoms, nutritional status, history of falls and fall risks, comorbidities, prescribed drugs taken.

Functional status was evaluated with the Activities of daily living (ADL) by using questionnaires of the Barthel Index.[26] Participants were asked to answer ten questions, including controlling bowels and bladder, feeding, moving from chair to bed and return, personal toilet, bathing, dressing, walking, using the toilet, ascending and descending stairs for which they needed assistance. Patients who got a score ≤ 95 in this test were considered as ADL-related disability. Cognitive status was assessed by means of the MMSE,[27] patients with the score ≤ 24 were considered as cognitive impairment. Geriatric depressive symptoms were screened by using the 15-item Geriatric Depression Scale (GDS-15).[28] Sum of score ≥ 6 was considered as having depressive symptoms. The nutritional status was documented by the shortened Mini Nutritional Assessment tool (MNA-SF).[29] Patients with the score ≤ 11 were considered as having the risk of malnutrition. Fall was defined as the unexplained non-accidental falls by patients self-reported in the last year. The participants were asked to answer the questions "Did you ever fall down during the preceding 12 months? If yes, the number of falls, fear of falling and use of any walking aids were recorded. Morse fall scale is a useful tool to predict the risk of anticipated physiological falls in older adults. Patients with the score > 45 in this scale were considered as having a high risk of fall.[30] Patients with five types or more clinical diagnosis were considered as comorbidities. To quantify Poly-pharmacy, we recorded the number of usual medications (prescribed). Drugs for chronic diseases were coded according to the chemical codes and anatomical therapeutic. Patients used with five or more medications were considered as Poly-pharmacy.

2.3 Physical performance

Physical performance was assessed by using Tinetti performance-oriented mobility assessment (POMA), the Five Time Sit to Stand Test (5tSTS) and four-meter walk, grip strength. Before performed these assessments, participants were asked to wear nonslip shoes and walk as briskly as possible with or without walking aids.

Tinetti POMA consisted of balance subscale (B-POMA) and gait subscale (G-POMA) was used to assess the ability of static and dynamic balance,[31] and then infer from the fall risk. The B-POMA with nine tasks of maximum 16 points included sitting balance, arises, attempts to arise, immediate standing balance, standing balance, nudged, eyes closed, turning 360 degrees, and sitting down); G-POMA with seven tasks of maximum 12 points included initiation of gait, step length, step symmetry, step continuity, path, trunk and walking stance. Sum of score ≤ 24 was considered as poor performance in Tinetti POMA test. The higher score indicated the better physical performance and the lower risk of falling.

In the 5tSTS, participants were asked to stand up and sit down from a standard chair (chair height: 44 cm) for five consecutive times without the chair's arm and hands supports, as quickly and safely as possible, the time was calculated. Inability to finish the test indicated worst physical function, and expended longer time indicated more risk of postural stability decline.

The speed of progression and physical capacity was assessed by the four-meter walk test. Subjects walked three trials at a comfortable speed with or without walking aids along a 4-m walkway. The shortest time of each test was recorded and expressed in seconds.

Handgrip strength was used to assess muscle strength by using the Camry EH101 Electronic Hand Dynamometer (Xiangshan Hengqi Corporation, Guangdong, China). Participants performed three times on the dominant hand, and the best result of the test was recorded. Handgrip strength was expressed in kilograms force (kg).

2.4 Laboratory monitoring and classification of vitamin D status

The fasting blood sample of all participants was used for determination of serum vitamin D, Parathyroid hormone (PTH), Calcium (Ca) and Phosphorus (P) levels. The vitamin D level was tested by the electro-chemiluminescence method using a Roche6000 device (Roche, Germany); and PTH level was determined by chemiluminescence method (Beckman, American) using a Beckman BXI800 device; Ca and P levels were determined by arsenazo III spectrophotometric method and molybdophosphate photometric method (Beckman, American), using a Olympus AU5400 device, respectively. All measurements were tested in the Clinical Laboratory of Zhejiang Hospital.

According to the data from vitamin D levels, participants were classified into vitamin D deficient group (vitamin D ≤ 20 ng/mL, n = 94) and vitamin D appropriate group (vitamin D > 20 ng/mL, n = 49).[5,32]

2.5 Statistical analysis

All the data of the study were analyzed using the SPSS version 18.0 software (Statistical Package for the Social Sciences, Chicago, IL, USA). The comparison of statistical difference between vitamin D deficient group (vitamin D ≤ 20 ng/mL, n = 94) and vitamin D appropriate group (vitamin D > 20 ng/mL, n = 49) was performed with the following analysis. Continuous variables with a normal distribution were compared using the unpaired t-test (for present as the mean ± SD), the Mann-Whitney U Test for the data without a normal distribution [for present as the median and interquartile range (IQR)]. Categorical variables were compared using the chi-square test or Fisher's exact test (for present as a percentage or constituent ratio). The associations among serum vitamin D level, geriatric Syndromes and physical performance were evaluated by Spearman rank correlation analysis. Meanwhile, by adjustment for age, sex, BMI, concomitant medical disease, Medical treatment (antihypertensive medications, taking vitamin D supplements, taking Calcium supplements), systolic blood pressure (SBP), diastolic blood pressure (DBP), uncontrolled hypertension, ADL, GDS-15, MMSE, MNA-SF, the binary logistic regression model was performed for further analysis about the relationship between vitamin D levels and physical performance components, odds ratios (ORs) and 95% confidence intervals (CIs) were presented for significant relationship. All statistical analysis was two-tailed, and P < 0.05 was accepted as statistical significance.

3 Results

3.1 Socio-demographic baseline data of the patients

One hundred and forty-three patients with hypertension were included in this study. According to the information on serum vitamin D levels, the patients were divided into two groups: vitamin D deficient group (n = 94, vitamin D ≤ 20 ng/mL) and vitamin D appropriate group (n = 49, vitamin D > 20 ng/mL). The socio-demographic data of two groups was presented in Table 1. Participants with vitamin D appropriate group were likely to be higher in the serum Ca level (2.300 ± 0.097 mmol/L) and lower in the Parathyroid hormone level [39.900 (27.450–48.500) pg/mL], compared with the vitamin D deficient group [2.250 ± 0.141 mmol/L; 47.100 (35.200–58.300 pg/mL), respectively, all P < 0.05] . In addition, correlation analysis found that serum vitamin D level had a weak positive association with serum calcium (r = 0.275, P < 0.01, data not shown) and a negative association with parathyroid hormone (r = –0.223, P < 0.05, data not shown). There were no significant differences in age, gender, body mass index, lifestyle factors (smoking and alcohol intake status) between the two groups (P > 0.05). In terms of serum phosphorus levels, both in taking vitamin D and Calcium supplement, no differences were observed between the two groups, as well as in the concomitant

Table 1. Comparison of baseline characteristics between the vitamin D deficient group and vitamin D appropriate group.

Characteristic	> 20 ng/mL vitamin D (n = 49)	≤ 20 ng/mL vitamin D (n = 94)
Socio-demographic characteristics		
Age, yrs[b]	76.780 ± 6.890	78.170 ± 6.483
Gender (men)	33 (67.3%)	53 (56.4%)
Divorced or widowed	15 (30.6%)	23 (24.5%)
Living alone	28 (63.6%)	71 (76.3%)
Current or former smokers[a]	8 (16.3%)	7 (7.4%)
Current or former drinkers[a]	5 (10.2%)	8 (8.5%)
BMI[b], kg/m^2	23.608 ± 2.933	24.292 ± 3.186
Concomitant medical conditions		
Diabetes mellitus	9 (18.4%)	24 (25.5%)
Cardiovascular disease	23 (46.9%)	45 (47.9%)
Cerebrovascular disease	9 (18.4%)	28 (29.8%)
Renal disease	7 (14.3%)	13 (13.8%)
Musculoskeletal disease	13 (26.5%)	26 (28.0%)
Hypertension correlated characteristics		
Duration of hypertension		
≤ 10 yrs	16 (32.7%)	23 (24.5%)
> 10 yrs	13 (26.5%)	30 (31.9%)
Unknown	20 (40.8%)	41 (43.6%)
Blood pressure, mmHg		
SBP[b]	133 ± 16	133 ± 16
DBP[b]	69 ± 18	70 ± 10
Hypertension stage		
Unknown	17 (34.7%)	28 (29.8%)
Stage 1	6 (12.2%)	5 (5.3%)
Stage 2	13 (26.5%)	26 (27.7%)
Stage 3	13 (26.5%)	35 (37.2%)
Antihypertensive medications		
Calcium channel blockers	26 (53.1%)	55 (58.5%)
ARB/ACEI	26 (53.1%)	49 (52.1%)
Diuretics	11 (22.4%)	22 (23.4%)
Beta blockers	10 (20.4%)	21 (22.6%)
Uncontrolled hypertension	16 (32.7%)	38 (40.9%)
Orthostatic hypotension	9 (18.4%)	17 (18.1%)
Medical treatment		
Taking vitamin D supplements	5 (10.2%)	13 (13.8%)
Taking Calcium supplements	6 (12.2%)	14 (14.9%)
Laboratory data		
vitamin D[b**], ng/mL	27.150 ± 5.911	12.660 ± 4.427
Calcium[b*], mmol/L	2.300 ± 0.097	2.250 ± 0.141
Phosphorus[c], mmol/L	1.100 (1.005–1.190)	1.090 (0.990–1.200)
Parathyroid hormone[c*], pg/mL	39.900 (27.450–48.500)	47.100 (35.200–58.300)

Data are presented as mean ± SD, n (%) or median (IQR); all data were analyzed by the chi-square test unless marked. [a]Fisher's exact test; [b]the unpaired t-test; [c]the Mann–Whitney U-test. $^*P$ < 0.05; $^{**}P$ < 0.01. ACEI: angiotensin-converting enzyme inhibitors; ARB: angiotensin receptor blocker; BMI: body mass index; DBP: diastolic blood pressure; IQR: interquartile range; SBP: systolic blood pressure.

medical conditions such as diabetes mellitus, cardiovascular disease, cerebrovascular disease, renal disease and musculoskeletal disease (P > 0.05).

As for hypertension correlated characteristics, including the hypertension stage, duration of hypertension and anti-hypertension medications, no statistical differences were found between the two groups (P > 0.05). Meanwhile, in terms of SBP, DBP, uncontrolled hypertension, and orthostatic hypotension, results showed no statistical differences between vitamin D deficient and vitamin D appropriate group.

3.2 Association between geriatric syndromes and vitamin D

Of the geriatric syndromes in elders with hypertension, patients with impaired ADL, MMSE, MNA-SF, GDS-15 and Morse fall scale showed no differences between the two groups (P > 0.05). Meanwhile, there were no significant differences in poly-pharmacy, comorbidities, using of walking aids and history of fall in the last year (P > 0.05). While spearman rank correlation analysis indicated that serum vitamin D level was not only negatively associated with Morse fall scale score (r = –0.238, P < 0.01), but also positively associated with ADL score (r = 0.235, P < 0.01). Details are presented in Table 2 and Table 3.

3.3 Comparison of physical performance between vitamin D deficient and vitamin D appropriate groups

Figure 1 shows that in the 5tSTS test, patients in vitamin D appropriate group took shorter time than vitamin D deficient group (13.275 ± 3.692 s *vs*. 15.765 ± 5.593 s, P < 0.01 Figure 1A). The median time of four-meter walk test in

Table 2. Geriatric syndromes correlated characteristics of the vitamin D deficient group and vitamin D appropriate group.

	Vitamin D > 20 ng/mL (n = 49)	Vitamin D ≤ 20 ng/mL (n = 94)	P
ADL (≤ 95 score)	18 (36.7%)	46 (48.9%)	0.164
MMSE (≤ 24 score)	13 (26.5%)	27 (29.0%)	0.753
MNA-SF (≤ 11 score)	7 (14.3%)	16 (17.0%)	0.673
GDS-15 (≥ 6 score)	6 (12.2%)	13 (13.8%)	0.791
Polypharmacy (≥ 5 drugs)	19 (39.6%)	48 (54.5%)	0.095
Comorbidities (≥ 5 diseases)	25 (51.0%)	42 (44.7%)	0.471
Morse fall scale (> 45 score)	37 (75.5%)	71 (75.5%)	0.998
Walking aids	3 (6.1%)	17 (18.1%)	0.050
History of fall in the last year	10 (20.4%)	34 (36.2%)	0.053

Data are presented as n (%); all data were analyzed by the chi-square test. ADL: activities of daily living; GDS-15: 15-item geriatric depression scale; MMSE: mini-mental state examination; MNA-SF: the shortened MNA form.

vitamin D deficient group was longer than in the vitamin D appropriate group [7.440 (5.620, 9.200) *vs*. 5.810 (4.728, 7.325), $P < 0.01$, Figure 1B]. As well as in the grip strength test, statistical difference was observed between vitamin D deficient and vitamin D appropriate group (28.049 ± 9.522 *vs*. 31.989 ± 10.217, $P < 0.05$, Figure 1C). In the balance test, the median score of Tinetti POMA and B-POMA in the vitamin D appropriate group were higher than in the vitamin D deficient group [26.5 (25, 28) *vs*. 26 (22, 27), $P < 0.05$, Figure 1E] *vs*. [15 (14, 16) *vs*. 14 (12, 16), $P < 0.01$, Figure 1D].

3.4 Association of vitamin D level with physical performance

The Spearman rank correlation analysis showed that serum vitamin D level was negatively associated with 5tSTS ($r = -0.249$, $P < 0.05$), as well as four-meter walk ($r = -0.277$, $P < 0.01$), and was positively associated with grip strength ($r = 0.213$, $P < 0.05$), Tinetti POMA ($r = 0.231$, $P < 0.01$), or B-POMA ($r = 0.260$, $P < 0.01$), respectively (Table 3).

Furthermore, as shown in Table 4, after adjusted for age, sex, BMI, concomitant medical disease, Medical treatment (antihypertensive medications, taking vitamin D supplements, taking calcium supplements), SBP, DBP, uncontrolled hypertension, ADL, GDS-15, MMSE, MNA-SF, logistic regression analysis showed significant associations between deficient vitamin D level and poor performance in 5tSTS, low Tinetti POMA and B-POMA score, and no significant association between deficient vitamin D level and low handgrip strength, poor performance in four-meter walk test. We observed that vitamin D deficient group was associated with a higher risk of worse performance in the 5tSTS (OR = 1.2, 95% CI: 1.050–1.331, $P = 0.006$), compared with the vitamin D appropriate group. Patients with vitamin D deficient level were associated with a higher risk of lower score in the Tinetti POMA test (OR = 3.7, 95% CI: 1.284–10.830, $P = 0.016$) than those with vitamin D appropriate level. Further analysis found that patients with vitamin D appropriate level decreased 20% risk of lower B-POMA

Table 3. Association among serum vitamin D level, geriatric syndromes and physical performance in elderly hypertensive patients.

	5tSTS	Four-meter walk	Grip strength	Tinetti POMA	B-POMA	ADL	Morse fall scale
Vitamin D (*r*)	–0.249*	–0.277**	0.213*	0.231**	0.260**	0.235**	–0.238**

Spearman rank correlation analysis indicates statistically significant difference; $^{*}P < 0.05$, $^{**}P < 0.01$. ADL: activities of daily living; B-POMA: the balance subscale of the Tinetti performance-oriented mobility assessment; 5tSTS: Five Time Sit to Stand Test.

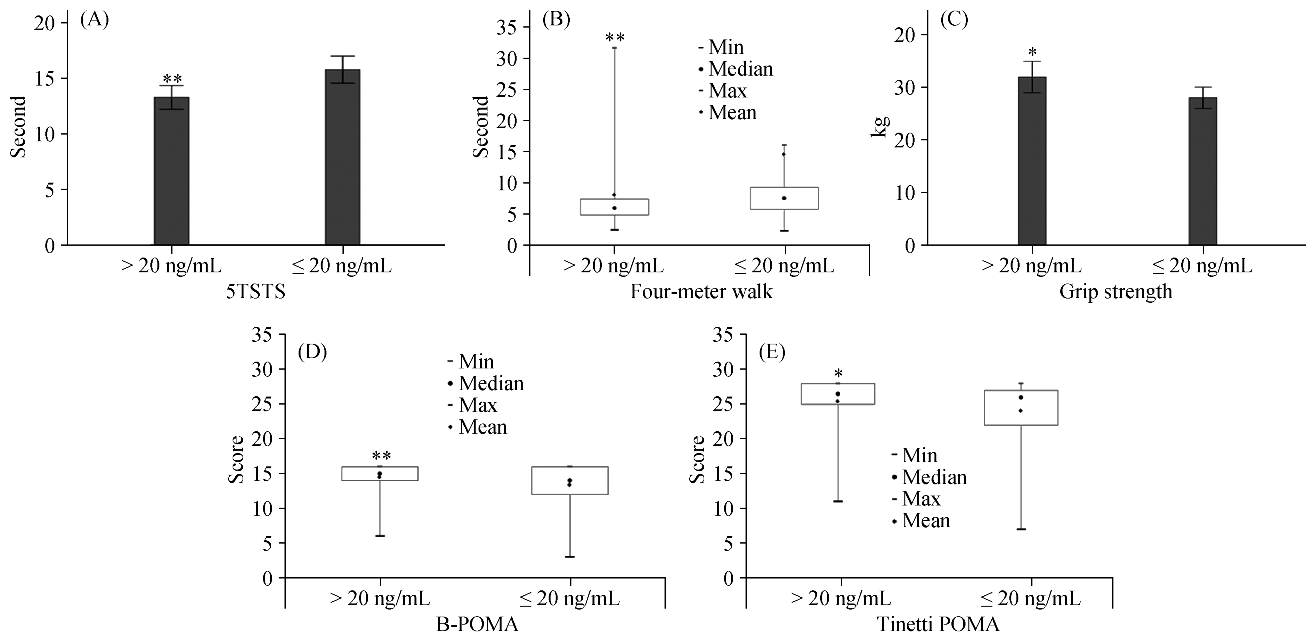

Figure 1. Physical performance of patients according to serum vitamin D group. $^{*}P < 0.05$; $^{**}P < 0.01$, compared to the vitamin D deficient group. (A): 5tSTS, the unpaired *t*-test; (B): four-meter walk, the Mann-Whitney *U*-test,; (C): grip strength, the unpaired *t*-test; (D): B-POMA score: the Mann–Whitney *U*-test,; (E): Tinetti POMA score, Mann–Whitney *U*-test. B-POMA: the balance subscale of the Tinetti performance-oriented mobility assessment; 5tSTS: Five Time Sit to Stand Test.

Table 4. Association between physical performance and serum vitamin D levels in elderly patients with hypertension.

	Vitamin D		
	P	**OR**	**95% CI**
5tSTS	0.006	1.2	1.050–1.331
Four-meter walk	0.993	1.0	0.184–3.633
Grip strength	0.058	0.9	0.891–1.002
Tinetti POMA	0.016	3.7	1.284–10.830
B-POMA	0.027	0.8	0.643–0.973

All data were from logistic regression analysis with adjustment for age, sex, BMI, concomitant medical disease, medical treatment (antihypertensive medications, taking vitamin D supplements, taking calcium supplements), SBP, DBP, uncontrolled hypertension, ADL, GDS-15, MMSE, MNA-SF. ADL: activities of daily living; BMI: body mass index; B-POMA: the balance subscale of the Tinetti performance-oriented mobility assessment; CI: confidence interval; DBP: diastolic blood pressure; GDS-15:15-item geriatric depression scale; MMSE: mini-mental state examination; MNA-SF: the shortened mini nutritional assessment form; OR: odds ratio; SBP: systolic blood pressure; 5tSTS: Five Time Sit to Stand Test .

score than those with vitamin D deficient level (OR = 0.8, 95% CI: 0.643–0.973, P = 0.027).

4 Discussion

In this study, elderly hypertensive patients with lower vitamin D level were more likely to have impairment of physical and functional capacity, including balance, postural stability and mobility than those with higher vitamin D level. We found that patients in vitamin D appropriate group had higher B-POMA and Tinetti POMA score and shorter time in 5tSTS, compared with patients in vitamin D deficient group. Moreover, there was significant association among serum vitamin D levels, functional fitness, risk of falling, serum calcium and parathyroid hormone in participants. However, no relationships were found among serum vitamin D levels, geriatric syndromes, SBP, DBP, hypertension stage, and anti-hypertension medications.

4.1 Physical performance and vitamin D

Various studies have demonstrated relationship between low physical performance and vitamin D deficiency in healthy elderly people.[9,22] In addition, some studies showed similar results in the elderly with aging-related disease, including osteoporosis and peripheral artery disease.[20,33] In line with those previous studies, we did observe this relationship in elderly patients with hypertension. In our analysis, involving 143 elderly hypertensive participants, 94 were in the vitamin D deficient group, and 49 were in the vitamin D appropriate group. Patients with deficient vitamin D level were associated with increased risk of physical and functional impairment, and had a longer time both in the 5tSTS test and the four-meter walk test, and a lower score both in the Tinetti POMA and B-POMA test than those with appropriate vitamin D level. Patients with deficient vitamin D level were also more likely to be weaker in the grip strength test compared with subjects in the vitamin D appropriate group. In the logistic regression analysis, after adjustment for possible confounders, serum vitamin D levels were significantly associated with 5tSTS, Tinetti POMA and B-POMA. Compared with the vitamin D appropriate group, the vitamin D deficient group increased 20% of the risk of postural stability decline. Meanwhile, the vitamin D deficient group increased 2.7 times of the risk of falling than the vitamin D appropriate group, and patients with vitamin D appropriate level decreased 20% of the risk of balance disorders than those with vitamin D deficient level. However, this association was not observed in Four-meter walk and Grip strength. Meanwhile, results in the spearman rank correlation analysis showed only a slight association between serum vitamin D levels and Four-meter walk, Grip strength. Our results are in accordance with previous studies from other authors.[34–36] These findings indicated that other factors, including age-related muscular changes, malnutrition, lacking of physical activity, comorbidity, or inflammation might have had a greater effect on muscle strength and gait speed than vitamin D levels in our body.[37,38] Impairment of physical performance is also commonly accompanied by an increase of age. A great decline of physical ability, which increased risk of vulnerability, hospitalization, disability, and can worsen quality of life in the elders.[39,40] The association of vitamin D deficiency with poor physical performance could be explained by various biological mechanisms. Vitamin D was activated by 1α-hydroxylase in the brain,[41] and the vitamin D receptor (VDR) is present in brain areas, especially in the cerebellum,[42] which is an important area for physical mobility, ability of gait and balance.[43] Furthermore, the VDR was also observed in muscle tissue and neurons,[44,45] which promotes muscle strength, muscle contraction speed, and the neuromuscular function. In current study, in line with the previous research have demonstrated the positive effects of vitamin D on physical performance, including balance and muscle strength,[46] while others shown no associations.[47,48] This discrepancy in the studies might have been resulted from the lack of standardized serum concentration on definitions of vitamin D deficiency and insufficiency,[5] and differences in the characters of research sample.

4.2 Geriatric syndromes and vitamin D

Geriatric syndromes can be a particularly and a greatly important problem for the elderly. Older patients who suffered from diseases such as decline of ADL, gait and balance disorders, cognitive and sensory impairment, depression, poly-pharmacy and incontinence (fecal and/or urinary), which all are defined as geriatric syndromes.[49,50] Previous studies have demonstrated the association between low vitamin D level and limitation in ADL,[51] and an association between vitamin D and the MMSE score.[52,53] However, here in our study, the results showed that no statistical differences in various aspects of geriatric syndromes (ADL, MMSE, MNA-SF, GDS-15, poly-pharmacy, comorbidities, Morse fall scale and history of fall in the last year) between the two groups. While association was analyzed by spearman rank correlation demonstrated that serum vitamin D level was positively associated with ADL score, and negatively associated with Morse fall scale score. Several mechanisms can explain those results. First of all, samples in our study were elderly hypertensive patients, and patients with hypertension have more risk of cardiovascular and stroke events than individuals without hypertension,[54,55] thereby other factors such as blood pressure management and hypertensive complication might have a greater effect on the incidence of geriatric syndromes than serum vitamin D levels. Moreover, geriatric syndromes would appear along with increase of age, and also can appear as an acute medical condition or as an exacerbation of chronic diseases. In addition, deficiency of vitamin D in patients is a process of long-term accumulation, which makes it difficult to investigate an association between deficient vitamin D level and geriatric syndromes.

4.3 Strengths and limitations

The strength of our study was using CGA to collect data for analysis, including functional capability, geriatric syndromes, physical performance. CGA is defined as systematical and multidimensional diagnostic assessments which focus on a frail elder's function status, psychological and medical condition. In fact, CGA has not been routinely applied to elderly Chinese people, who aged 65 years or older in the geriatric outpatient and ward. In addition, our study focused on the association between vitamin D and various aspects of geriatric syndromes, including functional declination, cognitive impairment, depressive, malnutrition, falls and fall risks, comorbidities and poly-pharmacy. However, this study also has a few limitations. Firstly, causes of low vitamin D level in older people were various, including decreased nutritional intake and lack of physical activity with less sunlight exposure, thereby reduced efficiency vitamin D synthesis, but we do not have enough information to investigate the potential mechanism of those factors. Secondly, because of the character of the cross-sectional study, we could not conclude the causal relationship among vitamin D, physical performance and geriatric syndromes. Finally, our study samples were hypertensive inpatients, which may be too partial to explore a significant association of deficient vitamin D level with increased incidence of some geriatric syndromes. Therefore, further studies with larger data, including a normotensive subjects would be needed to observe the possible mechanisms and associations between physical performance and vitamin D levels.

4.4 Conclusions

Our study indicated that for elderly hypertensive patients, deficient vitamin D level was associated with physical performance impairment, especially impaired balance performance and postural stability. Meanwhile, analysis through using CGA for older patients or healthy adults can be a systematical measurement to obtain comprehensive data of an elderly person's functional performance, psychological and medical status. Further studies are required to investigate possible biological mechanisms of the association between vitamin D deficiency and physical performance impairment, and to discover whether effective interventions for physical functional decline could decrease the risk of geriatric syndromes in elders with hypertension.

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