

Vitamin D Status and Its Association with Quality of Life among Community-Dwelling Older Adults in Beijing: A Postprint

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Abstract

Objective: To investigate vitamin D levels among community-dwelling elderly populations in Beijing and their correlation with health-related quality of life, thereby providing decision-making references for improving the life-cycle quality of life in this cohort. **Methods:** From November 2017 to July 2018, clinical information and biological samples were collected from residents across 10 communities in Chaoyang and Fengtai districts of Beijing, and the EQ-5D scale was employed to evaluate participants' quality of life. Based on 25(OH)D levels, 1,066 elderly participants were stratified into vitamin D deficiency, insufficiency, and sufficiency groups for statistical analysis. **Results:** Vitamin D deficiency was identified in 798 individuals (74.86%), insufficiency in 240 individuals (22.51%), with only 2.63% of participants exhibiting sufficient vitamin D levels and no cases of excess. In the deficiency and insufficiency groups, osteoporosis was present in 326 (40.85%) and 80 (33.33%) patients, respectively, compared to 9 (32.14%) in the sufficiency group. Regarding bone mineral density, significant inter-group differences were observed in left hip total T-score, right hip total T-score, and overall hip T-score across vitamin D status groups ($P < 0.05$). For grip strength testing, participants' grip strength demonstrated a declining trend with decreasing vitamin D levels, with statistically significant inter-group differences ($P < 0.05$). In health-related quality of life assessments, the vitamin D sufficiency group exhibited optimal performance in the "pain/discomfort" dimension and EQ-5D total utility value, with statistically significant inter-group differences ($P < 0.05$); no significant differences were observed among groups in remaining dimensions. **Conclusion:** The high prevalence of vitamin D deficiency or insufficiency among community-dwelling elderly populations in Beijing warrants attention. Vitamin D levels are positively correlated with bone mineral density, grip strength, and EQ-5D total utility values in the elderly. Early screening of vitamin D levels and timely adequate supplementation are crucial for maintaining and improving health-related quality of life in this population.

Full Text

Investigation on Vitamin D Level of the Elderly in Beijing Communities and Its Correlation with Quality of Life

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ABSTRACT

Objective: To investigate vitamin D levels among elderly residents in Beijing communities and their correlation with health-related quality of life, providing evidence for improving quality of life across the full life cycle of this population.

Methods: From November 2017 to July 2018, clinical information and biological samples were collected from residents in 10 communities across Chaoyang and Fengtai Districts in Beijing, with quality of life assessed using the EQ-5D scale. Based on 25(OH)D levels, 1,066 elderly subjects were stratified into vitamin D deficiency, insufficiency, and sufficiency groups for statistical analysis.

Results: Vitamin D deficiency was observed in 798 individuals (74.86%), insufficiency in 240 individuals (22.51%), and only 2.63% had sufficient levels; no subjects exhibited vitamin D excess. Osteoporosis was present in 326 patients (40.85%) in the deficiency group, 80 patients (33.33%) in the insufficiency group, and 9 patients (32.14%) in the sufficiency group. Regarding bone mineral density, statistically significant differences were found in left hip overall T-score, right hip overall T-score, and total hip T-score across vitamin D status groups ($P < 0.05$). For grip strength, values decreased progressively with declining vitamin D levels, with statistically significant intergroup differences ($P < 0.05$). In health-related quality of life, the vitamin D sufficiency group demonstrated optimal performance in the “pain/discomfort” dimension and total EQ-5D utility score, with statistically significant differences ($P < 0.05$), while no significant differences were observed in remaining dimensions.

Conclusion: Vitamin D deficiency and insufficiency represent a considerable

public health concern among elderly Beijing community residents. Vitamin D levels correlate positively with bone mineral density, grip strength, and EQ-5D total utility scores. Early screening and timely supplementation of adequate vitamin D intake are crucial for maintaining and improving health-related quality of life in this population.

Keywords: Elderly; Vitamin D; Quality of life; European five-dimensional health scale

Clinical trial registration: China Clinical Trial Registration Center (<http://www.chictr.org/en>), registration number ChiCTR-SOC-17013090

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INTRODUCTION

Population aging has become an extremely serious social issue in China. Data from the seventh national census indicate approximately 264 million people aged 60 and above, accounting for 18.70% of the total population [1]. The *National Medium- and Long-Term Plan for Actively Responding to Population Aging* [2] requires vigorous promotion of Healthy China initiatives and establishment of a comprehensive, continuous elderly health service system encompassing health education, preventive care, disease diagnosis and treatment, and rehabilitation. Consequently, research focusing on health-related quality of life in elderly populations benefits individual health services and lays the foundation for accelerating adjustments to existing health service models.

Vitamin D is a steroid hormone involved in bone and calcium metabolism, with serum levels declining with age [3]. Elderly individuals universally face risks of vitamin D deficiency or insufficiency [4-6], which not only constitute risk factors for osteoporosis, fractures, falls, and muscle weakness, but also increase risks for cardiovascular disease, cancer, diabetes, and respiratory disorders [7]. Recent attention has also focused on associations between vitamin D levels and quality of life [8] as well as mortality [9] in elderly populations.

Currently, domestic studies reporting vitamin D levels and their correlation with quality of life among elderly populations remain limited. Our research group previously investigated 1,540 Beijing community residents [10], systematically screening serum vitamin D levels and evaluating health-related quality of life using the EuroQol five-dimensional questionnaire (EQ-5D). This study obtained preliminary data on vitamin D levels among elderly residents in selected communities of Chaoyang and Fengtai Districts, aiming to provide scientific ev-

idence for guiding elderly populations to maintain adequate vitamin D levels and preserve health-related quality of life.

METHODS

This study utilized data from the BEYOND study database [10] conducted between November 2017 and July 2018 in Chaoyang and Fengtai Districts, Beijing. Following the age definition for elderly populations by the Chinese Gerontological Society [11], 1,066 subjects aged 60 and above were included for analysis. The study was approved by the Ethics Committee of Wangjing Hospital, China Academy of Chinese Medical Sciences (approval number: WJEC-KT-2017-020-P001) and registered with the China Clinical Trial Registration Center (registration number: ChiCTR-SOC-17013090).

Data Collection

Clinical data included: demographic and socioeconomic characteristics, left and right hand grip strength, chair stand test, fracture history, fall history, EQ-5D questionnaire, bone mineral density, and bone metabolism markers.

Osteoporosis Diagnostic Criteria

Dual-energy X-ray absorptiometry (DEXA) equipment (American HOLOGIC Wi) was used to examine the lumbar spine and bilateral hips, recording T-scores and Z-scores for each site. Diagnosis followed the *Guidelines for the Diagnosis and Treatment of Primary Osteoporosis (2017 Edition)* issued by the Chinese Medical Association Osteoporosis and Bone Mineral Disease Branch [12]: T-score ≥ -1.0 indicated normal bone mass; $-2.5 < \text{T-score} < -1.0$ indicated osteopenia; T-score ≤ -2.5 indicated osteoporosis.

Blood Biochemical Indicators

All subjects underwent fasting morning collection of 7 mL elbow venous blood by professional staff. Assays included 25-hydroxyvitamin D3 [25(OH)VitD3], β -crosslinked C-telopeptide of type 1 collagen (β -CTX), procollagen type 1 N-peptide (P1NP), phosphorus (P), magnesium (Mg), calcium (Ca), osteocalcin (OST), and other parameters. Blood samples were uniformly collected and managed by KingMed Diagnostics.

Grip Strength Measurement

Grip strength was measured using the Xiangshan EH101 standardized electronic dynamometer. Subjects were seated with feet flat on the floor, hips and knees flexed at 90°, arms hanging naturally. Each hand grasped the dynamometer with maximum effort, and the displayed values were recorded.

European Five-Dimensional Health Questionnaire (EQ-5D)

The EQ-5D, developed by the EuroQol Group, is a universal quality of life instrument widely used to measure health-related quality of life [13]. The Chinese version demonstrates good reliability and validity [14-15] and is suitable for evaluating quality of life in Chinese populations. The instrument comprises five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression, each with three response levels (no problems, some problems, extreme problems). This study applied Japanese time trade-off (TTO) conversion values to calculate EQ-5D index scores [16] (Table 1).

Statistical Analysis

Statistical analysis was performed using Stata 16.0 software. Normally distributed continuous data were expressed as mean \pm standard deviation (\pm s), while non-normally distributed data were presented as median (quartile range) [M(QR)]. Categorical data were expressed as frequency (%). Intergroup comparisons of normally distributed continuous data employed independent samples t-test or ANOVA, while non-normally distributed data used independent samples Kruskal-Wallis rank sum test. The significance level was set at $\alpha=0.05$, with $P \leq 0.05$ considered statistically significant.

RESULTS

Subject Characteristics

Among 1,066 subjects, 798 (74.86%) had vitamin D deficiency [≤ 20.0 ng/mL], 240 (22.51%) had insufficiency [$20.0-50.0$ ng/mL], and 28 (2.63%) were sufficient [> 50.0 ng/mL].

No statistically significant differences were observed in age, BMI, or marital status across groups ($P > 0.05$). However, significant differences existed in gender, income level, and occupation type ($P < 0.05$). Among males, 197 (60.06%) had vitamin D deficiency, 114 (34.76%) had insufficiency, and 17 (5.18%) were sufficient. Among females, 601 (81.44%) had deficiency, 126 (17.07%) had insufficiency, and 11 (1.49%) were sufficient. Vitamin D deficiency was more prevalent in females than males.

Bone Metabolism Markers, Bone Mineral Density, and Grip Strength

For bone metabolism markers, no significant differences were found in Ca, Mg, or P levels ($P > 0.05$), while significant differences were observed in P1NP, ALP, PTH, OST, and β -CTX ($P < 0.05$). Regarding bone mineral density, statistically significant differences were identified in left hip overall T-score, right hip overall T-score, and total hip T-score ($P < 0.05$), with T-scores increasing progressively from deficiency to insufficiency to sufficiency groups. Osteoporosis

patients numbered 326 (40.85%) in the deficiency group, 80 (33.33%) in the insufficiency group, and 9 (32.14%) in the sufficiency group (Table 5).

For grip strength, statistically significant intergroup differences were observed ($P < 0.05$), with values increasing as vitamin D levels increased. Bone density and grip strength results indicated that vitamin D-sufficient individuals had superior outcomes compared to deficient and insufficient groups. No statistically significant differences were found in chair stand test results ($P > 0.05$) (Table 4).

Quality of Life Assessment

Table 7 presents quality of life assessments by 25(OH)D levels. Among 1,066 subjects, the numbers reporting no difficulties in the five dimensions were 925 (86.77%), 1,053 (98.78%), 1,026 (96.25%), 668 (62.66%), and 935 (87.71%), respectively. Statistically significant differences were found between deficiency, insufficiency, and sufficiency groups in the “pain/discomfort” dimension and EQ-5D utility score ($P < 0.05$).

DISCUSSION

Vitamin D deficiency represents a major global public health issue, particularly pronounced among elderly populations [4-6]. Vitamin D plays a crucial role in bone and calcium regulation; insufficient serum 25-hydroxyvitamin D not only causes osteomalacia, osteoporosis, and rickets, but also leads to neuromuscular dysfunction and fractures [7]. One study measuring vitamin D levels in 1,083 orthopedic patients over 70 years found 86% had insufficient vitamin D, with only 8% in the 30-60 ng/mL range. Moreover, patients with comorbid obesity, hypertension, and osteoporosis had relatively lower vitamin D levels [17]. In a Spanish study of 273 elderly individuals, 89.9% had deficient or insufficient vitamin D levels. Research on 10,100 middle-aged and elderly community residents in Lanzhou reported 75.2% with vitamin D deficiency [18]. Vitamin D influences bone mass by mediating calcium absorption, reversing secondary hyperparathyroidism, and reducing bone turnover [19]. Li et al. [20] found that hip fracture patients had lower bone density and vitamin D levels when femoral neck bone density reached osteoporotic thresholds. However, Guo et al. [21] studied 178 elderly males and found that while 79.78% had relatively or absolutely deficient vitamin D levels, no direct correlation was identified between vitamin D and bone density. Our study focused on Beijing community elderly, revealing only 2.63% with normal vitamin D levels, with deficiency and insufficiency rates of 74.86% and 22.51%, respectively. These figures are slightly higher than other studies, possibly due to: (1) differences in geographic location and health status of study populations, as our research focused specifically on Beijing community elderly; and (2) variations in gender composition, as our study included both males and females.

Vitamin D deficiency constitutes one of the pathophysiological factors contributing to frailty in elderly patients [22]. Previous research indicates that good physical function is essential for fall prevention, while falls and fractures correlate with high mortality. In elderly populations, vitamin D levels correlate positively with grip strength and physical performance, and negatively with fall risk [23-26]. Low vitamin D is associated with low physical activity levels, gait speed, and balance [25]. Furthermore, vitamin D-deficient adults exhibit type 2 muscle fiber atrophy and muscle weakness, while vitamin D supplementation can reverse these characteristics and reduce fall risk in community or hospitalized elderly populations [28-29]. Studies have found correlations between vitamin D levels and composite lower extremity functional performance such as walking and stair climbing, with significant improvements observed after supplementation [31]. A meta-analysis indicated that vitamin D supplementation in community-dwelling elderly may reduce fall frequency through improved muscle function [30]. In vitro studies demonstrate that 25(OH)D or 1,25(OH)₂D can affect muscle cell calcium flux, intracellular signaling, and gene expression [32-35]. In our study, left and right hand grip strength differed significantly across vitamin D groups, with the sufficiency group showing markedly higher values than deficiency and insufficiency groups. However, no significant differences were observed in fall and fracture frequency. The relationship between vitamin D levels and falls/fractures remains controversial. One randomized placebo-controlled trial investigating whether 2,000 IU daily vitamin D₃ reduces fall risk found no reduction in healthy adults [36]. Meta-analyses have not demonstrated a correlation between vitamin D and reduced fall risk, though vitamin D₃ combined with calcium supplements may reduce fall incidence; additionally, vitamin D supplements have not shown benefits in reducing fracture rates [37-38].

The EQ-5D is widely used to assess quality of life in both healthy and patient populations. A study of 273 Spanish elderly subjects aged 65+ found serum vitamin D levels negatively correlated with self-reported anxiety/depression, daily activities, mobility, and three quality of life dimensions [26]. Other researchers have found vitamin D deficiency highly prevalent among patients with depression or anxiety, with supplementation significantly improving mental health [39]. Additionally, studies have identified associations between vitamin D levels and chronic widespread pain in women, though not in men. Grip strength, incorporated in frailty definitions, serves as an indicator of declining motor function and disability, correlating with quality of life [40]. In our study, significant differences were observed in EQ-5D utility scores and pain/discomfort dimension across vitamin D sufficiency, deficiency, and insufficiency groups. Furthermore, significant differences in bilateral grip strength suggest that vitamin D deficiency/insufficiency may affect quality of life through reduced muscle performance. Additionally, vitamin D deficiency is associated with increased risks of major depression and anxiety, potentially impacting quality of life through mental health pathways [41].

In summary, the high prevalence of vitamin D deficiency and insufficiency among elderly populations warrants attention, with vitamin D levels correlating

with bone mineral density, grip strength, and EQ-5D utility scores. Given the current status of vitamin D levels in elderly populations, enhanced screening and timely supplementation for target groups may be crucial for preventing declines in health-related quality of life and adverse health events, potentially yielding significant health and socioeconomic benefits.

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