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Relationship Between Vitamin D Status and Incidences of Falls Among the Elderly in Some South-Eastern Communities of Nigeria

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Abstract: *Background*: Vitamin D has been known to play an important role in musculoskeletal health. As a result, it is postulated that low vitamin D status is responsible for falls in the elderly due to the genomic role of the vitamin on Vitamin-D-receptors (VDR) in muscle cells and its non-genomic role in calcium influx into muscles. Hence, the present study aimed to establish the relationship between serum vitamin D levels and fall events in the elderly to reduce morbidity. *Methods*: It was a prospective, case-controlled, and cross-sectional study of 89 patients aged $\geq$ 60 years that had experienced at least one fall in the previous 12 months in three rural communities of Enugu State and their 124 age-matched controls. Serum 25(OH)D was assayed by enzyme-linked immune-sorbent assay and the number of falls was obtained from interviewer-administered questionnaires. Acquired data were analyzed using descriptive and comparative statistical methods. *Result*: The mean serum 25(OH)D level of patients was significantly lower than that of controls (patients 24.6±7.2 ng/mL versus controls 56.0±9.2 ng/mL; p=0.0001), and showed a significant negative correlation with the number of falls in the elderly (r=-0.347, p=0.002). Nevertheless, no significant difference in serum 25(OH)D levels of male and female patients and control groups was observed (p>0.05). There was a statistically increasing number of falls with increasing age and decreasing serum 25(OH)D levels (p=0.0001) among the patients. *Conclusion*: It can be concluded from this study that serum 25(OH)D level is inversely related to the number of falls experienced by the elderly irrespective of gender.

Keywords: Falls, Elderly, Vitamin D, Serum 25(OH)D

1. Introduction

Within the last decade, there have been substantial revisions in both actions and roles of Vitamin D in many body tissues and different age-related populations [1]. It is now known that Vitamin D does not only play important roles in diseases of the bones but plays significant roles in diseases affecting virtually all cell types of the body tissues [2]. As a result Vitamin D has been implicated in cases of falls, cancer, diabetes mellitus, hypertension, cardiovascular diseases, rheumatoid arthritis, tuberculosis, periodontal diseases, seasonal affective disorders, and

other psychological illnesses to name but a few [3]. Vitamin D deficiency is implicated in the above medical conditions because aside from the role of vitamin D in calcium and phosphorus metabolism, it has been found that virtually all the cells of the body have Vitamin D Receptors (VDR), which the vitamin interacts with to bring about transcriptional processes that modulate gene expression [4].

Fall is one of the conditions associated with vitamin D deficiency that is common among the elderly. It is defined as unintentional coming to rest on the ground or other lower surface with or without loss of consciousness and other than a consequence of sudden paralysis, epileptic seizure, or overwhelming external force [5]. It is estimated globally that a third of the elderly experience falls. The incidence of fall increases exponentially with age: to over an incidence rate of 50% in those aged 80 years and above [6]. It is reported that 30% of the elderly who fall suffer serious injuries, such as hip and other fractures, dislocations, subdural hematoma, head injury, and other soft tissue injuries. More than 60% of those who die from falls are aged 75 years and above [7]. Those who survive a fall suffer significant morbidity with greater functional decline in activities of daily living and physical and social activities. Falls that do not result in serious injury may still have serious consequences for an elderly person, who may fear falling again, which may lead to reduced mobility and increased dependence through loss of confidence [8].

The elderly (persons who according to the United Nations are aged 60 years and above) [9] are more prone to vitamin D deficiency due to the following risk factors: diminished sunlight exposure, decreased dietary intake, reduced skin thickness, impaired intestinal absorption, and impaired hydroxylation in the liver and kidneys [10-19]. This partly explains why the above-mentioned disease conditions associated with low vitamin D status are more common among elderly people.

Consequently, a local study to document the relationship between serum 25-hydroxyvitamin D, a measure of vitamin D status, and experience of falls among this age group with high-risk factors for low vitamin status is timely and its relevance is not to be over-emphasized.

Hence, the present study aimed to establish the relationship between serum vitamin D levels and fall events in elderly patients of Nigerian origin.

2. Materials and Methods

2.1. Study Design/Location/Area

This was a case-control cross-sectional study that involved the determination of the relationship between serum 25-hydroxy vitamin D concentrations and the number of falls among the elderly, which was conducted in three rural communities of Enugu State: Ituku community in Awgu Local Government Area (LGA), Akpakume and Nze communities both in Udi LGA of Enugu state [20]. It was estimated that over 5.3% of its population were elderly people [21] because of the emigration of younger people out of the rural communities. There is adequate sunlight lasting over 5 hours daily for more than 9 months of the year in the communities. Community dwellers are mainly farmers, who work outdoors in their farmlands. All laboratory analyses were done in the Department of Chemical Pathology, University of Nigeria Teaching Hospital (UNTH) Enugu, Nigeria.

2.2. Ethical Consideration

Ethical clearance was obtained from the Human Research Ethics Committee (HREC) of UNTH Enugu before the commencement of the study and permission was sought from community leaders of the communities that were involved in the research. Oral and written informed consent was obtained from each participant before enrolment into the study. But for those who were not mentally fit, their caregivers' approval was obtained.

2.3. Study Population

The study population was made up of a subset of elderly people who experienced falls.

2.4. Eligibility Criteria

2.4.1. Inclusion Criteria

Participants included those aged 60 years and above [9], who had experienced at least one fall in the previous 12 months. Fall was defined as an "unexpected event in which participants come to rest on the ground, floor or lower level [5].

2.4.2. Exclusion Criteria

Subjects who are on vitamin D supplementation, anti-hypertensive medication, anti-diabetic medication, those diagnosed with Parkinson's disease, hypertension, diabetic mellitus, musculoskeletal disease or a history of stroke were excluded from the study.

2.5. Sample Size Determination/Sampling Technique

The sample size was determined using the formula described by Araoye, 2004 [22]. The sampling technique was by the convenient sampling method where participants who satisfied the inclusion criteria and not fulfilling any of the exclusion criteria.

2.6. Data Collection

The survey was done during an organized medical outreach program. Questionnaires were administered by an interviewer to obtain information about their bio-data, medical history, and drug history.

2.7. Sample Collection and Processing

Five milliliters (ml) of venous blood was aseptically collected via venipuncture into plain tubes and allowed to

clot and fully retracted by allowing it to stand for at least one hour. Which was later centrifuged at 1,500g (which was verified by tachometer reading) for 10 minutes using a standard centrifuge (Labofuge II®, United Kingdom). Then serum samples were obtained for measurements of 25-hydroxyvitamin D concentration.

Sera were stored frozen (-20°C, which was verified by thermometer reading and monitored on freezer temperature chart) in a freezer (Haier Thermocool®, China) until analysis was performed. Repeated freeze-thaw cycles were avoided.

2.8. Laboratory Analysis

Serum 25-hydroxyvitamin D Concentration was done using enzyme-linked immunosorbent assay (ELISA) as described by Holick in 2009 [23]. The microwell reader plotted the standard curve and concentrations of 25(OH)D of the samples were read off from the curve.

2.9. Quality Control

Analytical accuracy and precision were ensured during serum 25-hydroxyvitamin D measurements by analysis of commercially prepared control sera (Calbiotech®, USA) to obtain within and between assay coefficients of variation, and also simultaneous analysis of the control sera with each batch of the sample during analysis.

2.10. Statistical Analyses

This was done using Statistical Package for Social Sciences (SPSS) version 25.0 (IBM®, USA). Normality was determined using Shapiro-Wilk analysis. Serum 25-hydroxyvitamin D (25(OH)D) concentrations had a non-Gaussian distribution and so were first logarithmically transformed. Then results of all parameters were then presented as mean ± SD. The student t-test or the analysis of variance (ANOVA) was then used to compare the mean results of each parameter between groups. Pearson's correlation coefficient was used to determine the relationship between 25(OH)D and the number of falls and between age and the number of falls among the participants. A p-value of<0.05 was considered statistically significant.

3. Results

3.1. Demographic and Biochemical Parameters of Patients and Controls

Table 1 shows the comparison of a total of 89 subjects aged 79.1±7.4 years and that of 124 controls aged 79.6±7.5 years with no age difference observed between both groups (p>0.05). Serum vitamin 25(OH)D was significantly lower among the patients compared to that of controls (patients: 24.6±7.2 ng/mL versus controls: 55.8±20.1 ng/mL; p=0.0001) (Table 1).

Table 2 shows results of male participants 25(OH)D as 26.4±7.3 ng/mL, female participants 25(OH)D as 22.7±8.2 ng/mL, male controls 25(OH)D as 52.6±8.7 ng/mL and that of female controls 25(OH)D as 57.2±8.5 ng/mL. No significant difference was observed in the serum 25(OH)D concentrations between the male and female patients on one hand, and between the male and female controls on the other hand (p>0.05) (Table 2).

Table 3 shows the distributions of the mean serum 25(OH)D levels based on the number of falls experienced in the previous 12 months among the patients. The Table showed a statistically decreasing level of serum 25(OH)D levels with increasing number of falls (p=0.0001) among the patients.

Figure 1 presents the Pearson correlation coefficient and p-value for the relationship between 25(OH)D and number of falls (r=-0.347, ρ=0.002) among the patients. Figures 2 and 3 present the Pearson correlation coefficients and p-values for the relationship between serum 25(OH)D levels and number of falls of male (r=-0.248, p=0.037) and female (r=-0.053, p=0.492) participants.

3.2. Age Distribution and Biochemical Parameters of Patients

Table 4 also shows a statistically increasing number of falls with increasing age and decreasing serum 25(OH)D levels (p=0.0001).

Figure 4 presents the Pearson correlation coefficient and p-value for relationship between ages and number of falls (r=0.212, p=0.085) of participants.

Table 1. *Demographic and Biochemical Parameters of Patients and Controls.*

Parameter	Patients M±SD/n	Control M±SD/n	p-value
Number (N)	89	124	NA
Age (years)	79.1±7.4	79.6±7.5	0.786
25(OH)D (ng/mL)	24.6±7.2	56.0±9.2	0.000*

M±SD: Mean ± Standard deviation; *Statistically significant; NA: not applicable.

Table 2. *Demographic and Biochemical Parameters of both Male and Female Patients and Controls.*

Parameter	Group	Male M±SD	Female M±SD	p-value
25(OH)D (ng/mL)	Patients	26.4±7.3 (38)	22.7±8.2 (51)	0.861
25(OH)D (ng/mL)	Controls	52.6±21.7 (62)	57.2±19.5 (62)	0.503

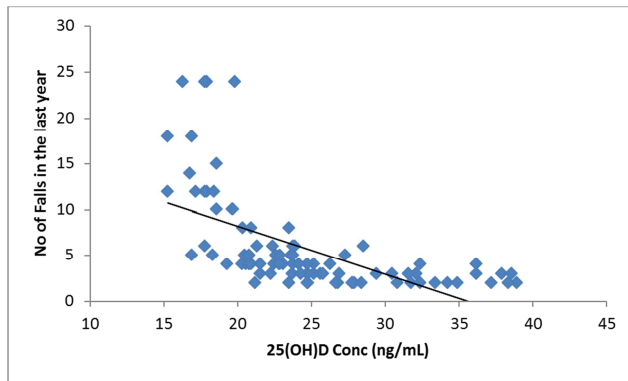*Statistically significant; M±SD: Mean ± Standard Deviation.

Figure 1. Chart showing correlation between 25(OH)D levels and number of falls among the participants (shows significant negative correlation, r=-0.347, p=0.002).
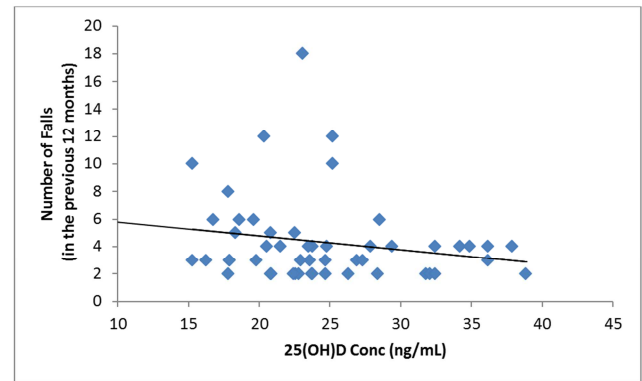

Figure 3. Chart showing correlation between 25(OH)D levels and number of falls of female participants (shows negative correlation with no significant difference, r=-0.053, p=0.492).
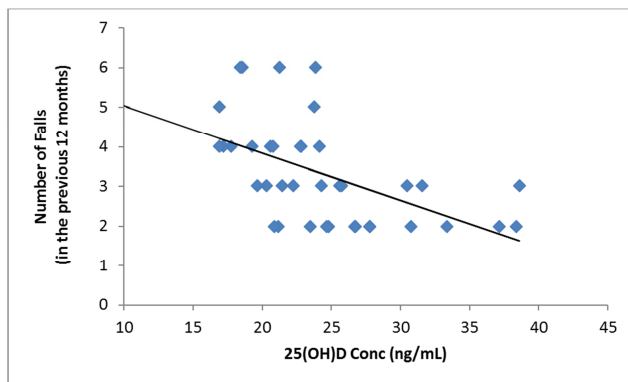

Figure 2. Chart showing correlation between 25(OH)D levels and number of falls of male participants (shows negative correlation with significant difference, r=-0.284, p=0.037).
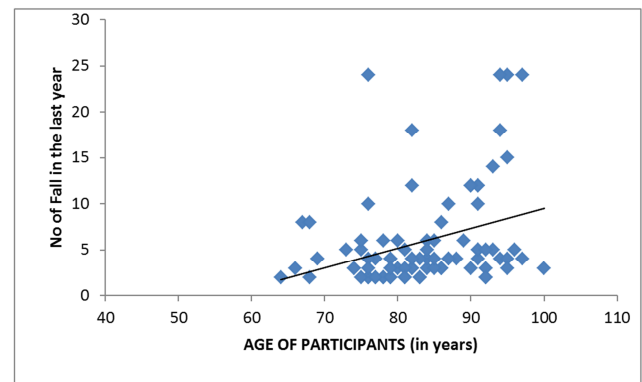

Figure 4. Chart showing correlation between ages and number of falls of participants (shows positive correlation with no significant difference, r=0.212, p=0.085).

Table 3. Biochemical parameters of Patients by Number of Falls.

Number of Falls (in the previous 12 months)	25(OH)D (ng/mL)
1	30.4±8.3
2	26.9±5.2
3	21.3±4.5
4	23.4±6.8
5 and above	18.5±7.1
p-value	0.0001*

*Statistically significant.

Table 4. Age Distribution and Biochemical Parameters of Patients by Age Groups.

Age distribution	Number	25(OH)D (ng/mL)	Number of falls (in the previous year)
60-64	4	32.7±4.4	6
65-69	9	27.2±5.8	13
70-74	11	24.6±7.3	12
75-79	24	20.5±6.4	87
80 and above	41	16.3±5.7	214
p-value	NA	0.0001*	NA

*Statistically significant; NA: not applicable.

4. Discussion

In this study, the age of participants was 79.1±7.4 years. The mean age is in the category of old elderly people, which is more than United Nations recommended age of 60 years as a cut-off for defining an elderly [9]. This finding is in agreement with Biscoff-Ferrari *et al* [14] and Dhesi *et al* [15] who observed that their study participants had a mean age of 75.9 years 76.6±6.1 years respectively. This suggests that

falls are more common among the elderly. However, local literature did not show the mean ages of their study participants but only provided their age ranges [12, 13]. It was also observed that serum 25(OH)D levels of patients decreased as their ages increased, with those aged 80 and above having their mean level within the vitamin D deficiency state (<20 ng/mL).

This may likely be associated with the effect of aging on vitamin D bioavailability; as they get older appetite becomes poor, digestion and absorption decrease, metabolic activities of vitamin D activation diminish, and their skins wrinkle, the resultant effect is vitamin D deficiency. It was also observed that the number of times they experienced falls increased with their age, such that on average those aged 80 and above fell more than 5 times in the previous 12 months. This may be related to effect of aging on the CNS and muscle effectors responsible for movement and balance.

There was positive correlation between age of patients and the number of times they experience falls within the previous 12 months although it was not statistically significant (r=0.212, ρ=0.085). Another study reported a strong positive correlation between age and falls among the elderly; as the older adults get older, the number of times they experience falls increases too [24]. But the study used a larger sample size of 4,301, which may explain why their result was statistically significant. This finding may be because coordination of gait, walking and balance involves complex interaction between the CNS and the musculoskeletal system, and such signaling processes are somewhat diminished in the elderly [24].

Finding from this study showed that serum 25(OH)D levels of participants was inversely proportional to the number of times they fell; all those who experienced fall more than once had vitamin D status in the insufficiency and deficiency states (<30 ng/mL) [25].

This is similar to results from other studies where elderly people who experienced falls were vitamin D deficient [26-28]. Additionally, it was observed that serum 25(OH)D levels of patients was lower than that of the controls, and that the mean serum 25(OH)D of these elderly who experienced falls was within the category of vitamin D insufficiency (20-29 ng/mL) [25]. This is in agreement with findings of many other researchers, but these other studies were longitudinal randomized-controlled trials in which baseline 25(OH)D of the subjects showed vitamin D deficient states [26, 27].

The levels of serum 25(OH)D of the participants correlated negatively (r=-0.347, ρ=0.002) with the number of falls among them: the less the concentration of vitamin D, the more the number of times these older adults fall. This is similar to findings in other longitudinal randomized trials in which low vitamin D status have been reported in elderly persons who suffer falls when compared to their healthy controls [27, 29] and that there was a significant reduction of falls in those older adults with vitamin D supplementation [28].

Furthermore, in this study more females (57.3%)

experienced falls. This is similar to a finding in a study in India in which 68% of elderly people who experienced falls were older women [30]. In that study the following observations were noted (i) follow-up surveys demonstrated that the older men remain more physically active than older women, (ii) muscle weakness and loss of lower body strength that follows inactivity are well-known risk factors for falls, (iii) differences in the level of physical activity may explain the reduced rates of falls as well as the severity of fall-related injuries in men, and (iv) the women were said to suffer rapid loss in bone mass in the first five years after menopause [30].

Again, it was found that there were no significant difference in serum 25(OH)D levels among males and females for both subjects and controls. The explanation may likely be the other confounders affecting vitamin D bioavailability overriding the effect of sex hormones. However, it is noteworthy to state that conflicting results have been published about the effect of gender difference on vitamin D status, even with the established role of sex hormones on vitamin D levels [17]. While some found higher levels of the vitamin in men, others found higher levels in women whereas others observed no difference in both genders [16, 18, 19].

For example in one of such studies that found no difference in serum 25(OH)D in both genders, it was postulated that maybe because the females are postmenopausal; so effects of these female hormones are waned off resulting in some biochemical parameters showing patterns similar to their male counterparts [31].

Limitations of the present study

The study design was a cross-sectional study, which is inherently flawed in that it cannot be used to make a causal inference. For example, observed low vitamin D status among the subjects could be the cause of the falls or due to reduced sunlight exposure from decreased outdoor activities resulting from fear of falling again. A prospective observational study would have been used in order to conclude, but for the time limit of this study.

The extent of sunlight exposure in the subjects could not be determined although the effort was made to exclude those with minimal outdoor activities by the use of the questionnaire. Also the amount of vitamin D-rich meal consumed by the subjects was difficult to estimate although effort at ascertaining good appetite was made by the use of the questionnaire.

5. Conclusion

There is low vitamin D status among elderly people who experience falls, such that the lower their serum 25(OH)D, the more the number of times they fall and vice versa. There is a positive correlation between the age of the elderly people who have falls and the number of times they fall; the more they age, the more they fall. Furthermore, there is no significant difference in vitamin D status between elderly males and females.

Disclosure Statement

All the authors do not have any possible conflicts of interest.

Authors' Contributions

All the authors were involved substantially in the concept and design of the study, data acquisition, analysis and interpretation of the data, drafting the article, revising the article critically for its intellectual content, and in the final approval of the version to be published.

Data Availability

The data analyzed and used in this study may be shared with other researchers on reasonable request provided the data comply with the same standards as the main dataset.

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