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PREVALENCE OF VITAMIN D INSUFFICIENCY AMONG OLDER ADULTS IN KNUST HOSPITAL, KUMASI

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ABSTRACT

Vitamin D insufficiency is a common issue among older adults, often attributed to inadequate sunlight exposure and a lack of vitamin D foods in their diets. This study focused on assessing the prevalence of this deficiency among older adults in Kumasi. It examined factors such as their sunlight exposure duration, consumption of vitamin D-rich foods and various body composition parameters. Conducted as a cross-sectional study, the research encompassed 125 regular attendees of the Geriatric Clinic at KNUST Hospital. Vitamin D concentrations were determined through blood analysis, while structured questionnaires assessed sunlight exposure duration and dietary intake of vitamin D-rich foods. Anthropometric measurements were also conducted to assess body composition parameters. The prevalence of vitamin D insufficiency, sunlight exposure duration, and body composition parameters were analysed using frequency distribution analysis. Additionally, Principal Component Analysis was utilized to predict dietary patterns associated with the consumption of vitamin D-rich foods. Results revealed that a significant proportion of participants (70.4%) had insufficient levels of vitamin D. Only 6.4% had sufficient duration of sunlight exposure, and a mere 22.3% were likely to include vitamin D-rich foods in their diets. Furthermore, the majority exhibited elevated values in the body composition parameters, including body fat (64.5%), visceral fat (95.6%), BMI (60.8%), and muscle mass (48%). The study uncovered a significant lack of adequate vitamin D levels in the older adults, which can impair their muscle performance and overall wellbeing. Consequently, it is crucial for them to engage in activities that can boost their vitamin D levels.

Keywords: Vitamin D insufficiency, sunlight exposure, vitamin D foods, older adults

INTRODUCTION

Vitamin D, classified as a fat-soluble steroid vitamin (Albahrani and Greaves, 2016), originates from two primary sources: dietary intake and endogenous production (Kweder and Eidi, 2018). Vitamin D_2 (ergocalciferol) and vitamin D_3 (cholecalciferol) are derived from dietary sources, with ergocalciferol sourced from plants and cholecalciferol from animal products. Sunlight stands as the primary natural supplier of vitamin D (Shah and Gupta, 2015), (Rosen, 2011) prompting endogenous synthesis upon exposure. According to Holick (2007), when the skin is exposed to sunlight of appropriate wavelength (290 -315 nm), 7-dehydrocholesterol in the epidermis and dermis absorb the ultraviolet B (UVB) radiation and converts to previtamin D_3, which undergoes thermal isomerization to form vitamin D_3 in the body. Regardless of the vitamin D source, it undergoes hepatic hydroxylation to form 25-hydroxyvitamin D [25(OH)D], subsequently converting into the active 1,25-dihydroxyvitamin D [1,25(OH)2D]. The concentration of 25(OH)D in the serum reflects overall vitamin D concentrations in the body (Holick, 2009).

Vitamin D is intricately involved in numerous physiological mechanisms crucial for upholding calcium homeostasis, as well as regulating other minerals like phosphate, iron, and zinc (Magno *et al.,* 2011), (Molina *et al.,* 2017). It plays a pivotal role in enhancing bone health by facilitating the absorption of intestinal calcium (Anderson *et al.,* 2012), supporting metabolic functions (Magno *et al.,* 2011), and promoting neuromuscular transmission (Kweder and Eidi, 2018). These effects collectively contribute to the enhancement and optimal functioning of both bones and muscles. Research has indicated that vitamin D supplementation can elevate fracture healing rates and reduce the incidence of bone fractures (Clutton and Perera, 2016). A research finding has demonstrated a direct correlation between reduced serum 25(OH)D concentrations and the emergence of frailty syndrome (Gutiérrez-Robledo *et al.,* 2016).

The intake of vitamin D-rich foods and exposure to sunlight hold the potential for elevating serum 25(OH)D levels (Kung and Lee, 2006). Sources like mushrooms, egg yolk, oily fish (such as salmon, mackerel, sardines, and tuna), and fortified foods are recognized for their notable vitamin D content. Among these, oily fish stands out with the highest vitamin D concentration. A 3.5 oz (100g) serving of cooked salmon can provide about 500 -1000 IU of vitamin D (Bates *et al*., 2014). While sunlight exposure contributes to vitamin D reserves, various factors such as sunscreen application, increased skin pigmentation and some cultural practices can reduce the skin's ability to trigger production of vitamin D, consequently impacting serum vitamin D levels.

Body composition factors, including body fat, can influence the body's accessibility to vitamin D. Several researchers have noted that an excess accumulation of fat can lead to a decrease in the body's stores and availability of vitamin D (Cassity *et al*., 2016), (Bhatt *et al.,* 2014), (Golzarand *et al.,* 2018).

On a global scale, approximately one billion individuals are reported to suffer from vitamin D insufficiency (Holick, 2007), (Palacious and Gonzalez, 2014). Amongst this estimate, the prevalence of insufficient vitamin D levels in the older population ranges from 14% to 59% (Holick, 2007). Notably, within the United States, vitamin D insufficiency is observed in 41.6% of Americans, with the highest rates seen in the black population (82.1%), followed by Hispanics (69.2%) (Forrest and Stuhldreher, 2011). Similarly, in South Africa, the reported prevalence of vitamin D deficiency and insufficiency stands at 27% and 38%, respectively (Chutterpaul *et al.,* 2019). Vitamin D insufficiency stands as a significant health concern; however, research specific to older adults in Kumasi remains limited, underscoring the motivation behind this current study. The objective was to assess the prevalence of vitamin D insufficiency among older adults in Kumasi. The insights gained from this study could offer potential interventions that could effectively address vitamin D insufficiency among older adults.

MATERIALS AND METHODS

Study Design and Setting

A cross-sectional study was conducted among 125 older adults who were 55 years and above.

Participants were recruited from the Kwame Nkrumah University of Science and Technology (KNUST) hospital in the Kumasi Metropolitan district of the Ashanti Region, Ghana.

Study Participants and Sample Size

Older adults attending the Geriatric Clinic at KNUST hospital were included in the study. A sample size of 125 was determined using Cochran's formula (Cochran, 1977). Approval was obtained from the Committee on Human Research, Publication and Ethics of the School of Medical Science, KNUST with the approval ID (CHRPE/AP/656/19) and KNUST Hospital. A consent form was signed by all participants before the commencement of the study.

Data Collection

A structured questionnaire was used to obtain information from the participants. Data collected included socio-demographics, duration of sunlight exposure, height, body composition parameters (body fat, visceral fat, muscle mass, and body mass index (BMI)), and biochemical data (vitamin D concentration).

Anthropometric Measurements

The heights of the participants were measured using a Stadiometer (Seca 213, mechanisch, cm/inch, China) to the nearest 0.1 centimetres. Body composition parameters were measured using the Bioelectrical Impedance Analyzer (Omron; model: HBF-514C). The participants were classified as having low, normal, or high parameters with the use of the cut-off points provided in the equipment's manual.

Determination of Vitamin D Concentration

Sample Collection

The participants' vitamin D levels were assessed using the Human Vitamin D Enzyme-Linked Immunosorbent Assay (ELISA) kit (MyBioSource, MBS735897). A volume of 5mls of venous blood was collected from the participants in a fasting state. To ensure aseptic conditions, the blood collection site was gently wiped with alcohol-soaked cotton before blood extraction. The obtained blood samples were placed into gel separating tubes and identified with participants' unique codes. Subsequently, the tubes were subjected to centrifugation at 5000rpm for a duration of five minutes. The resulting serum was carefully separated and transferred into labeled Eppendorf tubes, each corresponding to the participants' unique codes. The serum samples were placed in a refrigerator at a temperature of -4^{o}C.

Principle of the Assay Used

Enzyme Linked Immunosorbent Assay (ELISA) is based on the competitive binding enzyme immunoassay technique. The microtiter plate (Thermo Fisher Scientific Oy, Microplate reader, 51119100, Finland) is precoated with an antibody that is specific to vitamin D. In the reaction process, vitamin D in the blood sample competes with a fixed amount of biotin-labelled vitamin D for sites on the precoated monoclonal antibody. Excess conjugate and unbound samples and standards are washed from the plate with a diluted wash solvent in a microplate washer (Thermo Fisher Scientific Oy, Microplate washer, 5165000, Finland). After washing, avidin conjugated to Horseradish Peroxidase (HRP) and tetramethylbenzidine (TMB) substrate solution was added subsequently to each of the wells. The enzyme-substrate reaction was then brought to completion by adding a sulphuric acid solution and the colour change was spectrophotometrically measured at a wavelength of 450nm.

Procedure for Determining Vitamin D Concentrations Using ELISA

The samples designated for analysis were transferred from the refrigerator to room temperature. The samples stayed at room temperature for about 15-30 minutes before the commencement of the analysis. The necessary quantity of wells, as per the analysis requirement, was extracted from a sealed bag and securely placed into their designated holder. Among these, six wells were allocated for standards, considering the presence of six standard concentrations (48, 24, 12, 6, 3, 0ng/mL). The standard solution, comprising 50µL, was dispensed into the respective standard wells. For the testing sample wells, 40µL of the dilution solution was added initially, followed by the addition of 10µL of the actual samples.

The solutions within the wells were gently mixed for about 30 seconds. Subsequently, 100µL of the HRP-conjugate reagent was exclusively added to the testing sample wells. The samples, once covered with a closure plate membrane, were incubated for 60 minutes at a temperature of 37°C. Following the incubation period, the closure plate membrane was removed, and the liquid contents of the wells were discarded. The wells underwent five rounds of rinsing with the washing buffer, and absorbent paper was utilized to remove any residual water droplets. Each well received 500µL of chromogen solution A and an equivalent volume of chromogen solution B. These solutions were mixed gently for a period of 10 seconds. The samples were subsequently subjected to an additional 15-minute incubation at 37°C. To halt the reaction, 5µL of stop solution was added to each well, leading to a noticeable colour transition from blue to yellow. The concentration of the samples was determined by measuring the absorbance at 450nm within a 15-minute window.

Classification of Vitamin D Status

Vitamin D concentrations below 10ng/ml were categorized as “low,” concentrations ranging from 10 to 29ng/ml were categorized as “insufficient,” and concentrations greater than 29ng/ml were categorized as “sufficient.” (Ringe and Kipshoven, 2012).

Data Analysis

Statistical Package for Social Sciences (SPSS) version 20 was used to determine the frequency distribution of participants with low vitamin D status, insufficient vitamin D, and sufficient vitamin D. The duration of sunlight exposure was also determined using the frequency distribution of the participants. The dietary intake of vitamin D food patterns was determined using the Principal Component Analysis. Tables and figures were used to summarize the results obtained. Continuous variables with normal distribution were expressed as mean ±SD (standard deviation), while proportions were calculated for discontinuous variables.

RESULTS

Characteristics of Participants

The participants were categorized into two groups based on gender: males and females. A substantial majority of the participants were identified as females, constituting 70.4% of the total. Among the participants, the highest proportion was married individuals, accounting for 52.9%, while only a small fraction, 7.2%, possessed tertiary education qualifications. Furthermore, a significant portion of the participants, comprising

32.8%, had already retired. Table 1 indicates participant's characteristics.

Table 1: Characteristics of Participants

Mean ±SD
Variable N = 125

Age in years	**65.4 ± 8.2**
Variable	Frequency (%)
Gender	
Male	37(29.6)
Female	88(70.4)
Marital Status	
Never married	3(2.4)
Married	65(52.9)
Divorced	9(7.2)
Widowed	44(35.2)
Separated	4(3.2)
Educational Status	
None	21(16.8)
Primary	31(24.8)
JHS	32(25.6)
SHS/Technical/Diploma	32(25.6)
Tertiary	9(7.2)
Employment Status	
Employed for wages	9(7.2)
Self employed	38(30.4)
Retired	41(32.8)
Not working	37(29.6)

Prevalence and classification of vitamin D status among older adults

Table 2 provides insights into the mean vitamin D concentration, the prevalence of vitamin D, and the classification of vitamin D status. Notably, a significant majority of participants (97.6%) exhibited insufficient vitamin D levels. Within this group, 70.4% were classified as vitamin D insufficient, while 27.2% presented low vitamin D concentrations.

Table 2: Prevalence and classification of vitamin D status among older adults

Variable	**Mean ±SD N = 125**
Vitamin D concentrations	18.3 ± 3.2
Prevalence of Vitamin D status	Frequency (%)
Adequate vitamin D	3(2.4)
Inadequate Vitamin D	122(97.6)
Classifications of Vitamin D status	
Low	34(27.2)
Insufficient	88(70.4)
Sufficient	3(2.4)

Duration of sunlight exposure of participants

The evaluation of participants' exposure to sunlight unveiled that a substantial majority (66.4%) spend less than 30 minutes in the sun, whereas only a small fraction (6.4%) reported a duration of sunlight exposure exceeding one hour. The distribution of participants' sunlight exposure duration is represented in Figure 1.

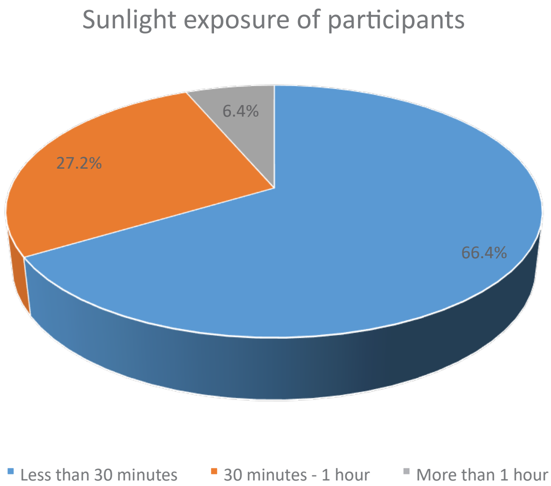

Figure 1: Duration of sunlight exposure of older adults

Dietary pattern of vitamin D food intake of participants

The assessment of participants' dietary patterns related to vitamin D-rich food intake was conducted through Principal Component Analysis, yielding two distinct patterns as detailed in Table 3. The first pattern revealed that 31.7% of participants were inclined to incorporate dairy products, mushrooms, seafood, egg yolk, and other vitamin D fortified foods into their diets. On the other hand, the second pattern demonstrated that 22.3% of participants were more prone to consume oily fish like sardine, salmon, and tuna, along with other fish-based meals. Notably, participants exhibited an inclination away from consuming egg yolk, despite it being source of vitamin D.

Table 3: Dietary pattern of vitamin D food intake of participants

	Pattern 1	**Pattern 2**
	Vitamin D-rich Foods Dairy products, seafood, mushroom, egg yolk, fortified foods	**Oily fish (salmon, sardine, tuna)**
% Variance	31.7%	22.3 %
Dairy products	0.738	
Seafood	0.644	
Mushroom	0.540	
Egg yolk	0.503	-0.605
Fortified foods	0.512	
Oily fish		0.629

Fortified foods such as breakfast cereals, orange juices.

Body composition parameters of participants

The analysis of body composition revealed that a significant majority of older adults exhibited elevated body fat stores (64.5%), high visceral fat stores (56.8%), and a high Body Mass Index (BMI) (60.8%). However, a mere 9.6% demonstrated high muscle mass, with the majority (48%) characterized by low muscle mass, as depicted in Figure 2.

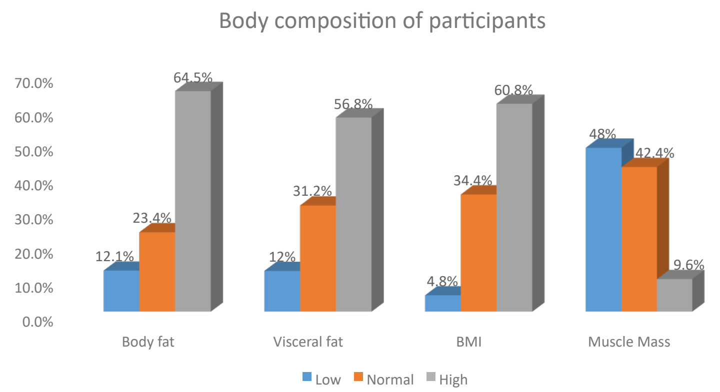

Figure 2: Body composition parameters of participants.

BMI – Body Mass Index.

DISCUSSION

The age of the participants ranged from 55 to 76 years, averaging 65.4 ± 8.2 years. Notably, a significant proportion of the participants were women, accounting for 70.4% of the total sample size. This aligns with a study carried out among older adults in Southern Brazil, where most of their participants were also females (86.7%) and had an average age of 69.3 ± 5.9 years (Oehlschlaeger *et al.,* 2015). Gender imbalances in sample composition are common in studies involving older adults, particularly when focusing on health conditions or behaviours that may be more prevalent or exhibit different patterns between genders. The imbalance may be linked to differences in willingness to participate. In the current study, women demonstrated more interest and willingness to participate than men, likely contributing to this outcome.

The analysis of participants' blood samples showed that majority (70.4%) exhibited insufficient levels of vitamin D. In contrast, only a minor percentage (2.4%) demonstrated sufficient vitamin D levels. Prior research has indicated that increased sunlight exposure and the consumption of vitamin D-rich foods can potentially enhance vitamin D levels (Subasinghe *et al*., 2019), (Bates *et al.,* 2014). In the current study, most (66.4%) participants were found to have less than thirty minutes of sunlight exposure. Subasinghe et al. (2019) reported in their study conducted in Sri Lanka that individuals with higher levels of vitamin D typically had about two hours of sunlight exposure. In contrast, those with limited sunlight exposure exhibited lower vitamin D levels. The authors suggested that prolonged exposure of about two hours may contribute to vitamin D adequacy, as it would stimulate the natural vitamin D synthesis process that will ultimately contribute to vitamin D concentrations. Regarding individuals with insufficient vitamin D levels, the authors attributed it to some practices such as wearing fully covered clothes, regular use of sunscreens, and little or no outdoor activities. Likewise, in the present study, it was noted that a significant portion of the participants predominantly remain indoors because most had retired and were thus primarily at home, leading to a curtailed period of sunlight exposure. This, in turn, limits the internal production of vitamin D, which possibly led to a considerable number of participants having insufficient vitamin D levels.

The study findings unveiled that participants were incorporating vitamin D-rich foods such as mushrooms, egg yolks, and seafood into their diets. However, there was a notable absence of consumption of oily fish (like sardines, tuna, and salmon). This could potentially be attributed to their limited awareness of these robust vitamin D sources, leading them to inadvertently omit these foods from their meals. Consequently, these dietary inclusions might not have been substantial enough to significantly contribute to their vitamin D levels. Bates et al. (2014) reported in their study on the impact of vitamin D foods on vitamin D concentrations that consistent consumption of oily fish and fish-based dishes can account for approximately 8% of the overall daily vitamin D requirement. This insight implies that if the participants had been regularly integrating oily fish and fish-based meals into their diets, it could have conceivably mitigated their deficiency in vitamin D levels.

Regarding the participants' body composition, a substantial portion (48%) exhibited low muscle mass. Vitamin D's influence on muscle mass is well-known, and its role in predicting muscle strength is acknowledged (Stoever *et al.*, 2017). Given that most of the participants demonstrated low muscle mass and consequently diminished muscle strength, there appears to be a potential for improved muscle strength and performance with adequate vitamin D status.

In the context of older adults with vitamin D insufficiency, a study highlighted that muscle biopsies revealed atrophy of type two muscle fibres and a decline in vitamin D receptors within muscles (Dawson-Hughes, 2017). The authors suggested that vitamin D's significance becomes pronounced as an individual ages. Therefore, ensuring sufficient vitamin D levels in older adults becomes crucial to mitigate potential complications to their overall health.

A larger proportion (64.5%) of older adults had elevated body fat levels. Several research studies have indicated that excessive body fat contributes to the development of chronic health conditions and may impede the synthesis and availability of vitamin D within the body (Forney *et al.,* 2014), (Drincic *et al*., 2012). This underscores the possibility that heightened body fat could compromise vitamin D levels. Consequently, reducing body fat could create favourable conditions for vitamin D synthesis. Studies have demonstrated that individuals with excess adiposity tend to exhibit reduced vitamin D concentrations compared to those with normal body fat levels (Cassity *et al*., 2016), (Bhatt *et al.,* 2014). In another study investigating the association between excessive body fat and vitamin D stores, the researchers observed that a reduction in body fat among participants led to a slight increase of 1.5 ng/ml in serum vitamin D concentration (Golzarand *et al.,* 2018). The authors suggested that this rise in concentration can be attributed to the release of vitamin D from the fat mass following fat loss, resulting in the observed elevation in vitamin D levels. Conversely, different researchers did not identify a positive correlation; rather, they noted a negative association between elevated body fat and vitamin D concentrations (Forney *et al.,* 2012). According to the authors, low vitamin D levels in obese individuals are attributed to insufficient intake of vitamin D-rich foods and limited sunlight exposure due to increased indoor activities. However, adiposity has been proposed as a significant factor for low serum vitamin D in individuals (Drincic *et al.,* 2012). Notably, another study indicated that weight reduction and subsequent decrease in fat mass led to an increase in vitamin D concentration. From the author's research, it revealed that about 10% reduction in fat mass resulted in about 4.2 ng/ml increase in vitamin D concentration.

Visceral fat, an integral component of body composition is characterized by excessive fat accumulation around the abdominal region. A significant proportion (56.8%) of the participants within this study exhibited elevated levels of visceral fat. A prospective and cross-sectional studies underscored that heightened visceral fat levels can adversely affect the synthesis and availability of vitamin D (Yao *et al.,* 2015), (Savastano *et al.,* 2017). The prevalent high visceral fat values among majority of the participants possibly contributed to their vitamin D insufficiency. The connection between elevated visceral fat and inadequate vitamin D status is reported to be associated with insulin resistance, a factor recognized for its disruptive impact on glucose homeostasis (Savastano *et al.,* 2017), (Fondjo *et al.,* 2017), (Sakyi *et al.,*2021).

Insufficient levels of Vitamin D have also been associated with elevated parathyroid hormone (PTH) levels, which is reported to also contribute to insulin insensitivity, possibly contributing to the onset of type 2 diabetes mellitus (Yao *et al.,* 2015). These investigations emphasize the adverse effects of vitamin D insufficiency on the overall health of older adults.

Furthermore, the study revealed that a significant portion (60.8%) of participants exhibited high body mass index (BMI). Some researchers have highlighted that elevated BMI can interfere with the functioning of vitamin D within the body (Vitezova *et al*.,2017). The authors study suggest that increased body fat impedes the accessibility and sufficiency of serum vitamin D. Consequently, to attain appropriate vitamin D levels, individuals should strive to reduce excess stored fat, potentially achieved through consistent engagement in moderate physical activity.

Inadequate vitamin D levels can affect the wellbeing of older adults. Thus, it is crucial for them to partake in endeavours that hold the potential to enhance their vitamin D status.

CONCLUSIONS AND RECOMMENDATIONS

The present study reveals a noteworthy prevalence of vitamin D insufficiency among older adults, with 70.4% of the participants falling into this category. These findings suggest that within Kumasi, a concerningly high proportion of older adults visiting the KNUST hospital are grappling with vitamin D insufficiency as a potential public health issue.

Nevertheless, it is recommended that further investigations be conducted across various locales in Kumasi to corroborate these findings. Moreover, enhancing awareness among the older population about the sources and significance of vitamin D for overall health is crucial. Implementing effective lifestyle adjustments such as increasing sunlight exposure, participating in regular physical activity, and incorporating vitamin D-rich foods into their diets are encouraged and adopted by older adults.

To address the risks of vitamin D deficiency among the older population, the government should collaborate with the Ministry of Health to establish a policy for providing vitamin D supplements to individuals entering older adulthood. This preventive measure can help mitigate the potential adverse health effects associated with inadequate vitamin D levels. Notably, Ghana's Ministry of Food and Agriculture, in partnership with the University of Ghana School of Public Health, has recently introduced the country's inaugural National Food-Based Dietary Guidelines tailored to meet the nutritional and health requirements of Ghanaians aged five and above. These guidelines could be updated to include a specific recommendation for older adults to consume vitamin D-rich foods as part of a balanced diet. The incorporation of vitamin D-rich foods in the dietary guidelines, coupled with a vitamin D supplementation program for older adults, can effectively combat the prevalence of vitamin D deficiency among Ghana's older population.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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