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RESEARCH ARTICLE

Relationship of Physical Activity and Vitamin D Levels in Elderly Women

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Abstract

Older adults are at risk of vitamin D deficiency, especially in older women, due to a decrease in the hormone estrogen, which causes decreased bone density and increased risk of fractures. There is a relationship between vitamin D deficiency and lack of physical activity due to the storage of vitamin D in adipose tissue. Physical activity was measured using the International Physical Activity Questionnaire (IPAQ). The aim was to determine the relationship between physical activity and vitamin D in elderly women. This cross-sectional analytic observational study was conducted at Nursing Home X in Surabaya city from May to August 2023. The variables were physical activity (measured by IPAQ to estimate physical activity levels) and vitamin D level (measured by VIDAS® instrument to determine 25(OH) levels). The subjects were all women aged ≥60 years. The sampling technique uses the purposive sampling method. For an analysis of the relationship between physical activity levels and vitamin D levels, the Pearson correlation test was used with a ratio data scale. This research received 49 respondents. The average physical activity level was 1316.82±720.90, and most respondents had a moderate physical activity level of 44.90%. Vitamin D levels were ≤30 ng/ml for 46 respondents (93.87%). The results of the Pearson correlation test were obtained with a r_{value}=0.089 and a significance value (Sig.) of 0.542. There was no significant correlation between physical activity and vitamin D levels. Other factors such as age, health conditions, and vitamin D intake can affect the results. Further research can be developed into measurements to examine physical activity in old age.

Keywords: IPAQ, elderly woman, nursing home, physical activity, vitamin D

Introduction

Vitamin D deficiency is a common global health problem with high prevalence, especially in South Asia countries. Vitamin D mainly regulates calcium and phosphorus metabolism and promotes bone growth.[1] Older adults are at risk of vitamin D deficiency because vitamin D production and metabolism change with age due to various factors, such as reduced sun exposure and skin production capacity.[2] Physically, geriatrics are less active and have poor nutritional status. In addition, there are physiological processes that exacerbate the decrease in vitamin D levels in the body, such as decreased production of vitamin D in the skin after sun exposure caused by skin atrophy, eating foods that are low in vitamin D, impaired gastrointestinal absorption, and decreased production 1,25$(OH)_2$D in the kidney.[3] Vitamin D deficiency is prevalent in postmenopausal women, and this undoubtedly exacerbates the risk of cardiovascular disease and menopause-related dyslipidemia. Estrogen levels drop significantly as women go through menopause, and a lack of estrogen weakens bones. Vitamin D helps the body absorb and use calcium to maintain bone structure. 25-hydroxyvitamin D [25(OH)D] serves the purpose of calcium absorption and appears to be hormonally sensitive. Vitamin D deficiency is associated with low bone mass and increased fracture risks. Menopausal women are at risk of decreased bone density and increased risk of fractures due to decreased estrogen levels,[1] reduced vitamin D synthesis in the skin, or changes in body composition relevant to vitamin

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D status and physiology.[4] Vitamin D deficiency is defined as vitamin D levels below 20 ng/ml (50 nmol/liter), and vitamin D deficiency is 21–29 ng/ml (525–725 nmol/liter). Vitamin D deficiency can also be a risk factor for diseases such as immune system diseases and infectious diseases caused by coronavirus disease 2019 (COVID-19).[5] Research by Pereira et al.[6] reported that low vitamin D levels were associated with COVID-19.

Research by Cui et al.[5] shows that 15.7% of the global adult population has vitamin D deficiency. Vitamin D deficiency can occur in all age groups, including menopausal women. Indonesia currently has 7.4% of menopausal women from the total population, and in 2020, it is estimated to reach 11.54% with an average age of menopause of 49 years. According to Statistics Indonesia, in 2015, the number of women in Indonesia who entered menopause reached 21.22 million. It is estimated that by 2025, there will be 60 million menopausal women.[7] Another study on the incidence of vitamin D deficiency in Indonesian women showed that 95% of them (148 subjects out of a total of 156) had vitamin D deficiency.[8]

There is a relationship between vitamin D deficiency and lack of physical activity due to the storage of vitamin D in adipose tissue due to its high fat solubility and decreased exposure to sunlight in obese subjects due to limited physical activity and limited mobility. It is proven that physical activity increases glucose, calcium, and vitamin D metabolism and reduces body weight by increasing lipolysis.[9] Someone who does high physical activity will be associated with increased vitamin D concentration. Suppose someone does less physical activity (low physical activity). In that case, it will cause a decrease in vitamin D concentration, while someone with high physical activity will most likely be associated with optimal vitamin D levels.[10] Vitamin D can also help improve the body's performance in physical activities in populations at risk of vitamin D deficiency. Previous research by Nascimento et al.[11] found a significant increase in levels and improvements in the body, so there was an interaction between vitamin D levels and physical activity in maintaining body performance.

Measurement of physical activity in this study used a questionnaire, namely the extended version of the International Physical Activity Questionnaire (IPAQ), which is used to estimate physical activity levels. Data on the relationship between physical activity and vitamin D levels in Indonesia have been collected by Suryadinata et al.,[12] conducted at Public Health Center Taman, Sidoarjo district, East Java, in March–July 2017. The results showed geriatrics with obesity and non-obesity had similar levels of physical activity, but vitamin D status in obesity tended to be lower than non-obese. However, similar studies have never been conducted on elderly women in nursing homes. These data would greatly assist health workers in improving the quality of life of these patients. This research aimed to determine the relationship between physical activity and vitamin D in elderly women.

Methods

This study used analytic observational research with a cross-sectional design. Data was collected from May 2023 to August 2023 at Nursing Home X in Surabaya city. The Institutional Ethical Committee of the University of Surabaya approved the study, 207/KE/VIII/2023.

This study's population was all women aged ≥60 who had experienced menopause in Nursing Home X in Surabaya city. The samples taken in this study were all populations that met the inclusion criteria. The sampling technique used is purposive sampling, which meets the requirement of not having physical limitations such as motor disorders.

Each respondent will be interviewed to fill out the IPAQ and take blood samples to check vitamin D levels. A phlebotomist from Pramita Laboratorium will take a blood sample and test it at an accredited laboratory.

Blood sampling was carried out simultaneously during the day by the phlebotomist, taking into account the time of blood sampling, which can affect vitamin D levels.[13] After blood collection, the laboratory will process the blood by centrifuging to obtain serum, which will then be tested for vitamin D levels using VIDAS® 25-OH Vitamin D Total (VITD), which is an automatic quantitative test used on the VIDAS® instrument to determine 25(OH) levels. D total in human serum or plasma with the enzyme-linked fluorescence assay (ELFA) technique.

The method for measuring physical activity uses the modified IPAQ. The physical activity questionnaire contains 12 questions about light, moderate, and vigorous physical activity activities. Respondents were interviewed, and then results were obtained, which categorized respondents into mild, moderate, and vigorous categories using the metabolic equivalent of task (MET). Physical activity is divided into three categories, namely the mild category (<600 MET minutes/week), the moderate category (600–1,500 MET minutes/week), and the vigorous category (>1,500 MET minutes/week). This questionnaire contains questions about the type of activity, duration, and frequency of a person doing physical activity in the last 7 days. Physical activity can be measured by measuring the amount of energy expended/needed in each minute of activity. According to the IPAQ assessment protocol, MET-minutes/week for a given activity (walking moderate-intensity activity or vigorous-intensity activity) is calculated by multiplying the MET value of the given activity (3.3 for walking, 4.0 for moderate-intensity activity, and 8.0 for high-intensity activities) according to hours spent in a particular activity, for example walking at work = 3.3 × minutes walking × days walking at work. MET-minutes/week = (MET × activity minutes × days). Information: MET-minutes/week = METs produced in one week MET = MET value based on activity level minutes = duration of activity in one day days = number of days in one activity.[14,15] Results are presented as estimates of energy expenditure in metabolic equivalent minutes per week (MET-hours/week).[16,17] The metabolic equivalent of task, or MET, is valid for describing energy expenditure from certain activities. MET is the ratio of the rate of energy expended during activity to the rate of energy expended at rest.[18]

Before use, the questionnaire (IPAQ)[11,16,19] must be used as a research instrument, and a validity test must first be carried out, consisting of content and construct validation. Content validity through rational analysis or expert judgment by a panel to ensure that measurements are representative. Meanwhile, construct validity refers to the extent to which a measuring instrument shows results following theory. Reliability shows that the questionnaire is reliable and consistently provides the same results when measured twice or more with the same instrument. Cronbach's alpha value was >0.6, so the research instrument would be reliable.

The relationship between physical activity levels and vitamin D levels was analyzed using the Pearson correlation test, with the data scale being the ratio. The data was tested for normality using the Shapiro-Wilk test; if the p-value>0.05, it was concluded that the data was normally distributed. The relationship test used the Pearson correlation test; if the p-value<0.05, it can be concluded that there is a significant relationship between physical activity and vitamin D levels.

Results

This research involved 49 geriatric women as respondents. Data were collected using physical activity questionnaire interviews and vitamin D serum tests. The study involved elderly women aged 60 years and over. The highest number of high-risk elderly women >70 years was 43 respondents, while the rest were in the 60–70-year age group.

Regarding body mass index (BMI) characteristics, most respondents were of normal weight, and 34 respondents had an average standard deviation of 21.58±2.16 kg/m^2. Most of them had no disease history (Table 1).

Based on the data in Table 2, respondents' most common physical activity profile was exercise (44 respondents) and walking 100 m (39 respondents). At the same time, physical activities that were only done by some respondents were cooking and cleaning the garden or the like. Seven respondents carry out physical activity in the mild category, 22 in the moderate category,

Table 1 Frequency Distribution of Respondent Characteristics

Characteristics	n=49
Age (years)	
60–70	6
>70	43
BMI (kg/m^2)	
Very thin (<16)	6
Skinny (16–18.4)	6
Normal (18.5–24.9)	34
Overweight (25–29.9)	3
Obesity (>30)	0
Medical history	
Type 2 diabetes mellitus	5
Hypertension	10
Osteoarthritis	7
Osteoporosis	3
There isn't any	27

Table 2 Profile of Respondents' Physical Activity Questionnaire Answers

No.	Types of Physical Activity	Answer (Minutes)	n=49
1	Walk 100 m	5	1
		10	5
		15	6
		20	1
		30	23
		60	3
		Didn't do	10
2	Walk more than 100 m	10	2
		15	3
		60	12
		Didn't do	32
3	Cook	Didn't do	49
4	Wash clothes by hand	10	4
		15	2
		20	2
		30	9
		Didn't do	32
5	Cleaning room	5	1
		10	5
		15	1
		30	2
		Didn't do	40
6	Exercise	10	7
		15	13
		20	4
		25	6
		30	4
		45	3
		60	8
		Didn't do	5
7	Cleaning the garden	Didn't do	49
8	Gardening/farming	30	2
		Didn't do	47
9	Sew with hand	10	2
		15	3
		20	1
		60	4
		Didn't do	39
10	Sewing by machine	60	1
		Didn't do	48
11	Read	10	4
		15	2
		20	1
		30	4
		60	4
		Didn't do	34
12	Watch TV	5	1
		10	3
		15	3
		20	1
		30	6
		60	2
		Didn't do	33

and 20 in the vigorous category. The average physical activity level was 1316.82±720.90, and most respondents had a moderate physical activity level of 44.90% (Table 3).

Vitamin D levels were measured during the research by taking blood samples from each respondent. In Table 4, the results showed that vitamin D levels[16,17] were <20 ng/ml for 27 respondents, vitamin D levels were 20–30 ng/ml for 19 respondents, and vitamin D levels were >30 ng/ml for as many as three respondents.

Based on Table 5, the results showed that deficiency (<20 ng/ml) for 27 respondents (mean±SD=17.40±2.07), insufficiency (20–30 ng/ml) for 19 respondents (mean±SD=23.64±2.42), and normal level (>30 ng/ml) for three respondents (mean±SD=31.33±1.15). The total mean±SD was 18.41±6.60. In the mild physical activity category, two respondents had vitamin D levels <20 ng/ml, and 20–30 ng/ml for five respondents. In the category of moderate physical activity, 14 respondents had vitamin D levels <20 ng/ml, and 20–30 ng/ml as many as eight respondents. In the category of vigorous physical activity, 11 respondents had vitamin D levels <20 ng/ml, six respondents had 20–30 ng/ml, and three had >30 ng/ml.

The normality test results are as follows: In the Shapiro-Wilk normality test, a significance value (Sig.) was obtained, which was 0.133 for physical activity and 0.94 for vitamin D levels. Because both data have a significance value of >0.05, it can be concluded that the physical activity data and vitamin D levels were usually distributed. The results of the Pearson correlation test are as follows: obtained an r_{value} (Pearson correlation) of 0.089 and a significance value (Sig.) of 0.542. Based on a significance value (α) >0.05, it means there is no significant correlation between physical activity and vitamin D levels (Figure).

Discussion

This research involved 49 geriatric women as respondents. Since this study only involved 49 respondents, which may need to be more representative of a larger group, the results cannot be generalized widely and only to elderly women with similar characteristics.

Based on age, the highest number in the group of high-risk elderly women, namely 70 years and over, was 43 respondents, while in the 60–70

Table 3 Physical Activity Level of Respondents

Category Physical Activity	n=49	Mean±SD	Total Mean±SD
Mild (<600)	7	312.21±162.37	1,316.82±720.90
Moderate (600–1,500)	22	1,038.75±401.43	
Vigorous (>1,500)	20	2,074.17±581.39	

Table 4 Presentation of Data on Vitamin D Level Values

Vitamin D Level (ng/ml)	n=49	Mean±SD	Total Mean±SD
Deficiency (<20)	27	17.40±2.07	18.41±6.60
Insufficiency (20–30)	19	23.64±2.42	
Normal (>30)	3	31.33±1.15	

Table 5 Cross Tabulation of Vitamin D Levels with Physical Activity

Physical Activity	Number of Respondents based on Vitamin D Level Value			Total n=49
	Deficiency n=27	Insufficiency n=19	Normal n=3	
Mild (<600)	2	5	0	7
Moderate (600–1,500)	14	8	0	22
Vigorous (>1,500)	11	6	3	20

Note: deficiency (<20 ng/ml), insufficiency (20–30 ng/ml), normal (>30 ng/ml)

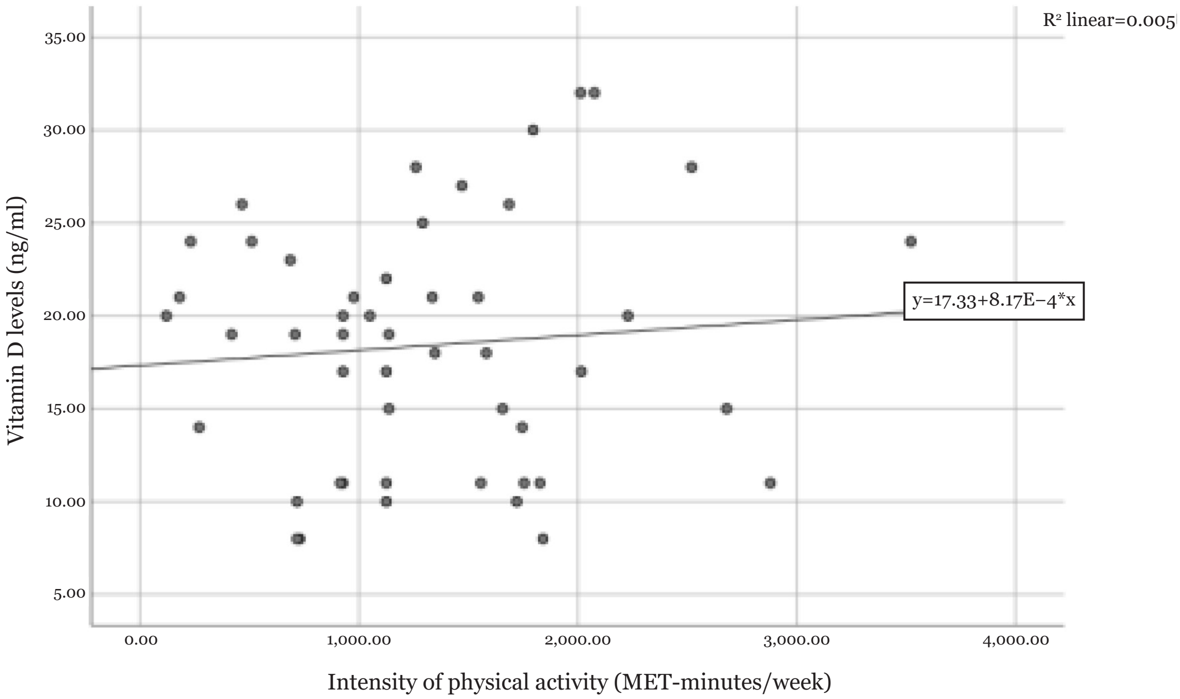

Figure Distribution of Physical Activity Data and Vitamin D Levels

year age group, there were only six respondents. Uneven age distribution may affect the results, especially physiological changes in different age groups. Age can affect vitamin D levels, such as a decreased vitamin D metabolism in old age. A decrease in calcium absorption causes this, the presence of intestinal resistance to absorption of circulating calcium $1,25(OH)_2D$, a decrease in kidney function resulting in a reduction of $1,25(OH)_2D$ production in the kidneys, and a decrease in vitamin D production in the skin, nine caused by decreasing the concentration of 7-dehydrocholestrol in the epidermis which can reduce the formation of vitamin D3. So aging can also cause calcium deficiency, hyperparathyroidism, increased bone loss, and osteoporosis.[20,21]

The majority of respondents (27 people) had no history of illness, while only several suffered from diabetes, hypertension, or osteoarthritis. This imbalance in health characteristics can affect physical activity and vitamin D levels. History of disease can affect vitamin D levels, including type 2 diabetes mellitus. The relationship between vitamin D deficiency and insulin resistance can develop through inflammation because vitamin D deficiency is associated with increased inflammatory markers. In addition, genetic polymorphisms of vitamin D-related genes may predispose to impaired glycemic control and type 2 diabetes. Epidemiological studies suggest an association between low serum 25-hydroxyvitamin D3 (25(OH)D3) concentrations and an increased risk of metabolic syndrome and type 2 diabetes. The increase in fat mass partly explains it.[20,21]

Most respondents had low vitamin D levels (<20 ng/ml), and only a few had levels above 30 ng/ml. This uneven distribution may limit statistical power for analysis and comparison between groups. The research showed no significant correlation between physical activity and vitamin D levels. It differs from previous research by Trovato et al.,[22] which stated that higher dietary intake of vitamin D and sunlight exposure are associated with a lower likelihood of having high perceived stress among physically active individuals. These results may be related to previous research by Zhang and Cao,[23] that endurance exercise can significantly increase serum 25(OH)D levels in vitamin D-deficient people but has no significant effect on vitamin D-sufficient people. The effects of exercise on 25(OH)D levels in the circulation may depend on factors such as vitamin D nutritional status, exercise type and intensity, and sex.

Physical activity can be measured with a tool, namely an accelerometer, pedometer, and self-report questionnaire (IPAQ) instrument. This research uses a self-report questionnaire because it has the advantage of cheaper costs, does not burden respondents, and obtains the flow of daily physical activity from respondents. Still, the self-report questionnaire has areas for improvement, such as less accuracy and reliability, because the data is based only on respondents' memories.[24]

This study used a modified IPAQ to measure the intensity of physical activity. The IPAQ is the most frequently and commonly used measurement tool in measuring physical activity levels. However, the questionnaire has limitations because it is based on respondents' memories. As in previous research by Cleland et al.,[16] results showed the majority of older adults under-report their level of moderate-to-vigorous physical activity and sedentary behavior when completing the IPAQ, and the linear relationship above the mean shows an error from under to over-reporting as the mean increases.

Suggestions for future research include expanding research on older-specific physical activity measures, such as previous research by VandeBunte et al.,[25] where actigraphy metrics are not available, standard self-report measures of PA are used in older adults to capture more structured activity and exercise routines (e.g., duration, type of exercise). The Community Healthy Activities Model Program for Seniors (CHAMPS) and the Physical Activity Scale for the Elderly (PASE) are two widely used self-report PA questionnaires in older adults. Fitbit monitors have demonstrated inter-device reliability with other actigraphy monitors. Results showed that Fitbit's step counts showed a stronger association with PASE, while Fitbit's burned calories were more strongly associated with CHAMPS-MET. Fitbit results had more consistent convergence with relevant outcomes of interest (e.g., brain and cardiometabolic health indices) compared to subjective measures; however, considerable heterogeneity in these associations was observed.

Most respondents had moderate physical activity levels, while only a few were categorized as mild or vigorous. This imbalance may limit the broad analysis of the relationship between physical activity and vitamin D. Based on the distribution of physical activity profiles; two physical activities are often done: gymnastics and walking 100 meters. Regarding walking activity alone, many age-related changes contribute to the increased energy requirements for walking, which can be two to four times that of a healthy adult. Age-related biomechanical factors, such as a flexed trunk, limited hip extension, and reduced ankle movement in gait, result in less use of stored passive energy and greater demands on muscle activity. Age-related neuromuscular factors alter efficient muscle recruitment patterns and the timing of limb movements, resulting in inefficient walking due to compensating for body changes.[20] Several factors can influence a person in carrying out physical activity, including:[14,15]

(1) Intrinsic factors. This factor is more directed at a person's inner motivation for activities. A person with good feelings will do more activities, while a person with bad feelings will do less. Even though the questionnaire has been validated, a person's motivation to move can also influence a person's physical activity.

(2) Environmental factors. The environment can influence physical activity, and weather that is too hot or rainy can be a barrier. Changing environmental weather conditions can also affect a person's ability to carry out physical activities, mainly because most respondents' physical activities are carried out in open areas, which the weather and environment will significantly influence.

(3) Physical consideration factors. A person's body condition can influence their physical activity. They will do physical activity if they feel their body is in good condition, but they will not if they feel tired or injured. In this study, activity restrictions are one of the requirements for research subjects so that the influence of this factor can be minimized.

(4) Routine factor. In the routine factor, a person carries out daily physical activity and/ or other demands. External factors such as sun exposure, dietary intake, or, although these factors can significantly affect vitamin D levels.

During the research, vitamin D levels were measured to determine vitamin D levels in elderly women by taking blood samples from each research respondent. From a total of 49 elderly women, the majority of vitamin D levels <20 ng/ml were obtained by 27 respondents (55%) with an average of 17.40 ng/ml.

Blood samples were collected only once. This may need to be revised to adequately reflect the variation in vitamin D levels, which can change depending on daily conditions, such as sun exposure and diet. Daily variation was minimized by collecting samples at the same time of day. Blood sampling was carried out simultaneously during the noonday by the phlebotomist, taking into account the time of blood sampling, which can affect vitamin D levels.[13]

This technique can cause bias because the sample is selected based on specific criteria and does not represent the entire population of elderly women. As a result, the study's results may be challenging to apply to all older adults. To minimize the influence of vitamin D variations, several factors that can affect vitamin D variations in the respondent's body condition are minimized by not having significant changes in these factors from one month earlier (such as medication, health conditions, and lifestyle). Several factors can influence vitamin D levels, including the following:[20,21]

(1) Body mass index (BMI). Vitamin D is a fat-soluble vitamin, and people with a BMI >30 kg/m^2 tend to have higher fat than those with a normal BMI. The association between vitamin D deficiency and overweight and obese patients may be explained by the storage of vitamin D in adipose tissue due to its high-fat solubility and decreased exposure to sunlight in obese subjects due to limited physical activity and mobility.

(2) Lack of intake. All age-related changes in vitamin D metabolism are magnified if there is concomitant vitamin D deficiency, as it limits the supply of substrates for 25OHD and, ultimately, $1,25(OH)_2D$. Substrate deficiency is a common problem in older people and is essential to recognize because it can be prevented and treated. There may be a vitamin D deficiency either from diet or from lack of sunlight, and a subsequent decrease in serum 25OHD limits $1,25(OH)_2D$ production, especially if there is also renal dysfunction. Serum $1,25(OH)_2D$ levels decrease when serum 25OHD levels fall below 10 ng/mL in young and older adults.

Conclusions

The correlation test results between physical activity and vitamin D levels in elderly women showed no significant correlation. Other factors affecting the research results include age, which has a wide range of variations, health conditions, and vitamin D intake. Further research can develop measurements specifically for examining physical activity in old age.

Conflict of Interest

The authors declare no conflict of interest.

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