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Vitamin D and Lifestyle Factors in Active Smoker in Indonesia

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Abstract

Smoking can affect vitamin D levels in the blood. Decrease in vitamin D levels is also influenced by a person's lifestyle habits, such as smoking habits, sun exposure, food intake, and physical activity. This study aimed to determine the relationship between vitamin D and lifestyle factors in active smokers. This research used a cross-sectional design. The subjects were adult male active smokers in Rungkut Subdistrict, Surabaya City, from October 2023 to February 2024. The sampling method was a purposive sampling technique. Data collection by measurement of smoking severity (Brinkman Index (BI)), vitamin D levels in blood (serum 25(OH)D), food intake (by SQ-FFQ (semi-quantitative food frequency questionnaire) and 24-hour food recall), and physical activity (by IPAQ (International Physical Activity Questionnaire)). The relationship is measured using the Spearman method (ordinal scale). There were 47 respondents. The majority of research respondents were moderate smokers, namely 38 people (80.85%). The respondents had an average 25(OH)D level of 23.19±8.86 ng/mL. The risk of vitamin D deficiency due to lack of sun exposure was 26 people (55.32%). The average consumption of foods containing vitamin D by SQ-FFQ was 5.75±5.68 mcg/day, and 24-hour food recall was 5.77±5.72 mcg/day. Most respondents had high physical activity (70.21%), and the total mean was 8210.23±4955.89. The Spearman correlation coefficient was 0.742 (smoking severity), 0.117 (sun exposure), 0.726 (food intake by FFQ), 0.742 (food intake by 24-hour recall), and 0.824 (physical activity). Vitamin D levels had a significant association with the severity of smoking, food intake, and physical activity. However, they were not related to sun exposure.

Introduction

Smoking is responsible for a high proportion of morbidity and mortality in Indonesia (Holipah *et al.*, 2020). Based on Global Adult Tobacco Survey (GATS) data in 2021, the number of smokers in Indonesia increased by 8.8 million people from 2011, namely 60.3 million to 69.1 million people smoked, and 65.5% of them are male smokers (GATS, 2021). The prognosis for these health problems is worsened by the fact that smoking can cause vitamin D deficiency (Yang *et al.*, 2021; Yang *et al.*, 2022), and this vitamin D deficiency has an impact on various diseases (Amrein *et al.*, 2020). A meta-analysis study, which included 24 studies and involved 11,340, showed that 25(OH)D levels in smokers were lower than in non-smokers (Yang *et al.*, 2021). Sources of vitamin D come from food and exposure to sunlight (Suryadinata *et al.*, 2021). The primary causes of vitamin D deficiency are decreased skin synthesis due to low sunlight exposure, age, certain drugs that can reduce vitamin D levels, and obesity (Lorensia *et al.*, 2022). Data on the prevalence of vitamin D deficiency in various European, American, and Asian countries varies widely, from 42% to 90%. A study in Indonesia showed that

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50% of women aged 45-55 years had vitamin D deficiency. In addition, there was another study in Jakarta and Bekasi, which stated that 74 female subjects aged 60-75 years had a fairly high vitamin D deficiency, namely 35 .1%. The results of collaborative research between Malaysia and Indonesia, conducted in Kuala Lumpur and Jakarta, also found that the subjects had an average serum 25(OH)D concentration of 48nmol/L. Based on several studies presented, it can be concluded that people living in tropical countries are not fully guaranteed a vitamin D status (Rimahardika *et al*., 2019).

Smoking can affect vitamin D levels in the body in many ways, including affecting vitamin D intake, synthesis, hydroxylation, and catabolism of vitamin D (Mousavi *et al*., 2019). When someone inhales cigarette smoke, as many as 4000 chemicals are inhaled and enter the lungs, especially nicotine (Pemerintah Republik Indonesia, 2012). The potential effects on the central nervous system (CNS) regulation of nicotine can also influence appetite, distracting from the perception of hunger or the desire to consume food and energy expenditure. This decrease in appetite in smokers can cause a decrease in food intake containing vitamin D, which can result in vitamin D deficiency (Wu *et al*., 2021). In Indonesia, previous research by Lorensia *et al*. (2024) involved 144 subjects, consisting of 73 non-smokers and 71 smokers. The smokers' group had a 2,553 times higher risk of vitamin D deficiency than non-smokers.

Vitamin D is a fat-soluble vitamin found in food and can also be produced in the body after exposure to sunlight. Sources of vitamin D can come from animal foods, namely fatty fish, tuna, milk, egg yolks, seafood, and foods derived from plants, like mushrooms (Dominguez *et al*., 2021). According to the 2019 Regulation of the Minister of Health of the Republic of Indonesia, the Nutritional Adequacy Rate (AKG), recommended vitamin D intake is 15 mcg/day (Kementrian kesehatan. Peraturan Mentri Kesehatan Republik Indonesia Nomor 28 Tahun 2019, 2019). The first process of vitamin D is in the liver into the prehormone 25-hydroxycholecalciferol or 25(OH)D. Vitamin D deficiency is defined as 25(OH)D levels <20 ng/mL (Amrein *et al*., 2020; Mustafa and Shekhar, 2021). Awareness of the importance of consuming foods containing vitamin D must be implemented from an early age to prevent vitamin D deficiency, especially in the smoking population, where nicotine in cigarette smoke can reduce the intake of foods containing vitamin D (Yang *et al*., 2022). The more frequently you consume cigarettes, the more nicotine content enters the CNS, and the more it will reduce an individual's food intake (Menshov *et al*., 2022).

Dietary intake affects individual health (Zhou *et al*., 2023). Assessment of the adequacy of an individual's intake of food containing vitamin D needs to be carried out for early action to prevent vitamin D deficiency. This assessment can employ a dietary evaluation to assess the intake of food containing vitamin D consumed by the individual, using the semi-digestive method. -quantitative Food Frequency Questionnaire (SQ-FFQ) and 24-hour Food Recall. Semi-quantitative FFQ will assess respondents' eating patterns retrospectively within the last month. The 24-hour Food Recall is also a method of dietary assessment, retrospectively. It provides information about the food and drinks consumed by respondents in the last 24 hours (Watkins *et al*., 2021; Moridpour *et al*., 2022). The combination of FFQ and 24-hour Food Recall improves the correlation with actual intake to predict individual diet, so that it can be correlated with individual health conditions (Kostaras *et al*., 2021).

Vitamin D is linked to physical activity; indoor physical activity is associated with increased vitamin D levels (Al-Daghri *et al*., 2023). There is an increase in plasma vitamin D concentrations with both indoor and outdoor physical activity. Smokers who had intense physical activity had the strongest positive relationship with vitamin D levels. Measurement of physical activity uses a questionnaire, namely the International Physical Activity Questionnaire (IPAQ). The IPAQ is an instrument developed to establish a standardized and culturally adaptable measurement tool to measure physical activity in different cultural regions of the world (Andriyani *et al*., 2020; Anindya *et al*., 2022). All values are expressed in MET- minutes/

week. Metabolic Equivalents (METs) are used to express the intensity of physical activity. Metabolic Equivalent of Task (MET) is the ratio of a person's average working metabolic rate to their resting metabolic rate (Chandrashekar *et al.*, 2019). This study aimed to determine the relationship between vitamin D and the severity of smoking, sun exposure, food intake containing vitamin D, and physical activity.

Method

This research uses a cross-sectional design. It took place in Rungkut Village, Surabaya City, considering that it had met the inclusion criteria. This research took time from October 2023 to February 2024. The variables in this study consist of the independent variable, namely vitamin D levels, and the dependent variables consist of: smoking level, sun exposure, food intake containing vitamin D, and physical activity. An active smoker is someone who consumes cigarettes regularly, no matter how small, even if only 1 (one) cigarette a day (Hackshaw *et al.*, 2018). Smoking activity is the activity of burning tobacco and then inhaling the smoke, either using a cigarette or using a pipe (Sutfin *et al.*, 20221). Smoking activity in this study was measured from two indicators, namely smoking frequency and cigarette type.

The population in this study was adult male active smokers in Rungkut Subdistrict, Surabaya City. The sample in this study was taken from part of the population that met the criteria, including respondents in the category of teenagers to adults with an age range of 19 years and over, and who were willing to participate in the research. The number of adult males in Rungkut sub-district was 125, and there were 51 people who had the status of active adult smokers. To calculate the minimum number of samples needed, a calculation is required using the Slovin formula. N=Total Population (51 respondents who are active adult smokers) e=Desired critical value (accuracy limit) (percentage of tolerance for inaccuracy due to sampling error) (5%). Based on the results of these calculations, the minimum sample size in this study is at least 46 respondents. The sampling method used in this research is a purposive sampling technique.

Smoking frequency was obtained from respondent interviews regarding the number of cigarettes smoked per day and the length of smoking (years). Brinkman Index (IB) = number of cigarettes smoked per day x smoking length (years). The Brinkman Index has been standardly used in Indonesia to determine a person's smoking frequency/degree. The results of IB are classified into 3, namely: mild (0-200), moderate (201-600), and severe (>600) (Herath *et al.*, 2022; Onishi *et al.*, 2022). Then, measurement of Vitamin D (25(OH)D) levels in human serum uses VIDAS® 25 OH Vitamin D TOTAL (VIT D), which is an automatic quantitative test by the ELFA (Enzyme Linked Fluorescent Assay) technique. VIDAS® 25 OH Vitamin D TOTAL will be used as an aid in the assessment of Vitamin D adequacy. Serum 25(OH)D levels can be classified into several categories, namely: deficiency (<20 ng/mL), insufficiency (20-29 ng/mL), sufficient (20-29 ng/mL), and potential toxicity (>100 ng /mL) (Mustafa and Shekhar, 2021).

The main components in this questionnaire are a list of foods, the frequency of foods at certain times, and the portions of food consumed. Interviews were conducted with the help of a food photo book published by the Indonesian Ministry of Health in 2014 (Benedik, 2022) to make it easier to measure the URT portion of food consumed by respondents. Calculation of vitamin D nutrition in the food consumed by respondents is carried out by recording the type and amount of food consumed during the previous 24 hours using the URT tool, then the data will be converted from URT into weight (grams), using the nutrisurvey application and then in the total amount of vitamin D intake from the entire list of foods consumed by respondents and matched with the Recommended Nutritional Adequacy List (DKGA) in Indonesia (Watkins *et al.*, 2021; Moridpour *et al.*, 2022; Kostaras *et al.*, 2021). This research does not carry out validity because it has been carried out in previous research by Suryadinata *et al.* (2019) and Lorensia *et al.* (2019). The method for measuring physical activity uses the IPAQ (International Physical Activity Questionnaire) questionnaire. The data scale obtained from the measurement of physical activity was an ordinal data scale, where the results obtained from the patient questionnaire were categorized into low, medium, and high physical activity (Lorensia *et al*., 2022; Sember *et al*., 2020). The collected data will be compiled and analyzed to determine the factors that influence 25-hydroxycholecalciferol (25(OH)D) levels through the intake of foods containing vitamin D in active smoker respondents. The method used in this research is an ordinal data scale. Ordinal data scale using the Spearman test.

Result and Discussion

The research took place in Rungkut District, Surabaya City, from October 2023 to February 2024, after obtaining ethical clearance from the University of Surabaya Ethics Committee with the number: 236/KE/IX/2023. The preliminary study regarding the number of active smokers by distributing questionnaires identified 79 residents as active smokers. However, during the meeting at the community head's activity with residents, which had been previously designed with researchers, only 51 active smoking residents were present. After explaining the research and taking measurements from respondents, four people were excluded from the research due to exclusion criteria, including two vegetarians and two obese people who had a BMI >27 kg/m^2, so the final number obtained was 47 respondents.

The average age of research respondents was 51±6.43 years, which fell into the middle-aged category, namely around 46 people (97.87%). Based on the latest educational data, most respondents were high school graduates, namely 21 people (44.68%). Most respondents had a normal BMI, namely 26 (55.32%) respondents, and the average BMI value of research respondents was 24.13±1.95 kg/m^2. Data on the smoking activity of respondents in this study have been obtained. Smoking activity data in this study were assessed using two assessment indicators, namely smoking frequency and type of cigarette used. Based on smoking frequency data in Table 4.1, the majority of research respondents were moderate smokers, namely 38 people (80.85%) (**Table 1**).

Measurement of Vitamin D (25(OH)D)

Table 1. Characteristics Profile of Research Respondents

Respondent Characteristics		Category	Frequency (n=47)	Percentage (%)
Demographics	Age (Years)	Adulthood (18-39)	1	2.13
		Middle-aged youth (40-60)	46	97.87
	Education Level	No school	1	2.13
		Elementary school	8	17.02
		Junior high school	9	19.15
		Senior high school	21	44.68
		Bachelor's degree	8	17.02
Anthropometrics	BMI (kg/m^2) (Khanna et al., 2022)	Normal (18.5-25)	26	55.32
		Overweight (25.1-27)	21	44.68
Smoking Activities	Index Brinkman (Herath et al., 2022; Onishi et al., 2022)	Mild Smoker (IB <200)	9	19.15
		Moderate Smoker (IB 201-600)	38	80.85

Source: Primary Data, 2024

Table 2. Profile of Research Respondents Based on Results of 25(OH)D Levels

Categories of 25(OH)D level (ng/mL)*	Frequency (n=47)	Percentage (%)	x ± SD (ng/mL)
Deficiency (<20)	15	32	23.19 ± 8.86
Insufficiency (20-29)	23	49	
Enough (30-100)	9	19	

* Serum 25(OH)D Level Examination Results from a Standardized Laboratory (Lorensia *et al*., 2024; Mustafa and Shekhar, 2021; Georgakopaulou *et al*., 2020)

Source: Primary Data, 2024

Table 3. Sun Exposure Profile of Respondents

No.	Questions	Answers	Frequency (n= 47)	Percentage (%)
1.	What time do you usually get direct sunlight?	07.00-09.00	26	55.32
		10.00-11.00	12	25.53
		12.00-14.00	7	14.89
		15.00-17.00	2	4.26
2.	Do you use skin protection equipment (umbrella, hat, jacket, sunscreen cream, etc.) from direct exposure to sunlight direct?	Yes	44	93.62
		No	3	6.38
3.	What skin protective equipment do you use **(There can be more than one answer)**	Umbrella	2	4.26
		Hat	29	61.70
		Jacket	26	55.32
		Sun block/sunblock	3	6.38
		Other	2	4.26
4.	How often do you use skin protection equipment in question **no.3** ?	Everyday	7	14.89
		Sometimes	26	55.32
		Seldom	11	23.40
		Never	3	6.38
5.	Do you usually wear closed clothes, such as long-sleeved shirts and long trousers? day ?	Yes	32	68.09
		No	15	31.91
6.	Which parts of the body do you want to protect from direct sunlight with the protective equipment you chose in question **no. 3** ? **(there can be more than one answer)**	Face	26	55.32
		Hand	7	14.89
		Arm	9	19.15
		Foot	2	4.26
		Back and shoulders	19	40.43
		Whole body	6	12.77
		Never	3	6.38
7.	Do you use cosmetic products (facial moisturizer, cream and body *(body cream)* , powder etc with SPF content?	Yes	5	10.64
		No	42	89.36
8.	Does the cosmetics you use contain protection from UVA and UVB?	Yes	2	4.26
		No	45	95.74
	Classification of risk of deficiency due to lack of sun exposure		**Frequency (n= 47)**	**Percentage (%)**
	Has a risk of deficiency due to lack of sun exposure		26	55.32
	Has no risk of deficiency due to lack of sun exposure		21	44.68

Source: Primary Data, 2024

level of 23.19±8.86 ng/mL. There were only 9 respondents who had sufficient 25(OH)D levels (19%), then 23 people (49%) fell into the Insufficiency category, and 15 people (32%) had vitamin D deficiency (**Table 2**).

Frequency and percentage results of exposure to sun in active smokers show that in the group at risk of vitamin D deficiency due

levels in the serum of research respondents was carried out by a standardized laboratory, using VIDAS® 25 OH Vitamin D TOTAL (VIT D), which is an automatic quantitative test using the ELFA (Enzyme Linked Fluorescent Assay) technique. The results of serum 25(OH)D levels were grouped into three based on the VIDAS® 25 OH Vitamin D TOTAL reference range. The results of grouping respondents showed that respondents had an average 25(OH)D

Table 4. Results of Food Intake Containing Vitamin D for Research Respondents

Food Intake Method	Results of Intake of Foods Containing Vitamin D (mcg/day) (Benedik, 2022)	Category	Frequency (n=47)	Percentage (%)	x ± SD (mcg/day)
SQ-FFQ	>15	Enough	10	21.28	5.75 ± 5.68
	<15	Not enough	37	78.72	
24-hour Food Recall	>15	Enough	9	19.15	5.77 ± 5.72
	<15	Not enough	38	80.85	

Source: Primary Data, 2024

Table 5. Profile Distribution Frequency Activity Physique Respondent

Respondent		Frequency (n: 47)	Percentage (%)	Average	Average total	SD
Category Activity Physique (MET-min/week) (Lorensia et al., 2022; Sember et al., 2020)	Low	7	14.89	340.9	8,210.23	4955.89
	Moderate	7	14.89	1064.1		
	High	33	70.21	6805.23		

Source: Primary Data, 2024

Table 6. Spearman Correlation Analysis between the Serum 25(OH) Vitamin D and Lifestyle Factors

Lifestyle Factors	R	P value
Smoking severity	0.742*	0.000
Sun exposure	0.117	0.624
Food intake by FFQ	0.726*	0.000
Food intake by recall 24 hours	0.742*	0.000
Physical activity	0.824*	0.000

R = Spearman rho.

*Correlation is significant at the 0.01 level (2-tailed)

Source: Primary Data, 2024

to lack of sun exposure, namely, as many as 26 people (55.32 %), and those who did not have a risk were as many as 21 people (44.68%). The respondent's answer profile can be seen in **Table 3**.

Data on food intake containing vitamin D from research respondents was obtained using two methods of measuring food intake, namely the semi-quantitative food frequency questionnaire (SQ-FFQ) and 24-hour food recall. SQ-FFQ measures respondents' food intake over the past month which was collected using the SQ-FFQ questionnaire containing a list of 11 foods that contain vitamin D, by adding fortified products such as milk with a vitamin D content of 7.5 mcg/35g, milk with a vitamin D content of 2.5 mcg/32g and eliminating shiitake mushrooms and button mushrooms because based on preliminary studies, no community around the research location consumed these foods. Milkfish has the highest vitamin D content. Every 100 g of milkfish contains 10 mcg of vitamin D; however, in the SQ-FFQ results, respondents only consumed an average of 7.59g of milkfish, which contained 0.8 mcg of vitamin D/day. The vitamin D content in fortified products such as milk used by respondents in this study is that every 35g of milk contains 7.5 mcg of vitamin D. Respondents consumed milk with a vitamin D content of 7 mcg/35g of 10.53g with a vitamin D result of 2.3 mcg/day, while the least is tilapia fish, namely every 40g of tilapia fish contains 0.4 mcg of vitamin D (**Table 4**). The average consumption of foods containing vitamin D in research respondents was 5.75 ± 5.68 mcg/day. Only 10 respondents

(21.28%) could meet the daily RDA for vitamin D; the other 37 respondents (78.72%) did not meet the RDA for vitamin D (**Table 4**).

The average 24-hour food recall results show that the foods containing vitamin D that respondents consumed most were eggs (37.66g), then pindang fish (10.21g), milk with a Vitamin D content of 7 mcg/35g (9.93g), while the least consumed was anchovies (0.89g). The results of the interview regarding food intake containing vitamin D were obtained using a food recall, and the vitamin D value per person per day was obtained using the Nutrisurvey application. On average, food products that have the highest vitamin D value are milk with a Vitamin D content of 7 mcg/35g (2.1 mcg), catfish (0.7 mcg), milkfish (0.7 mcg), pindang fish (0.6 mcg), and the food with the least vitamin D value is tilapia fish (0 mcg) (**Table 4**).

The average results of food intake containing vitamin D from the Nutrisurvey application for all research respondents (47 respondents), namely the 1st recall which was carried out on weekdays, resulted in an average intake of vitamin D of 5.0 ± 6.7 mcg/day, recall The second recall which was also carried out on weekdays resulted in an average vitamin D intake of 5.5 ± 6.2 mcg/day and the third recall which was carried out on holidays resulted in an average vitamin D intake of 6.9 ± 6 .6 mcg/ day mcg/day. It is in accordance with existing theory, which states that the effect of holidays can provide a different picture of intake because food intake on holidays is usually greater than on weekdays. The average intake of foods containing vitamin D consumed by respondents was 5.77±5.72 mcg/day. Table 4 shows that only 9 people (19.15%) were said to consume enough foods containing vitamin D according to the AKG recommendations, and 38 people (80.85%) did not meet the AKG recommendations for vitamin D. Based on **Table 5**, 45 respondents with high physical activities had the largest percentage, namely (69.23%), and 10 respondents each with moderate and light physical activities had a percentage of (15.38%). The total mean was 8210.23, and the SD was 4955.89.

The association between the serum vitamin D levels and lifestyle factors (included: smoking severity, sun exposure, food intake, and physical activity), which was calculated using the Spearman correlation coefficient method was, 0.742 for smoking severity, 0.117 for sun exposure, and 0.726 for food intake by FFQ 0.742 for food intake by recall 24 hours, and 0.824 for physical activity. Most of the P values were <0.005 (significant positive correlation). There was a significant positive correlation between vitamin D levels and smoking severity, food intake by FFQ, food intake by 24-hour recall, and physical activity, except for sun exposure (**Table 6**).

The average 25(OH)D level of respondents was 23.19±8.86 ng/mL, which was included in the vitamin D insufficiency category. The 25(OH)D level was chosen as the best indicator to assess vitamin D status in the body, because it can reflect production of endogenous vitamin D3 (synthesized in the skin) and vitamin D (D2 and D3) from food. 25(OH)D also has a longer half-life, namely 3-4 weeks, compared to calcitriol, which is only 4-6 hours (Dominguez *et al.*, 2021). Apart from that, the body's homeostatic process when it finds out that there is a lack of vitamin D levels in the blood is that the body will give a signal for the secretion of parathyroid hormone (PTH) and increase calcitriol synthesis in the kidneys, so that calcitriol levels will remain maintained in conditions of vitamin D deficiency (Dominguez *et al.*, 2021; Charoenngam and Holick, 2020).

The results of the respondents' smoking frequency show that the majority are moderate smokers. The results of this study are supported by a study that examined the relationship between the degree of smoking assessed using the Brinkman index and early detection of chronic obstructive pulmonary disease in Indonesia, which stated that the highest degree of smoking was moderate smoking (Khasanah *et al.*, 2023). This is because the majority of respondents in this study were of productive age (still working). Smoking while working is a culture in Indonesia (Salsabila *et al.*, 2022).

The frequency of smoking can reduce the intake of foods containing vitamin D. This is because smoking can cause vitamin D deficiency through several mechanisms, namely the nicotine content in cigarette smoke can reduce the intake of foods containing vitamin D. This theory is proven by a study by Yang et.

al. (2022) who concluded that consumption of food containing vitamin D decreased with increasing smoking frequency. 11 This theory and research is in accordance with the results of this study, showing that the majority of respondents were moderate smokers and consumed less food containing vitamin D (Yang *et al*., 2022). Long duration of smoking was associated with decreased serum 25(OH)D levels. A study by Yuan and Ni (2022), regarding smoking and serum 25(OH)D levels, stated a dose-response relationship between smoking and 25(OH)D levels, showing tobacco smoke exposure may disrupt vitamin D levels among the general population, with an increasing temporal trend and age, gender differences in risk. It can be caused, apart from the nicotine content in cigarette smoke which can reduce the intake of foods containing vitamin D, the content of Benzo(a)pyrene or BaP in cigarette smoke can increase the catabolism of 25(OH)D to 24.25(OH)D by increasing the expression of 24-hydroxylase (CYP24A1) thereby reducing serum vitamin D levels (Mousavi *et al*., 2019).

The vitamin D status assessment category is based on the median cut-off point. Answers to the total questionnaire score of <6 are categorized as having no risk of deficiency, while having a risk of deficiency if the total score is ≥6. Most respondents were exposed to the sun between 07.00 and 09.00 (55.32%). The best time for sun exposure is from 10.00 WIB to 14.00 WIB. During these hours, UVB and UVA sunlight can stimulate human skin to produce vitamin D. If exposure to sunlight is less than 10.00 or more than 14.00, the body will not get enough vitamin D, so that human skin synthesizes little vitamin D (Raymond-Lezman and Riskin, 2023). The time of exposure is one of the important factors in the synthesis of vitamin D. Based on previous research, research was conducted on elderly women in Jakarta, Indonesia (6°south latitude) who were exposed to sunlight from 07.00 WIB to 16.00 WIB using a UV meter to obtain values MED (minimum erythemal dose) per hour. This research shows that the highest UVB intensity occurs from 11.00 WIB to 13.00 WIB in the afternoon. UVB obtained from sunlight can help the synthesis of vitamin D in the skin (Setiati, 2008).

Most respondents also use skin protection to avoid direct exposure to sunlight (93.62%), especially jackets and hats. Based on the theory, individuals who avoid sun exposure, including using sunscreen, hats, and umbrellas, are at risk of vitamin D deficiency. Using skin protective equipment is not a problem, but it is better to let your face get sun exposure 3 times a week to get enough vitamin D (Raymond-Lezman and Riskin, 2023). Vitamin D deficiency can be prevented by allowing the body to be exposed to direct sunlight for 15-20 minutes with a minimum of 40% of the skin surface exposed to sunlight. Holick's rules mention that having sunlight exposure for 25 minutes, 3 times a week at 09.00 am can meet the body's vitamin D needs (Raymond-Lezman and Riskin, 2023; Setiati, 2008).

Questions about using cosmetic products containing SPF. 42 respondents used cosmetic products containing SPF (89.36%). Cosmetic products containing SPF 8 can reduce previtamin D3 by 93% while SPF 15 can reduce it by 99%. Regular use of sunblock can significantly reduce vitamin D production in the skin. Using good sunscreen gives 15 minutes without using it on the face and arms daily, which is enough to maintain vitamin D (Kaur *et al*., 2024; Neale *et al*., 2019). Sun Protection Factor (SPF) is a means of protecting the skin from UVB rays. When the SPF value increases, protection from UVB rays also increases. Although the use of sunblock will have a risk of low vitamin D status, infrequent use will have a small impact on reducing vitamin D synthesis in the skin (Raymond-Lezman and Riskin, 2023).

In addition, smoking is considered a factor that can contribute to human skin aging. Vitamin D is the only vitamin that is synthesized endogenously in the human body. Through the skin, 7-dehydrocholesterol, with the help of sunlight (UVB radiation), will be converted into previtamin D3. Previtamin D3 is thermodynamically unstable and requires isomerization to form vitamin D3 (cholecalciferol). Cholecalciferol will then move from the skin to the systemic circulation, then through an enzymatic process in the liver mediated by 25-hydroxylase to form 25-hydroxyvitamin D (also called 25-hydroxycholecalciferol or 25(OH)

D or calcidiol). Increased skin aging can significantly reduce the ability to convert 7-dehydrocholesterol into previtamin D (Dominguez *et al*., 2021; Passeron *et al*., 2019). In this study, qualitative calculations were not carried out for the duration of sun exposure obtained by research respondents, which is a limitation of this study.

The average intake of food containing vitamin D consumed by research respondents using both methods of measuring dietary patterns was almost the same, namely, using the SQ-FFQ method (5.75 ± 5.68 mcg/day), while using the 24-hour food recall (5, 77±5.72 mcg/day). The results in Table 4.3 using the SQ-FFQ method show that only 10 (21.28%) respondents stated that they consumed enough foods containing vitamin D in accordance with the recommended RDA for Vitamin D (minimum 15 mcg/day) whereas with the 24 hour food recall method, showed that only 9 (19.15%) respondents stated that they consumed enough foods containing vitamin D according to the recommended RDA for Vitamin D (minimum 15 mcg/day). Differences in the results of these two methods may occur because both methods rely heavily on respondents' memories, especially the SQ-FFQ method, which asks about food consumption in the last month. In the 24-hour food recall method, there is the flat slope syndrome, namely the tendency for thin respondents to report consuming more (overestimate) and for obese respondents to tend to report less (underestimate).

The food that contains vitamin D, most frequently consumed by respondents, is eggs. Eggs are a source of vitamin D. The part of the egg that contains the highest vitamin D is the egg yolk, which contains 5.4 mcg of vitamin D per 67 grams. A study regarding the loss of vitamin D during the egg cooking process has been published. The vitamin D and 25(OH)D in eggs are lost, in similar amounts, during home cooking: Hard-boiled eggs (10 minutes of cooking) will lose about 10% of the vitamin D and 25(OH)D, scrambling an egg for 3 minutes lost around 20% of vitamin D and 25(OH)D, whereas when eggs were baked for 40 minutes around 60% of vitamin D and 25(OH)D were lost (Barnkob *et al*., 2020). Most of the respondents in this study consumed eggs that had been cooked first, namely fried/boiled. One egg, if converted, produces 60g. In the Nutrisurvey application, eggs with a fried/boiled cooking process weighing 60g both contain 0.6 mcg of vitamin D. This is one of the reasons why the average vitamin D consumption of research respondents is less than the RDA recommendation. Vitamin D is a minimum of 15 mcg/day (Mendivil, 2021).

Apart from eggs, fish is a food source that contains vitamin D. The frequency of fish consumption can affect vitamin D status. A meta-analysis study investigating the effect of fish consumption in RCT trials on serum 25(OH)D levels in healthy adults, stated that fish consumption was minimal. 2 times a week or the equivalent of 300g/week for at least 4 weeks can increase serum 25(OH)D levels, the research also stated that compared to the control group (which on average consumed meat) fish consumption could increase serum 25(OH)D levels the average is 1.76 ng/mL, the type of fish also plays an important role, namely consumption of fatty fish produces an average difference of 2.72 ng/mL, while for lean fish the average difference is 0.76 ng/mL (Mendivil, 2021). The type of fish most consumed by research respondents is catfish, which is a group of fatty fish. In the Nutrisurvey application, 70g of catfish contains 7 mcg of vitamin D. Respondents' average consumption of catfish is 7.62-7.66 grams/day, with the result of vitamin D in the Nutrisurvey application being 0.8 mcg/day. Indonesians still rarely consume fish; Indonesians consume tofu, tempeh, and chicken more often, as proven by the results of interviews with respondents in this study who used the 24-hour food recall method. This is one of the reasons why the average vitamin D consumption of research respondents is less than the recommended RDA for vitamin D, namely a minimum of 15 mcg/day.

The food source that contributed the greatest value of vitamin D in this study was milk, with a vitamin D content of 7.5 mcg/35g, namely 2.1 mcg/day. Milk with a vitamin D content of 7.5 mcg/35g is a fortified product that contains vitamin D. A study by Torres et. al. (2020), examined the relationship between milk consumption and vitamin D status in the United States population, stating that milk intake (especially low-fat milk) was positively associated with serum vitamin D status and with a 31-42% higher probability of meeting serum 25(OH)D levels. Recommended (>50 nmol/L) among all age groups, and research results also show that milk consumption consistently has higher serum 25(OH)D levels (Torres *et al*., 2020). Another thing that could cause research respondents not to meet the recommended RDA for vitamin D is that smoking can reduce the intake of foods containing vitamin D. It can happen because when someone inhales cigarette smoke, as many as 4000 chemicals will be inhaled and enter the lungs, especially nicotine (Yang *et al*., 2021). Nicotine can suppress a smoker's appetite. The nicotine content in a cigarette is 0.3–2.8 mg. Nicotine will be quickly absorbed into the bloodstream and carried to the brain, and will bind to nicotinic receptors, which are connected to ion channels and cause cations, including sodium and potassium, to enter and release various neurotransmitters. This process causes the release of catecholamines, dopamine, serotonin, norepinephrine, GABA, and other neurotransmitters, so that the central nervous system will release neurotransmitters that are related to decreased appetite. The higher the level of nicotine in the blood, the greater the postsynaptic stimulation of nicotinic receptors. This decrease in appetite in smokers can cause a decrease in food intake containing vitamin D (McEwan *et al*., 2022). Intake of food containing vitamin D is significantly correlated with serum 25(OH)D levels (Andrade *et al*., 2022). There has been no research related to reducing the intake of foods containing vitamin D in men who are active smokers. This study is the first study to examine the effect of smoking activity on the intake of foods containing vitamin D in male active smokers.

The instruments used to measure physical activity have various methods. For example, by using accelerometers, pedometers, and self-report questionnaires (IPAQ, Physical Activity Readiness Questionnaire (PAR-Q). This research uses self-report questionnaire instruments because they have the advantage of lower costs. Respondents are not burdened, and getting answers from physical activity activities during the last week from respondents, of course, there are also shortcomings, namely that there can be a slight data bias because the data obtained is only based on the respondents' memories (Anindya *et al*., 2022; Andriyani *et al*., 2020; Suryadinata *et al*., 2020). Previous research by Lorensia *et al*. (2021) involved 124 adult smokers in Surabaya, Indonesia, and showed that the level of physical activity did not correlate with respiratory problems; these problems were more common in the vigorous category.

Conclusion

Most of the respondents' classifications had a level of insufficiency in vitamin D levels. The most consumed were eggs (37.66g), then pindang fish (10.21g), milk with a Vitamin D content of 7 mcg/35g (9.93g), while the least consumed was anchovies (0.89g). The average intake of foods containing vitamin D consumed by respondents was 5.77±5.72 mcg/day, and only 9 people (19.15%) consumed enough foods containing vitamin D. Vitamin D levels had a significant effect on smoking severity (P=0.000), food intake (P=0.000), and physical activity (P=0.000). The higher the food intake and physical activity, the higher the vitamin D levels. However, the results also showed that the higher the exposure to smoking, the higher the vitamin D levels. However, vitamin D levels are not related to sun exposure (p-value = 0.624) in active smokers.

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