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RESEARCH ARTICLE

Relationship of Vitamin D Intake with Obesity in Adolescents

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Abstract

Vitamin D deficiency is a problem worldwide, with the primary source of it being sun exposure, which activates the skin's vitamin D substrate. A diet lacking in vitamin D can put people at risk for obesity. The study aimed to determine the relationship between the risk of vitamin D deficiency and obesity in adolescents in Surabaya. It is a case-control research design conducted from March 2018 to January 2019 in a private university in Surabaya, East Java. Respondents were 200 students divided into two groups. The data collection method used the Food Frequency Questionnaire with Spearman correlation analysis to determine the relationship between vitamin D intake and obesity. The results are that the relationship between intake of vitamin D in food and obesity was very strong (0.816). The comparison between the two groups of respondents was 0.666, indicating that the non-obese group had an increased risk of vitamin D deficiency by 0.6 times compared to the obese group. There was a significant relationship between vitamin D intake in food and obesity. It is necessary to investigate further the intake of other foods and the factors that influence obesity in students.

Keywords: Food Frequency Questionnaire, obesity, students, vitamin D

Introduction

Vitamin D deficiency is a problem of concern today. The primary source of vitamin D is sun exposure, which activates the skin's vitamin D substrate. Sub-tropical and tropical countries show a high prevalence of vitamin D deficiency.[1] Vitamin D deficiency occurs not only in areas with less sunlight intensity but also in sub-tropical and tropical areas.[2] The prevalence of vitamin deficiency in South Asia is estimated to be around 70%, and in Southeast Asia, this figure varies between 6–70% depending on skin color, age, and habits of avoiding sun exposure.[1,2]

In tropical countries in Asia, such as Indonesia, the need for sunlight should be sufficient, but it is estimated that the prevalence of vitamin D deficiency reaches 63%.[3] Data on the prevalence of vitamin D deficiency in various countries varies widely.[2] Modernization also brings changes in lifestyle and diet to be low in vitamin D. In addition, increased pollution prevents sunlight from reaching the earth, blocking sun exposure on human skin.[4] Asian people's daily behavior can also be associated with vitamin D deficiency. The classic beauty standard causes white people to look more beautiful than dark-skinned people. So that most Asian people choose to protect their skin from sun exposure with sunscreen, which can prevent sun exposure to the skin.[1]

According to the Regulation of the Minister of Health of the Republic of Indonesia in 2019,[5] vitamin D's nutritional adequacy rate (recommended dietary allowances, RDA) is 15 mcg. Vitamin D deficiency can be one of the causes of various chronic diseases.[6] Vitamin D is associated with multiple diseases such as cancer, hypertension, diabetes mellitus, and the increasing incidence of obesity.[7] Low levels of vitamin D in the body are generally suffered by adolescents who are obese.[3] Obesity is one of the most common health problems in modern times. Obesity is an abnormal or excessive fat accumulation that can interfere with health.[8]

Adolescents, including students, are most at risk of unhealthy lifestyles.[9] A student usually has a reasonably high level of education but tends to have limited physical activity,[10] and low vitamin D levels.[11] An unhealthy lifestyle, including an unhealthy diet, also triggers obesity. Many students also experience obesity.[12]

Adolescents are vulnerable to malnutrition due to unhealthy eating patterns and require higher nutrients due to increased physical growth.[13] Excessive eating habits in adolescents without paying attention to the intake of nutrients consumed, especially energy intake.[12] The study stated that 90% of people who are obese also

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experience vitamin D deficiency. Research also shows that subjects given additional vitamin D will experience decreased appetite and weight loss.[10] Modern lifestyles such as excessive eating patterns and limited physical activity will trigger obesity, which also causes low levels of vitamin D in the blood. Excess body weight that causes obesity can cause a decrease in the bioavailability of vitamin D from the skin and food because it accumulates in body fat.[14] Although a high intake of dietary nutrients can cause weight gain, proper and healthy nutritional intake can increase vitamin D levels in the blood. Calcium and vitamin D intake can affect body weight, but this still requires further research and will depend on a person's healthy lifestyle.[14]

Related to the problem of low vitamin D levels in obese people, they may not consume enough foods that contain vitamin D. Vitamin D intake was assessed through the Food Frequency Questionnaire (FFQ) form. The advantage of FFQ compared to other methods is that it can provide a qualitative description of the frequency of food consumption patterns within a certain period. FFQ can be used to assess the condition of vitamin D intake validly.[15,16]

This study aimed to determine the relationship between the risk of deficiency in intake of foods containing vitamin D and obesity in adolescents in Surabaya.

Methods

The design used a case-control research design conducted from March 2018 to January 2019. This research received an ethics certificate No. 034/KE/I/2018 from Universitas Surabaya.

The variable was the frequency of foods containing vitamin D. The frequency of foods containing vitamin D was the amount of vitamin D intake from food and beverages that were often consumed by respondents and measured using FFQ.[15,16]

The population used in this study were students (18–25 years old) from a private university in Surabaya, East Java. The respondents in this study were obese (BMI=27.0 kg/m^2),[17] and non-obese (BMI<27.0 kg/m^2) students. The criteria are willing to become research respondents and not on a special diet (diet for chronic diseases and a strict vegetarian diet, as well as in a program to gain or lose weight). The sampling technique used was purposive sampling. The sample size was 100 people for each group.

The data collection process was first the preparation of the FFQ (containing: a list of foods, the frequency of food at a specific time, and the portion of food consumed). This questionnaire began with determining a list of foods containing vitamin D. The frequency of eating was calculated by how many times the food has been consumed per day, week, and month. Meanwhile, the food portion was calculated based on the household size of each food;[18] Secondly, we conducted a preliminary study to determine the types of food available and commonly consumed by the community around the research location. This preliminary study conducted interviews with 20 respondents. Foodstuffs that had never been or were not widely consumed are excluded from the list; Third, finalizing the list of foods to be used in the FFQ. Then an interview was conducted by exploring the foods often consumed by the respondents, asking about the frequency and portion, and recording it on the FFQ.

The data were processed using a NutriSurvey and determining the difference in the frequency of foods containing vitamin D in obese and non-obese students. Statistical analysis was carried out using SPSS for windows version 24.0. Spearman correlation test was conducted to determine the relationship between vitamin D intake and the risk of obesity (ordinal data scale). The odds ratio was used to compare the risk of deficiency related to the intake of foods containing vitamin D in obese (BMI=27.0 kg/m^2) and non-obese students (BMI<27.0 kg/m^2).

Results

Data were collected by conducting interviews with research subjects of obese and non-obese student groups, with each group having 100 respondents.

Table 1 describes the distribution of the respondent's age, gender, and body mass index (BMI). Based on gender, in the non-obese group, there were 22% (22 people) male and 78% (78 people) female, while respondents in the obesity category were male 31% (31 people) and female 69% (69 people).

Foods that contain vitamin D most who consumed two groups of respondents are eggs (20 SI D3 and D2), milk (100 SI/240 mL D3), cheese (100 SI/85 gram), catfish, fish, and shrimp (100 SI D3, Table 2).

From Table 3, the correlation coefficient was

Table 1 Characteristics of Respondents

Characteristics	Groups			
	Non-obese		Obese	
	n=100	%	n=100	%
Gender				
Male	22	22	31	31
Female	78	78	69	69
BMI (kg/m^2)				
Thin (<18.50)	2	2		
Normal (≥18.5–<24.9)	86	86		
Overweight (≥25.0–<27.0)	12	12		
Obesity (≥27.0)			100	100

0.816. It means that the level of strength of the relationship (correlation) between intake of vitamin D in food and obesity was very strong (>0.01). Therefore, when vitamin D intake is increased, the risk of obesity decreases. In addition, the significant value was 0.000 (p value<0.05), which means that there was a significant relationship between vitamin D intake in food and the risk of obesity.

The results of the analysis of vitamin D adequacy in the non-obese and obese respondent groups can be seen in Table 4. The non-obese group with a vitamin D deficit was 83% (83 people) and 88% (88 people) in the obese group. The data was analyzed using the prevalence odds ratio test to calculate the risk of vitamin D deficiency among the non-obese and obese groups.

The risk comparison between the two groups of respondents can be observed from the prevalence odd ratio (POR) value. The odd ratio (OR) value was 0.666 with a significant 95% CI of 0.300–1.478, indicating that the non-obese group of respondents had an increased risk of vitamin D deficiency by 0.6 times compared to the obese respondent group. In other words, it can be interpreted that the non-obese group had 1.6 times less at risk than the obese group (Table 4).

Discussion

In this study, the respondents included in the study were students. Healthy adolescents are still at risk for vitamin D deficiency. Daily vitamin D intake in young adults was often below the recommended intake of 200 international units (IU) per day. In Indonesia, the daily vitamin D requirement for ages 18–25 is 15 mcg.[6] The increasing use of sunscreens to reduce skin damage or cancer reduces or eliminates skin vitamin D synthesis.[19]

The respondents involved in this study were 200 people. Gender factors affect nutritional needs. Generally, men need more nutrients than women.[20] This study used respondents in the age range of 18–25 years which was included in the category of late teens. Based on previous research, young adults or adolescents were known to be at risk for vitamin D deficiency which was influenced by habits such as consuming vitamin D below the recommended limit per day and lack of outdoor physical activity.[21]

Respondents involved in this study consisted of non-obese and obese groups. Obesity was a risk factor for vitamin D deficiency.[7,10] Research has shown that an increase in BMI was associated with lower levels of 25-hydroxyvitamin D (25D), the active form of vitamin D in the body.[19–21] The mechanism of vitamin D deficiency in obese patients included high-fat accumulation resulting in a decrease in the bioavailability of vitamin D in the body due to the fat-soluble nature of vitamin D, causing a reduction in the release of vitamin D from fat into the systemic circulation.[22,23]

There are two pathways for vitamin D intake: the first comes from food and beverages consumed. The second is the biosynthetic pathway for provitamin D to become vitamin D with the help of sunlight on the skin. The two tracks had a relationship because the skin has a biosynthetic path with the sun's UV rays that will be able to take place if the body has provitamin D fundamental ingredients obtained from the food we eat. Likewise, the opposite effect will be observed if there is no source of food containing

Table 2 Frequency of Foods Containing Vitamin D that Most Consumed by Respondents

Type of Food	Frequency		Groups				Total	
			Non-obese		Obese			
			n=100	%	n=100	%	n=200	%
Egg	Daily	1×	7	7	7	7	14	7.0
	Weekly	1–3×	25	25	16	16	41	20.5
		4–6×	64	64	71	71	135	67.5
	Monthly	1×	2	2	2	2	4	2.0
		>1×	1	1	2	2	3	1.5
	Never		1	1	2	2	3	1.5
Milk	Daily	1×	57	57	59	59	116	58.0
	Weekly	1–3×	21	21	22	22	43	21.5
		4–6×	10	10	13	13	23	11.5
	Monthly	1×	5	5	0	0	5	2.5
		>1×	5	5	0	0	5	2.5
	Never		2	2	6	6	8	4.0
Cheese	Daily	1×	1	1	3	3	4	2.0
	Weekly	1–3×	12	12	13	13	25	12.5
		4–6×	4	4	7	7	11	5.5
	Monthly	1×	40	40	31	31	71	35.5
		>1×	10	10	9	9	19	9.5
	Never		33	33	37	37	70	35.0
Catfish	Weekly	1–3×	46	46	63	63	109	54.5
		4–6×	8	8	2	2	10	5.0
	Monthly	1×	1	1	4	4	5	2.5
		>1×	2	2	7	7	9	4.5
	Never		43	43	24	24	67	33.5
Milkfish	Weekly	1–3×	10	10	23	23	33	16.5
		4–6×	1	1	0	0	1	0.5
	Monthly	1×	20	20	14	14	34	17.0
		>1×	0	0	6	6	6	3.0
	Never		69	69	57	57	126	63.0
Indonesian salted-boiled fish (*pindang*)	Weekly	1–3×	31	31	39	39	70	35.0
		4–6×	2	2	2	2	4	2.0
	Monthly	1×	13	13	13	13	26	13.0
		>1×	9	9	12	12	21	10.5
	Never		45	45	34	34	79	39.5
Shrimp	Weekly	1–3×	13	13	57	57	70	35.0
		4–6×	33	33	4	4	37	18.5
	Monthly	1×	11	11	4	4	15	7.5
		>1×	3	3	8	8	11	5.5
	Never		40	40	27	27	67	33.5

Table 3 Relationship of Vitamin D Deficiency Related to Vitamin D Consumption

Vitamin D Status	Groups				Total n=200	Spearman	
	Non-obese		Obese			Correlation Coeffficient	Sig. (2-tailed)
	n=100	%	n=100	%			
Deficiency	83	41.5	88	44.0	171	0.816	0.000
Adequate	17	8.5	12	6.0	29		

Table 4 Risk of Vitamin D Deficiency Related to Vitamin D Consumption

Vitamin D Status	Groups				Total n=200	Odd Ratio	
	Non-obese		Obese			POR	Conclusion
	n=100	%	n=100	%			
Deficiency	83	41.5	88	44.0	171	0.666	The non-obese group had a 0.6-fold risk of vitamin D deficiency compared to the obese group
Adequate	17	8.5	12	6.0	29		

vitamin D. The body will still lack vitamin D because there are no ingredients that will be used as vitamin D. Vitamin D obtained from food before use needs to be metabolized to become the active form. At the same time, vitamin D obtained from sunlight needs to be synthesized first by the skin and then processed in the body to produce an active form of vitamin D. Both states require sunlight to convert it into provitamin cholecalciferol (D3) and vitamin ergocalciferol (D2). Vitamin D3 forms in the skin by ultraviolet light from 7-dihydro cholesterol. The amount of provitamin D and the active ingredients developed depends on the intensity of ultraviolet radiation, skin pigmentation, use of sunscreen, and the length of time exposed to sunlight.[22,23]

Vitamin D was absorbed in the small intestine along with lipids with the help of bile and transported by D-plasma binding protein (DBP) to storage sites in the liver, skin, brain, bones, and other tissues. The process of vitamin D metabolism first begins in the liver. Vitamin D precursors, with the help of vitamin D-25-hydroxylase (25-OHase), are converted into 25-hydroxyvitamin D2 and D3. It will then be converted in the kidneys to 1,25-dihydroxy-vitamin D with the help of the 25-hydroxyvitamin D-1α-hydroxylase (1-OHase);[24] where the addition of two hydroxyl groups at the position so that it becomes an active form and functions to absorb calcium in the intestine. Increasing the amount of 1,25-dihydroxy vitamin D will affect 25-hydroxyvitamin D-24-hydroxylase (24-OHase) to catabolize 1,25-dihydroxy vitamin D and 25-hydroxyvitamin D to calcitroic acid, an inactive and water-soluble form so that can be excreted outside the body. Provitamin D comes from animals to form 1,25-dihydroxycholecalciferol, also known as calcitriol. If it is extracted from plants, it forms 1,25-dihydroxy ergocalciferol or ercalcitriol. Calcitriol in the small intestine increases the absorption of phosphorus and calcium. Parathyroid hormone is needed to stimulate the production of 1,25-dihydroxycholecalciferol by the kidneys. This hormone is released when the amount of calcium in the blood is low, affecting the increase in calcitriol synthesis carried out by the kidneys.[25]

In the liver, the vitamin D3 molecule is converted to 25-hydroxyvitamin D3 (25(OH)D3), the serum's most stable and abundant vitamin D metabolite. It has traditionally been used as a biomarker for individual vitamin D status. Further hydroxylation at carbon one yields 1α,25-dihydroxy vitamin D3 (1,25(OH)2D3), which acts as an endocrine hormone as a high-affinity ligand to the transcription factor vitamin D receptor (VDR). The primary source of endocrine production of 1,25(OH)2D3 is the proximal tubular cells of the kidney. In a paracrine or autocrine fashion, monocytes, macrophages, and dendritic cells of the innate immune system, osteoblasts in bone, and skin keratinocytes are also capable of producing the hormone.[26]

Factors that influence obesity are nutritional factors, physical activity, and genetic factors. The role of nutrition begins in the womb. The mother's weight affects the body fat and the baby's growth. Obese people have a higher average energy intake than non-obese people. Adolescents with high energy intake are 4.69 times more likely to be obese than adolescents with sufficient energy intake. Likewise, the input of fat and carbohydrates shows that most obese adolescents have an average intake of more. Adolescents with more fat and carbohydrate intake have a two times greater risk of being obese than adolescents with sufficient fat and carbohydrate intake.[27]

The physical activity level of obese adolescents is lower when compared to non-obese adolescents—people who are less active need fewer calories than highly engaged people. Someone whose life is less active (sedentary life) or does not do a balanced physical activity and consumes foods high in fat will tend to be

obese. A lifestyle that lacks physical activity will affect a person's body condition. Physical activity is needed to burn energy in the body. If the energy intake is excessive and not balanced with balanced physical activity, it will make it easier for someone to become fat.[28]

The results showed that adolescents with fathers and mothers with obese status had a greater risk of becoming obese than those with fathers and mothers who were not obese. Families pass on dietary habits and lifestyles that can contribute to the incidence of obesity. Families share the same food and physical activity habits, so the relationship between genes and the environment is mutually supportive.[28,29]

Food frequency is a method to obtain qualitative food consumption data and descriptive information about consumption patterns. However, the FFQ can also be used to assess food consumption quantitatively. In practice, the frequency of food is often met with questions for respondents in the form of two main components: the list of foods and the frequency of food use. In the food frequency approach, the principle is that the relationship between food intake and the onset of reactions results from the long-term average intake starting from weekly, monthly to yearly. Using this method, it is also possible to know the value of using a particular food or food group (for example, a source of fat, a source of nutrition, a source of vitamin D, etc.).[30] Suggestions for further research are on the measurement of BMI. It is ideal because the body weight measurement should be done when waking up and adding a parameter of a serum 25(OH)D examination to determine vitamin D levels.

Conclusions

There was a significant relationship between vitamin D intake in food and the risk of obesity. Non-obese had an increased risk of vitamin D deficiency compared to obese.

Conflict of Interest

All authors stated that there was no conflict of interest in this study.

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This achievement received a positive response from researchers, lecturers, and health observers indicated by the articles submitted, three times the number of articles received initially. The quality of the articles also shows improvement in terms of methodology and writing that is useful for audiences. Research results were best to disseminate as early as possible to good use. Publication of the **Global Medical and Health Communication** every **6 (six) months** in a year will be published every **4 (four) months** starting in 2017.

The news from science and health about challenges and opportunities in Indonesia is still very rare and **Global Medical and Health Communication** hopes to become the best means to support researchers, lecturers, and health practitioners to become the voice of Indonesia, especially in health.

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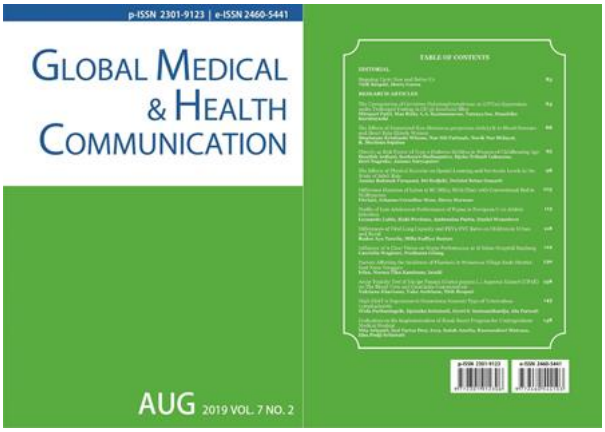

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RELATIONSHIP OF VITAMIN D INTAKE WITH OBESITY IN ADOLESCENTS

Amelia Lorensia, Rivan Virlando Suryadinata, Gesti Nurulalita Arganitya

Abstract

Vitamin D deficiency is a problem worldwide, with the primary source of it being sun exposure, which activates the skin's vitamin D substrate. A diet lacking in vitamin D can put people at risk for obesity. The study aimed to determine the relationship between the risk of vitamin D deficiency and obesity in adolescents in Surabaya. It is a case-control research design conducted from March 2018 to January 2019 in a private university in Surabaya, East Java. Respondents were 200 students divided into two groups. The data collection method used the Food Frequency Questionnaire with Spearman correlation analysis to determine the relationship between vitamin D intake and obesity. The results are that the relationship between intake of vitamin D in food and obesity was very strong (0.816). The comparison between the two groups of respondents was 0.666, indicating that the non-obese group had an increased risk of vitamin D deficiency by 0.6 times compared to the obese group. There was a significant relationship between vitamin D intake in food and obesity. It is necessary to investigate further the intake of other foods and the factors that influence obesity in students.

Keywords

Food Frequency Questionnaire; obesity; students; vitamin D

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Relationship of Vitamin D Intake with Obesity in Adolescents

by Amelia Lorensia

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RESEARCH ARTICLE

Relationship of Vitamin D Intake with Obesity in Adolescents

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Abstract

Vitamin D deficiency is a problem worldwide, with the primary source of it being sun exposure, which activates the skin's vitamin D substrate. A diet lacking in vitamin D can put people at risk for obesity. The study aimed to determine the relationship between the risk of vitamin D deficiency and obesity in adolescents in Surabaya. It is a case-control research design conducted from March 2018 to January 2019 in a private university in Surabaya, East Java. Respondents were 200 students divided into two groups. The data collection method used the Food Frequency Questionnaire with Spearman correlation analysis to determine the relationship between vitamin D intake and obesity. The results are that the relationship between intake of vitamin D in food and obesity was very strong (0.816). The comparison between the two groups of respondents was 0.666, indicating that the non-obese group had an increased risk of vitamin D deficiency by 0.6 times compared to the obese group. There was a significant relationship between vitamin D intake in food and obesity. It is necessary to investigate further the intake of other foods and the factors that influence obesity in students.

Keywords: Food Frequency Questionnaire, obesity, students, vitamin D

Introduction

Vitamin D deficiency is a problem of concern today. The primary source of vitamin D is sun exposure, which activates the skin's vitamin D substrate. Sub-tropical and tropical countries show a high prevalence of vitamin D deficiency.[1] Vitamin D deficiency occurs not only in areas with less sunlight intensity but also in sub-tropical and tropical areas.[2] The prevalence of vitamin deficiency in South Asia is estimated to be around 70%, and in Southeast Asia, this figure varies between 6–70% depending on skin color, age, and habits of avoiding sun exposure.[1,2]

In tropical countries in Asia, such as Indonesia, the need for sunlight should be sufficient, but it is estimated that the prevalence of vitamin D deficiency reaches 63%.[3] Data on the prevalence of vitamin D deficiency in various countries varies widely.[2] Modernization also brings changes in lifestyle and diet to be low in vitamin D. In addition, increased pollution prevents sunlight from reaching the earth, blocking sun exposure on human skin.[4] Asian people's daily behavior can also be associated with vitamin D deficiency. The classic beauty standard causes white people to look more beautiful than dark-skinned people. So that most Asian people choose to protect their skin from sun exposure with sunscreen, which can prevent sun exposure to the skin.[1]

According to the Regulation of the Minister of Health of the Republic of Indonesia in 2019,[5] vitamin D's nutritional adequacy rate (recommended dietary allowances, RDA) is 15 mcg. Vitamin D deficiency can be one of the causes of various chronic diseases.[6] Vitamin D is associated with multiple diseases such as cancer, hypertension, diabetes mellitus, and the increasing incidence of obesity.[7] Low levels of vitamin D in the body are generally suffered by adolescents who are obese.[3] Obesity is one of the most common health problems in modern times. Obesity is an abnormal or excessive fat accumulation that can interfere with health.[8]

Adolescents, including students, are most at risk of unhealthy lifestyles.[9] A student usually has a reasonably high level of education but tends to have limited physical activity,[10] and low vitamin D levels.[11] An unhealthy lifestyle, including an unhealthy diet, also triggers obesity. Many students also experience obesity.[12]

Adolescents are vulnerable to malnutrition due to unhealthy eating patterns and require higher nutrients due to increased physical growth.[13] Excessive eating habits in adolescents without paying attention to the intake of nutrients consumed, especially energy intake.[12] The study stated that 90% of people who are obese also

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experience vitamin D deficiency. Research also shows that subjects given additional vitamin D will experience decreased appetite and weight loss.[10] Modern lifestyles such as excessive eating patterns and limited physical activity will trigger obesity, which also causes low levels of vitamin D in the blood. Excess body weight that causes obesity can cause a decrease in the bioavailability of vitamin D from the skin and food because it accumulates in body fat.[14] Although a high intake of dietary nutrients can cause weight gain, proper and healthy nutritional intake can increase vitamin D levels in the blood. Calcium and vitamin D intake can affect body weight, but this still requires further research and will depend on a person's healthy lifestyle.[14]

Related to the problem of low vitamin D levels in obese people, they may not consume enough foods that contain vitamin D. Vitamin D intake was assessed through the Food Frequency Questionnaire (FFQ) form. The advantage of FFQ compared to other methods is that it can provide a qualitative description of the frequency of food consumption patterns within a certain period. FFQ can be used to assess the condition of vitamin D intake validly.[15,16]

This study aimed to determine the relationship between the risk of deficiency in intake of foods containing vitamin D and obesity in adolescents in Surabaya.

Methods

The design used a case-control research design conducted from March 2018 to January 2019. This research received an ethics certificate No. 034/KE/I/2018 from Universitas Surabaya.

The variable was the frequency of foods containing vitamin D. The frequency of foods containing vitamin D was the amount of vitamin D intake from food and beverages that were often consumed by respondents and measured using FFQ.[15,16]

The population used in this study were students (18–25 years old) from a private university in Surabaya, East Java. The respondents in this study were obese (BMI=27.0 kg/m^2),[17] and non-obese (BMI<27.0 kg/m^2) students. The criteria are willing to become research respondents and not on a special diet (diet for chronic diseases and a strict vegetarian diet, as well as in a program to gain or lose weight). The sampling technique used was purposive sampling. The sample size was 100 people for each group.

The data collection process was first the preparation of the FFQ (containing: a list of foods, the frequency of food at a specific time, and the portion of food consumed). This questionnaire began with determining a list of foods containing vitamin D. The frequency of eating was calculated by how many times the food has been consumed per day, week, and month. Meanwhile, the food portion was calculated based on the household size of each food;[18] Secondly, we conducted a preliminary study to determine the types of food available and commonly consumed by the community around the research location. This preliminary study conducted interviews with 20 respondents. Foodstuffs that had never been or were not widely consumed are excluded from the list; Third, finalizing the list of foods to be used in the FFQ. Then an interview was conducted by exploring the foods often consumed by the respondents, asking about the frequency and portion, and recording it on the FFQ.

The data were processed using a NutriSurvey and determining the difference in the frequency of foods containing vitamin D in obese and non-obese students. Statistical analysis was carried out using SPSS for windows version 24.0. Spearman correlation test was conducted to determine the relationship between vitamin D intake and the risk of obesity (ordinal data scale). The odds ratio was used to compare the risk of deficiency related to the intake of foods containing vitamin D in obese (BMI=27.0 kg/m^2) and non-obese students (BMI<27.0 kg/m^2).

Results

Data were collected by conducting interviews with research subjects of obese and non-obese student groups, with each group having 100 respondents. Table 1 describes the distribution of the respondent's age, gender, and body mass index (BMI). Based on gender, in the non-obese group, there were 22% (22 people) male and 78% (78 people) female, while respondents in the obesity category were male 31% (31 people) and female 69% (69 people).

Foods that contain vitamin D most who consumed two groups of respondents are eggs (20 SI D3 and D2), milk (100 SI/240 mL D3), cheese (100 SI/85 gram), catfish, fish, and shrimp (100 SI D3, Table 2).

From Table 3, the correlation coefficient was

Table 1 Characteristics of Respondents

Characteristics	Groups			
	Non-obese		Obese	
	n=100	%	n=100	%
Gender				
Male	22	22	31	31
Female	78	78	69	69
BMI (kg/m²)				
Thin (<18.50)	2	2		
Normal (≥18.5–<24.9)	86	86		
Overweight (≥25.0–<27.0)	12	12		
Obesity (≥27.0)			100	100

0.816. It means that the level of strength of the relationship (correlation) between intake of vitamin D in food and obesity was very strong (>0.01). Therefore, when vitamin D intake is increased, the risk of obesity decreases. In addition, the significant value was 0.000 (p value<0.05), which means that there was a significant relationship between vitamin D intake in food and the risk of obesity.

The results of the analysis of vitamin D adequacy in the non-obese and obese respondent groups can be seen in Table 4. The non-obese group with a vitamin D deficit was 83% (83 people) and 88% (88 people) in the obese group. The data was analyzed using the prevalence odds ratio test to calculate the risk of vitamin D deficiency among the non-obese and obese groups.

The risk comparison between the two groups of respondents can be observed from the prevalence odd ratio (POR) value. The odd ratio (OR) value was 0.666 with a significant 95% CI of 0.300–1.478, indicating that the non-obese group of respondents had an increased risk of vitamin D deficiency by 0.6 times compared to the obese respondent group. In other words, it can be interpreted that the non-obese group had 1.6 times less at risk than the obese group (Table 4).

Discussion

In this study, the respondents included in the study were students. Healthy adolescents are still at risk for vitamin D deficiency. Daily vitamin D intake in young adults was often below the recommended intake of 200 international units (IU) per day. In Indonesia, the daily vitamin D requirement for ages 18–25 is 15 mcg.[6] The increasing use of sunscreens to reduce skin damage or cancer reduces or eliminates skin vitamin D synthesis.[19]

The respondents involved in this study were 200 people. Gender factors affect nutritional needs. Generally, men need more nutrients than women.[20] This study used respondents in the age range of 18–25 years which was included in the category of late teens. Based on previous research, young adults or adolescents were known to be at risk for vitamin D deficiency which was influenced by habits such as consuming vitamin D below the recommended limit per day and lack of outdoor physical activity.[21]

Respondents involved in this study consisted of non-obese and obese groups. Obesity was a risk factor for vitamin D deficiency.[7,10] Research has shown that an increase in BMI was associated with lower levels of 25-hydroxyvitamin D (25D), the active form of vitamin D in the body.[19–21] The mechanism of vitamin D deficiency in obese patients included high-fat accumulation resulting in a decrease in the bioavailability of vitamin D in the body due to the fat-soluble nature of vitamin D, causing a reduction in the release of vitamin D from fat into the systemic circulation.[22,23]

There are two pathways for vitamin D intake: the first comes from food and beverages consumed. The second is the biosynthetic pathway for provitamin D to become vitamin D with the help of sunlight on the skin. The two tracks had a relationship because the skin has a biosynthetic path with the sun's UV rays that will be able to take place if the body has provitamin D fundamental ingredients obtained from the food we eat. Likewise, the opposite effect will be observed if there is no source of food containing

Table 2 Frequency of Foods Containing Vitamin D that Most Consumed by Respondents

Type of Food	Frequency		Groups				Total	
			Non-obese		Obese			
			n=100	%	n=100	%	n=200	%
Egg	Daily	1×	7	7	7	7	14	7.0
	Weekly	1–3×	25	25	16	16	41	20.5
		4–6×	64	64	71	71	135	67.5
	Monthly	1×	2	2	2	2	4	2.0
		>1×	1	1	2	2	3	1.5
	Never		1	1	2	2	3	1.5
Milk	Daily	1×	57	57	59	59	116	58.0
	Weekly	1–3×	21	21	22	22	43	21.5
		4–6×	10	10	13	13	23	11.5
	Monthly	1×	5	5	0	0	5	2.5
		>1×	5	5	0	0	5	2.5
	Never		2	2	6	6	8	4.0
Cheese	Daily	1×	1	1	3	3	4	2.0
	Weekly	1–3×	12	12	13	13	25	12.5
		4–6×	4	4	7	7	11	5.5
	Monthly	1×	40	40	31	31	71	35.5
		>1×	10	10	9	9	19	9.5
	Never		33	33	37	37	70	35.0
Catfish	Weekly	1–3×	46	46	63	63	109	54.5
		4–6×	8	8	2	2	10	5.0
	Monthly	1×	1	1	4	4	5	2.5
		>1×	2	2	7	7	9	4.5
	Never		43	43	24	24	67	33.5
Milkfish	Weekly	1–3×	10	10	23	23	33	16.5
		4–6×	1	1	0	0	1	0.5
	Monthly	1×	20	20	14	14	34	17.0
		>1×	0	0	6	6	6	3.0
	Never		69	69	57	57	126	63.0
Indonesian salted-boiled fish (*pindang*)	Weekly	1–3×	31	31	39	39	70	35.0
		4–6×	2	2	2	2	4	2.0
	Monthly	1×	13	13	13	13	26	13.0
		>1×	9	9	12	12	21	10.5
	Never		45	45	34	34	79	39.5
Shrimp	Weekly	1–3×	13	13	57	57	70	35.0
		4–6×	33	33	4	4	37	18.5
	Monthly	1×	11	11	4	4	15	7.5
		>1×	3	3	8	8	11	5.5
	Never		40	40	27	27	67	33.5

Table 3 Relationship of Vitamin D Deficiency Related to Vitamin D Consumption

Vitamin D Status	Groups				Total n=200	Spearman	
	Non-obese		Obese			Correlation Coeffficient	Sig. (2-tailed)
	n=100	%	n=100	%			
Deficiency	83	41.5	88	44.0	171	0.816	0.000
Adequate	17	8.5	12	6.0	29		

Table 4 Risk of Vitamin D Deficiency Related to Vitamin D Consumption

Vitamin D Status	Groups				Total n=200	Odd Ratio	
	Non-obese		Obese			POR	Conclusion
	n=100	%	n=100	%			
Deficiency	83	41.5	88	44.0	171	0.666	The non-obese group had a 0.6-fold risk of vitamin D deficiency compared to the obese group
Adequate	17	8.5	12	6.0	29		

vitamin D. The body will still lack vitamin D because there are no ingredients that will be used as vitamin D. Vitamin D obtained from food before use needs to be metabolized to become the active form. At the same time, vitamin D obtained from sunlight needs to be synthesized first by the skin and then processed in the body to produce an active form of vitamin D. Both states require sunlight to convert it into provitamin cholecalciferol (D3) and vitamin ergocalciferol (D2). Vitamin D3 forms in the skin by ultraviolet light from 7-dihydro cholesterol. The amount of provitamin D and the active ingredients developed depends on the intensity of ultraviolet radiation, skin pigmentation, use of sunscreen, and the length of time exposed to sunlight.[22,23]

Vitamin D was absorbed in the small intestine along with lipids with the help of bile and transported by D-plasma binding protein (DBP) to storage sites in the liver, skin, brain, bones, and other tissues. The process of vitamin D metabolism first begins in the liver. Vitamin D precursors, with the help of vitamin D-25-hydroxylase (25-OHase), are converted into 25-hydroxyvitamin D2 and D3. It will then be converted in the kidneys to 1,25-dihydroxy-vitamin D with the help of the 25-hydroxyvitamin D-1α-hydroxylase (1-OHase);[24] where the addition of two hydroxyl groups at the position so that it becomes an active form and functions to absorb calcium in the intestine. Increasing the amount of 1,25-dihydroxy vitamin D will affect 25-hydroxyvitamin D-24-hydroxylase (24-OHase) to catabolize 1,25-dihydroxy vitamin D and 25-hydroxyvitamin D to calcitroic acid, an inactive and water-soluble form so that can be excreted outside the body. Provitamin D comes from animals to form 1,25-dihydroxycholecalciferol, also known as calcitriol. If it is extracted from plants, it forms 1,25-dihydroxy ergocalciferol or ercalcitriol. Calcitriol in the small intestine increases the absorption of phosphorus and calcium. Parathyroid hormone is needed to stimulate the production of 1,25-dihydroxycholecalciferol by the kidneys. This hormone is released when the amount of calcium in the blood is low, affecting the increase in calcitriol synthesis carried out by the kidneys.[25]

In the liver, the vitamin D3 molecule is converted to 25-hydroxyvitamin D3 (25(OH)D3), the serum's most stable and abundant vitamin D metabolite. It has traditionally been used as a biomarker for individual vitamin D status. Further hydroxylation at carbon one yields 1α,25-dihydroxy vitamin D3 (1,25(OH)2D3), which acts as an endocrine hormone as a high-affinity ligand to the transcription factor vitamin D receptor (VDR). The primary source of endocrine production of 1,25(OH)2D3 is the proximal tubular cells of the kidney. In a paracrine or autocrine fashion, monocytes, macrophages, and dendritic cells of the innate immune system, osteoblasts in bone, and skin keratinocytes are also capable of producing the hormone.[26]

Factors that influence obesity are nutritional factors, physical activity, and genetic factors. The role of nutrition begins in the womb. The mother's weight affects the body fat and the baby's growth. Obese people have a higher average energy intake than non-obese people. Adolescents with high energy intake are 4.69 times more likely to be obese than adolescents with sufficient energy intake. Likewise, the input of fat and carbohydrates shows that most obese adolescents have an average intake of more. Adolescents with more fat and carbohydrate intake have a two times greater risk of being obese than adolescents with sufficient fat and carbohydrate intake.[27]

The physical activity level of obese adolescents is lower when compared to non-obese adolescents—people who are less active need fewer calories than highly engaged people. Someone whose life is less active (sedentary life) or does not do a balanced physical activity and consumes foods high in fat will tend to be

obese. A lifestyle that lacks physical activity will affect a person's body condition. Physical activity is needed to burn energy in the body. If the energy intake is excessive and not balanced with balanced physical activity, it will make it easier for someone to become fat.[28]

The results showed that adolescents with fathers and mothers with obese status had a greater risk of becoming obese than those with fathers and mothers who were not obese. Families pass on dietary habits and lifestyles that can contribute to the incidence of obesity. Families share the same food and physical activity habits, so the relationship between genes and the environment is mutually supportive.[28,29]

Food frequency is a method to obtain qualitative food consumption data and descriptive information about consumption patterns. However, the FFQ can also be used to assess food consumption quantitatively. In practice, the frequency of food is often met with questions for respondents in the form of two main components: the list of foods and the frequency of food use. In the food frequency approach, the principle is that the relationship between food intake and the onset of reactions results from the long-term average intake starting from weekly, monthly to yearly. Using this method, it is also possible to know the value of using a particular food or food group (for example, a source of fat, a source of nutrition, a source of vitamin D, etc.).[30] Suggestions for further research are on the measurement of BMI. It is ideal because the body weight measurement should be done when waking up and adding a parameter of a serum 25(OH)D examination to determine vitamin D levels.

Conclusions

There was a significant relationship between vitamin D intake in food and the risk of obesity. Non-obese had an increased risk of vitamin D deficiency compared to obese.

Conflict of Interest

All authors stated that there was no conflict of interest in this study.

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