ORIGINAL ARTICLE
Intisari Sains Medis 2020, Volume 11, Number 1: 352-356
P-ISSN: 2503-3638, E-ISSN: 2089-9084

Published by DiscoverSys

The association between Body Surface Area (BSA) and vitamin D level among obese adolescent patients in Denpasar, Bali, Indonesia

Luh Gede Yuliadewi NS,* I Gusti Lanang Sidiartha

ABSTRACT

Background: Prevalence of obesity in adolescent in Indonesia is still high. An obese adolescent is likely to stay obese into adulthood and tends to develop into cardiovascular and metabolic diseases. Obese subjects have larger body surface area and should be able to produce more vitamin D from cutaneous synthesis. This study aims to determine the prevalence of obesity in adolescent in Denpasar, determine vitamin D status among obese adolescents and obtained an association between body surface area and vitamin D levels.

Methods: A descriptive observational study using a cross-sectional approach has been conducted among 51 obese adolescents in Denpasar during May to December 2018. Several variables assessed in this study were age, sex, weight, height, Body Mass Index (BMI), Body Surface Area (BSA), and vitamin D levels. Factors associated with vitamin D levels in obese adolescence were analyzed with appropriate statistical analysis. Data were analyzed using SPSS version 17 for Windows.

Results: From 51 subjects, 32 (62.74%) male and 19 (37.26%) female subjects were enrolled in this study. The mean weight and height of respondents were 89.4±9.8 kg and 158.6±7.3 cm. In addition, the average Body Mass Index (BMI) and Body Surface Area (BSA) were 33.6±3.4 kg/m2 and 2.1±0.2 m2. The mean Vitamin D levels was 18.9±4.9 ng/mL with 40 subjects (78,4%) were known in a vitamin D deficiency state. There was a significant weak positive association between BSA and vitamin D levels (r=0.32; p=0,002).

Conclusion: Most obese adolescents were in vitamin D deficiency with a significant weak positive association between BSA and vitamin D levels.

Keywords: Obese, Adolescent, BSA, Vitamin D
Cite This Article: Yuliadewi NS, L.G., Sidiartha, I.G.L. 2020. The association between Body Surface Area (BSA) and vitamin D level among obese adolescent patients in Denpasar, Bali, Indonesia. *Intisari Sains Medis* 11(1): 352-356. DOI: 10.15562/ism.v11i1.629

INTRODUCTION

Obesity can be defined as an excess of body fat. Childhood obesity has reached epidemic levels in developed as well as in developing countries.[1] A previous study found that overweight and obese prevalence tends to increase and varies based on age and gender in Asian Countries.[2] According to the previous study by Rachmi CN et al., the prevalence of obesity in adolescence in Indonesia is still high and differs based on age, gender, and environment.[3] This systematic review found that the prevalence of obesity range from 2.3% until 32.4% during 1993-2011 study period.[3] In addition, a study conducted by Susilowati D found that the prevalence of obesity among adolescents (10-19 years) difference based on gender, boys (9.8%) and girls (10.8%).[4]

Obesity in childhood and adolescence is known to have a significant impact on both physical and psychological health, social, emotional well-being, and self-esteem.[5,6] It also associated with poor academic performance and lower quality of life experienced by the child.[7,8] Obese adolescence are likely to stay obese into adulthood and more likely to develop a non-communicable disease like diabetes and cardiovascular disease at a younger age.[6] The mechanism of obesity development is not fully understood and it is believed to be a disorder with multiple causes. Environmental factors, lifestyle preference and cultural background, play vital roles in the rising prevalence of obesity worldwide.[9]

Micronutrition deficiency was found in obesity such as vitamin D, chromium, biotin and thiamine.[9] Vitamin D deficiency in obesity is caused by lack of intake, lack of outdoor activity and the use of sunscreen.[10] In obesity, there is a decrease of bioavailability of vitamin D because it accumulates in fat tissue. In the other hand, vitamin D synthesis also decreases due to reduced absorption in the intestine.[10]

The most well-known source of vitamin D is synthesis in the skin induced by sun exposure.[11] A whole-body exposure to Ultraviolet B (UVB) radiation for 15 to 20 minutes is able to induce the production of up to 250 µg vitamin D (10.000 IU).[11] Cutaneously synthesis of vitamin D from the plasma membrane and enter the systemic circulation and bound to the vitamin D binding protein.[12] Obese children have a large Body Surface Area (BSA) due to excess in body weight. The body surface area

Department of Child Health, Faculty of Medicine, Universitas Udayana, Sanglah General Hospital, Bali, Indonesia

*Correspondence to:
Luh Gede Yuliadewi NS; Department of Child Health, Faculty of Medicine, Universitas Udayana, Sanglah General Hospital, Bali, Indonesia;
sayayuliadewi@gmail.com

Received: 2019-09-25
Accepted: 2020-03-12
Published: 2020-04-01

(BSA) is the measured or calculated surface area of a human body, and it is lack affected by abnormal adipose mass.[13] Only a few studies have dealt with the importance of BSA and its correlation with endogenous vitamin D synthesis. A previous study reported that the increase of vitamin D levels related to the BSA it could be due to the vitamin D response after UVB irradiation reached a plateau when more than 33% of the body surface area was irradiated.[13]

Based on those mentioned above, this study aims to determine prevalence obesity in adolescent in Denpasar, determine vitamin D levels among obese adolescents and to identify any association between BSA and vitamin D level in the obese adolescent. The expected benefits of this study are the results of this study will later be input for colleagues of paediatricians and general practitioners and can be the basis of further research.

METHODS

An observational analytic study with cross sectional approach has been conducted among 51 respondents who met the inclusion criteria such as obese, aged 10 to 18 years old, and registered as junior or Senior High School in Denpasar. Besides, the exclusion criteria were respondents who had a history of infection, chronic disease, malignancy, or parents were not willing to participate in the research.

Several variables included in this study were age, gender, body weight and height, Body Surface Area (BSA), obesity status, Body Mass Index (BMI), and vitamin D levels. Bodyweight was measured by digital scales ranging from 0,1 to 150 kg and recorded with accuracy to 0,1 kg. Body height was measured with a stadiometer, which has a 90-degree angle to the stadiometer and can be moved with a range of 70 to 200 cm. Body height was recorded with accuracy 0,1 cm. In addition, the BSA was calculated with the Mosteller formula and expressed in a unit of square meters (m^2). Obesity was determined as a condition where excess body fat accumulates that causes body weight above normal which is measured by calculating the BMI curve based on age and sex of CDC 2000. Diagnosis obesity was obtained if BMI above the 95th percentile on kg/m^2. Then, the vitamin D levels are the level of 25(OH) D measured from blood samples expressed with a numerical scale with units of nanogram per millilitre (ng/mL).

All of the data obtained from the samples then collected and processed into SPSS version 17 for Windows. Descriptive analysis was carried out to describe the characteristics of research subjects presented in frequency, percentage, mean and standard deviation. Kolmogorov-Smirnov was conducted to assess the normality of data. The independent samples T-test was performed to determine the mean difference in BSA in the group with vitamin D sufficiency and deficiency. In addition, the linear regression analysis was also performed to determine the association between BSA and vitamin D levels.

RESULTS

The baseline characteristics of the respondents were shown in Table 1. The recent findings suggest that about 19 (37.0%) males and 32 (63.0%) females participated in this study. The mean age of this study was 15.00±4.31 years old, followed by weight (89.4±9.8 kg), height (158.6±7.3 cm), Body Mass Index (BMI) (33.5±3.4 kg/m2), and Body Surface

Table 1 Baseline characteristic of respondents

	Respondents (N=51)	
Variable	**N (%)**	**Mean±SD**
Age (Years)		15.0±4.31
Gender		
Male	19 (37.0)	
Female	32 (63.0)	
Weight (kg)		89.4±9.8
Height (cm)		158.6±7.3
BMI (kg/m2)		33.5±3.4
BSA (m2)		2.1±0.2
Vitamin D (ng/mL)		18.9±4.9
Sufficient	11 (21.6)	
Deficiency	40 (78.4)	

BMI: Body Mass Index; BSA: Body Surface Area; SD: Standard Deviation

Table 2 Comparison of body surface area based on vitamin D category

Variable	Vitamin D category (mean±SD)		Mean Difference	p
	Suficient (n=11)	Deficiency (n=40)		
BSA (m^2)	2.01±0.14	1.95±0.14	0.055	0.026

BSA: Body Surface Area; SD: Standard Deviation

Table 3 Association between BSA, age, and sex with vitamin D levels using linier regression model

Variable	r	β	95%CI	p value
BSA (m^2)	0.32	3.82	7.8-15.4	0.002
Age (years)	0.17	0.60	-0.48-1.94	0.230
Sex	0.65	0.65	-2.32-3.64	0.660

BMI: Body Mass Index; BSA: Body Surface Area; r: coefficient correlation; CI: Confidence Interval; P: statistically significant if less than 0.05

Area (BSA) (2.1±0.2 m^2). In addition, the average of vitamin D levels was 18.9±4.9 ng/ml, divided into two classification: Sufficient (30-100 ng/ml)(21.6%) and Deficiency (<20 ng.ml)(78.4%) (Table 1).

Normality evaluation using Kolmogorov-Smirnov test found that all data were normally distributed (p>0.05). Independent samples T-test was performed to determine the mean difference of BSA between those with vitamin D deficiency and insufficiency (Table 2). There was a statistically significant difference between the mean of BSA levels in vitamin D deficiency group were 1.95±0.14 m^2 and 2.07±0.14 m2 in vitamin D sufficiency group (p=0.026) (Table 2)

Multivariate analysis using linear regression performed to obtain association between BSA, age, and sex are shown in Table 3. Based on the result of linear regression analysis, there was a weak positive association between BSA and vitamin D levels (r=0.32; p=0.002; 95%CI: 7.80-15.40). However, no significant difference in the age and sex variables (p>0.05) (Table 3).

DISCUSSION

Adolescence is a period that is vulnerable to obesity because in this phase needs high nutritional intake for physical growth.[13] The causes of obesity in adolescents are multifactorial such as increasing consumption of fast food, low physical activities, genetic factor, a psychological factor that leads to imbalance calories and excess body fat.[13,14]

This study obtained the prevalence of obesity in adolescents aged 10 to 18 years old was 3,3%. This result was similar with data from the previous study that shown prevalence obesity in child aged 13-15 years is 4,2% and 2,6% in children aged 16-18 years old.[3] Proportion obesity was also found higher among female subjects, but still different with Osmancevic A at al., which is obtained the prevalence obesity in adolescent was 18.6% in male and 15.0% in female subjects.[15] This might be influenced by differences in body fat distribution. For the Body Mass Index (BMI), the woman typically presents with 10% higher body fat compared to men.[16] At compared levels of total adiposity, women have more subcutaneous adipose tissue (SAT) both in abdominal and gluteofemoral area, whereas men have more muscle mass.[16] The mean BMI of this study also lower compared with Osmancevic A et al. that found mean for BMI was 29,3 kg/m^2.[15] This difference can be explained because in the previous study the range of body weight of the subject was more extensive than our study because the subject was overweight and obese adolescent.

There is general agreement that circulating serum concentration of 25-hydroxy vitamin D or 25(OH)D are the best available indicator of the net incoming contribution from cutaneous synthesis and total intake of food and supplements.[11] The society for adolescent health and medicine has suggested that 25(OH)D levels of 30-100 ng/ml are sufficient and less than 20 ng/ml are deficient.[12] Excess adiposity in obesity has been associated in vitamin D deficiency.[17]

Vitamin D deficiency is associated with obesity because in an obese person, there is decreased in the bioavailability of vitamin D. After all, more vitamin D will be accumulated in excess adipose tissue so the amount of circulating vitamin D will be reduced.[18] In obesity, there is also an alteration in protein binding and faster metabolic clearance that could lead to lower serum 25(OH)D.[18] Epidemiological data from Turer CB at al also suggest that prevalence of vitamin D deficiency in obese children directly related to the degree of adiposity with overweight children at 29%, obese at 34% and severely obese at 49%.[16] The result of Turer CB was similar with our study where the average of vitamin D levels was 18.96 ng/mL and 78.40% were vitamin D deficiency. Still, in this study, we did not include adolescent with overweight and did not divide obese adolescent into the obese and super obese group.

The majority of vitamin D (80-90%) comes from endogenous production that required exposure skin to ultraviolet-B (UVB) rays from sunlight. UVB radiation (290-320 nm) initiates the cutaneous synthesis of vitamin D by the photoconversion of 7-dehydrocholesterol (7 DHC) to pre-vitamin D3.[15] Then, for 1-2 days at body temperature, pre-vitamin D3 isomerized to D3, once formed it is sterically unacceptable and ejected from the cell membrane into the extracellular space and then to the circulation. Increased vitamin D3 after UVB exposure was independently due to the size of the exposed area.[14] Obese adolescent have larger BSA than normal. According to the National Health and Nutrition Examination Survey, the average BSA for the adolescent is 1,73 m^2.[14,15] This study obtained the mean BSA was higher than the previous study because the subjects used in this study all with obesity. Whereas the National Health and Nutrition Examination Survey had a wide weight range, so the average of BSA was lower than our study. Although having a more extensive body surface area but obese adolescent still having vitamin D deficiency. A study from Wortsman J et al. found that skin of normal weight and obese subjects does not differ in the amount of the 7 DHC or the functional capacity to produce vitamin D3.14 This study also indicating increased in vitamin D3 synthesis 24 hours after whole body UVB irradiation was 57% lower in obese than in normal subjects.[19]

This study found that adolescent with vitamin D sufficiency has larger body surface area compared with vitamin D deficiency group. An increase in body surface area is directly proportional to body weight and this difference was statistically significant. As the majority of vitamin D3 is produced endogenously in the skin, it is logical to expect that a correlation would exist between body surface area and vitamin D status.[17] The previous result from Judith et al. found a significant correlation between percentage BSA with serum 25(OH)D concentration ($r = 0,456$; $p < 0,00001$) in population with a wide range of body mass index (BMI) including subject with obesity.[20] A previous study also found a similar result that percentage BSA and the sun exposure increase serum 25(OH)D.[21] A study from Bogh MK et al. investigate the importance of BSA and ultraviolet B (UVB) dose on vitamin D production after UVB exposure in 37 subjects with obese.[13] They found that the increase of 25(OH)-D after irradiation was positively correlated with BSA, however, in obese subjects, the vitamin D production reaches a plateau with irradiation more than 33% of body surface area.[13,21]

This study has several limitations because of there also the other factors that contribute to serum 25(OH)D concentration such as sun exposure times, location, season, percentage of clotting covers, personal UV radiation exposure and vitamin D supplementation. This study also did not collect data on dietary intake of vitamin D sources., outdoor physical activity, use of sunscreen and vitamin D supplementation that can alter the serum 25(OH)D concentration. Also, this study did not examine the vitamin D3 (cholecalciferol) levels which better reflects cutaneous production of vitamin D. Further study needed to be done to overcome a limitation in this study.

CONCLUSION

The prevalence of obesity in adolescent in Denpasar was 3,3%, and most obese adolescent had low vitamin D levels, where 78,4% had vitamin D deficiency. There was a weak positive association between body surface area and vitamin D levels in the obese adolescent.

CONCLUSION

The prevalence of obesity in adolescent in Denpasar was 3,3% and most obese adolescent had low vitamin D levels where 78,4% had vitamin D deficiency. there was a weak positive association between body surface area and vitamin D levels in obese adolescent.

CONFLICT OF INTEREST

There is no competing interest regarding the manuscript.

ETHICS CONSIDERATION

The research conducted after the approval of the Ethics Committee of Medical Faculty of Medicine/ Sanglah Hospital. Ethical approval number for this study was 546/UN14.2.2/KEP/2018.

FUNDING

The authors are responsible for the funding of the study without the involvement of grant, scholarship, sponsorship, or any other resource of funding.

AUTHOR CONTRIBUTIONS

All of the authors are equally contributed to the study from the conceptual framework, data gathering, data analysis, until interpreting the results through publication.

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Published by DiscoverSys | *Intisari Sains Medis* 2020; 11(1): 352-356 | doi: 10.15562/ism.v11i1.629