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Association between Body Mass Index and Vitamin D Serum in Asian Population: A Systematic Review

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ABSTRACT

Background and purpose: Asian population is known to have a higher body fat percentage than other populations with the same body mass index (BMI). Fat accumulation is suspected of mediating the rise and fall of Vitamin D levels linked to BMI. However, the results of studies assessing the association between BMI and Vitamin D serum in Asian population still varied. This study is conducted to determine the association between BMI and vitamin D serum in the Asian population.

Methods: This study was conducted with a systematic review method to identify scientific articles reporting the association between BMI and Vitamin D serum in the Asian population. The data collected for this systematic review were from 5,477 studies filtered with the inclusion and exclusion criteria, resulting in eleven studies presenting 7,496 respondents.

Results: Nine studies concluded an association between increasing BMI from the normal range and decreasing Vitamin D serum ($p<0,05$). One study has concluded an association between decreasing BMI from the normal range and decreasing Vitamin D serum ($p<0,05$). Another has concluded there is no association between BMI and Vitamin D serum ($p>0,05$).

Conclusion: This systematic review study concludes an association between increasing and decreasing BMI with decreasing Vitamin D serum in the Asian population. Further study using clinical trial in obese people and control to compare the metabolism of Vitamin D should be conducted.

Keywords: Vitamin D, body mass index, underweight, obesity, Asian

INTRODUCTION

The incidence of Vitamin D deficiency continues to increase worldwide.[1] A high prevalence of Vitamin D deficiency is reported across the country among people in all age groups, both sexes, and young healthy adults. According to a study in China, Vitamin D deficiency in females is worse than males according to higher amount of subcutaneous fat in females than males.[2] There is still no data on the prevalence of Vitamin D deficiency worldwide. However, according to the comparison among regions, Middle East and South Asia are the most severe Vitamin D deficiency regions.[3] The prevalence of Vitamin D deficiency in Malaysia (2017) is 60%, in India (2018) is 66%, in China (2019) is 61.3%.[4–6] Research conducted by Aji et al. (2019) in pregnant women in Minangkabau shows approximately 82.8% of samples had vitamin D insufficiency.[7]

Vitamin D in the body comes into several forms: previtamin D_3, 25-hydroxyvitamin D (25(OH)D) called calcidiol, and calcitriol.[8,9] According to the *Institute of Medicine* (IOM), a person is said to have Vitamin D deficiency if the concentration of calcidiol in serum is <12 ng/mL and according to the clinical practice guidelines of the Endocrine Society Task Force on Vitamin D is <20 ng/mL.[10,11] However, a person is categorized as having Vitamin D insufficiency if the concentration of calcidiol in serum is 21-29 ng/mL and an adequate amount of 30 ng/mL.[11]

The increase and decrease in Vitamin D levels in the body are influenced by several factors, such as sun exposure, food intake, genetic linkages, and skin color. In addition, nutritional status is also related to Vitamin D levels in the blood, both levels, and metabolism.[12] According to the sequestration theory, Vitamin D is a fat-soluble vitamin, so when there is an increase in fat in obese patients, there is an increase in the accumulation of Vitamin D in fat. This accumulation causes the level of Vitamin D in the serum to decrease.[8,13]

Body mass index (BMI) is the quotient of a person's weight in kilogram with the square of a person's height in meters (kg/m^2).[14] According to World Health Organization (WHO), the world population's BMI has increased globally.[15] Asians have a higher body fat percentage than Australian-Caucasians at the same BMI level, so there is a separate BMI classification according to the Western Pacific Regional Office (WPRO).[16] WPRO states the classification of BMI in Asians, where there are underweight (BMI<18.5 kg/m^2), normal (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2), and obese (>30 kg/m^2).[16] Asians have more than double the risk of developing type 2 diabetes and cardiovascular diseases than the other ethnic. Increases in weight over time are more harmful in Asians than in the other ethnic groups.

A study conducted by Man et al. (2018) in Singapore showed a relationship between BMI and Vitamin D levels, underlining the low proportion of Vitamin D adequacy in respondents with an increase in BMI of 35.8%.[5] Meanwhile, research conducted by Wang et al. (2020) in Taiwan stated different results in no relationship between BMI and Vitamin D levels (p=0.75).[17]

Based on the phenomenon of obesity and the severe Vitamin D deficiency in Asia, this study aims to examine the previous evidence regarding the relationship between BMI and vitamin D levels in Asia. Several previous studies have also highlighted the pros and cons of this relationship.[5,17] A systematic study of the relationship between BMI and Vitamin D levels will be carried out in studies that focus on Asian populations. This systematic study aims to increase public awareness and knowledge about the relationship between BMI and the incidence of Vitamin D deficiency and its impact on body health.

METHODS

We conducted a systematic review following the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) statement guideline to identify research on the association between 25(OH)D concentration and BMI. Two authors performed data analyses. The search was conducted in PubMed, EBSCO, and Proquest with several inclusion criteria; cross-sectional study, human studies aged 19 or older, Asian population, published in English, between 2010 to 2020, p-value and methods were described. The search terms were 'Body Mass Index', 'BMI', 'Obesity', 'Weight' combined with 'Vitamin D', 'Cholecalciferol', '25 hydroxyvitamin D', 'Calcidiol' combined with 'Asian'. Studies with respondents who consume Vitamin D supplements, have liver or kidney diseases and have malabsorption syndrome were excluded from this systematic review. Table 1 shows the terms used in each database and the number of studies obtained.

Table 1. Terms used in literature search

Database	Keywords	Studies found
Pubmed	((("Body Mass Index"[MeSH Terms] OR "Obesity"[MeSH Terms] OR "BMI"[Title/Abstract] OR "Body Mass Index"[Title/Abstract] OR "Obesity"[Title/Abstract] OR "Weight"[Title/Abstract]) AND "Vitamin D"[MeSH Terms]) OR "Cholecalciferol"[MeSH Terms] OR "Vitamin D Serum"[Title/Abstract] OR "25 hydroxyvitamin D"[Title/Abstract] OR "Cholecalciferol"[Title/Abstract] OR "Calcidiol"[Title/Abstract]) AND "Asian"[Title/Abstract]	222
Proquest	("BMI" OR "Body Mass Index" OR "Obesity" OR "Weight") AND ("Vitamin D Serum" OR "25 Hydroxyvitamin D" OR "Cholecalciferol" OR "Calcidiol") AND ("Asian")	3225
Ebsco	("BMI" OR "Body Mass Index" OR "Obesity" OR "Weight") AND ("Vitamin D Serum" OR "25 Hydroxyvitamin D" OR "Cholecalciferol" OR "Calcidiol") AND ("Asian")	2028

After collecting various studies, results were imported into Endnote X9 to remove duplicates. Next, we filtered the studies by reading the title and abstract. Relevant studies were read in their entirety and excluded if they meet the exclusion criteria. A PRISMA flow diagram was used to serve the literature search process. Figure 1 shows the study selection process.

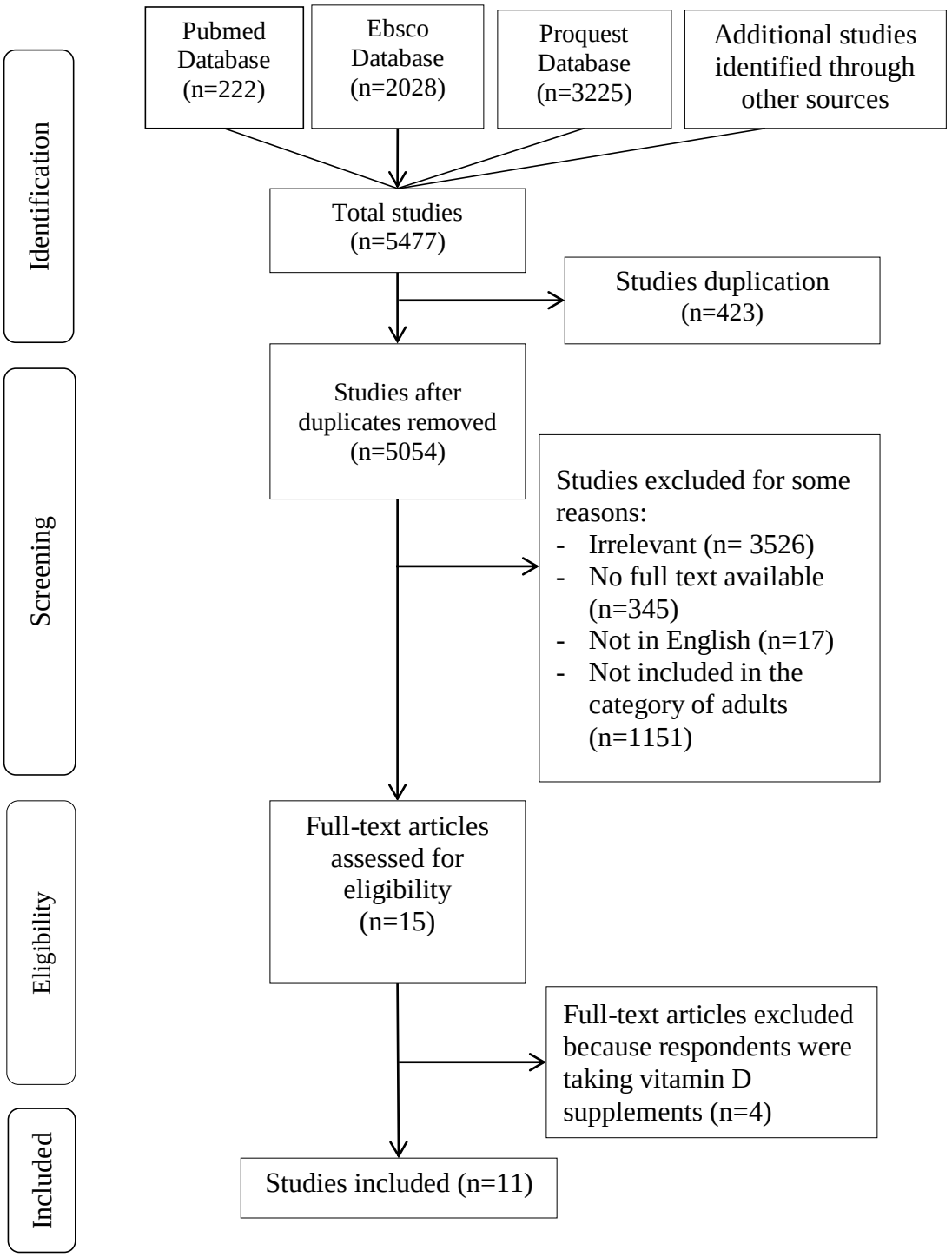

Figure. 1 Study selection process

We assessed the quality of the literatures in this study with the Adapted Newcastle-Ottawa Quality Assessment Scales (NOS) tool. NOS can assess the methodological quality by assessing the appropriateness of the study design, representativeness of the sample, objectivity/reliability of results, and accuracy of statistical analysis.[18] Table 2 describes the criteria assessment by NOS and Table 3 describes the quality assessment by NOS.[19]

Table 2. Criteria assessment by NOS

Criteria (*)	Accepted (*)	Not accepted (-)
Representativeness of the sample (*)	Truly or somewhat representative of the average in the target population	The selected group of users or no description of the sampling strategy
Sample Size (*)	Justified and satisfactory (There is a sample calculation)	Not justified
Non-Respondents (*)	Comparability between respondents and non-respondents characteristics is established, and the response rate is satisfactory	No description
Factors were controlled (*)(**) *≤2; **>2	Other factors are adjusted, such as age, gender, location of residence, season, and food consumption	No description
Assessment of the outcome (**)	Independent blind assessment or Record linkage	No description
Statistical test (*)	The statistical test used to analyze the data is clearly described and appropriate, and the measurement of the association is presented, including confidence intervals and the probability level (p-value)	The statistical test is not appropriate, not described, or incomplete

Table 3. Study quality assessment by NOS

Point	Risk of Bias
7-8	Low
6	Moderate
≤5	High

RESULT AND DISCUSSION

The number of respondents obtained from 11 studies is 7,496 Asian populations with an average age included in the adult category. Table 4 describes the demographic characteristics of each study. Assessment of the quality of the study in this research was using the NOS tool. Table 5 describes the assessment of the quality of the studies on the relationship between BMI and Vitamin D levels in Asian populations.

Based on the quality assessment, the results of the risk of bias were obtained for each study. The studies conducted by Hao et al., Shafinaz IS and Moy FM, and Chiang et al. had a low risk of bias.[20–22] The studies conducted by Yin et al., Kim et al., Wang et al., and Suryanarayana et al. had a moderate risk of bias.[17,23–25] Study conducted by Moy FM and Bulgiba A, Fatima et al., Manet al., and Erkus et al. had a high risk of bias.[5,26–28]

Ten of the eleven studies obtained for this systematic review concluded a relationship between BMI and

Vitamin D levels with a p-value of <0.05.[5,20–23,25–28] Nine studies concluded that increased BMI was associated with insufficient serum Vitamin D levels.[5,20–23,25–28] This is in accordance with a study conducted by Aladeen et al. (2019) in Saudi Arabia, which concluded that there was a strong relationship between an increase in BMI and a decrease in serum Vitamin D levels. About 26% of respondents with normal BMI have Vitamin D deficiency, while 90% of obese respondents have Vitamin D deficiency.[29] Likewise, research conducted by Forrest et al. (2011) concluded that Vitamin D deficiency is associated with obesity in the adult population in America.[30]

Several theories link a person's BMI to Vitamin D levels. The first theory is the sequestration theory, in which Vitamin D is a fat-soluble vitamin. When there is an increase in fat in the increase of BMI, there is an increase in Vitamin D in fat. This causes the level of Vitamin D in the serum to decrease.[13] In addition, overweight people tend to avoid sunlight and outdoor activities so that Vitamin D synthesis decreases. Volumetric dilution is considered one of the reasons for lower serum Vitamin D concentrations in people with higher BMI. In people with increased BMI, the distribution of Vitamin D in a larger volume causes the serum concentration to appear lower.[31]

Genetic factors have a role in the mechanism between Vitamin D and obesity. Decreased expression of the cytochrome P450 2J2 gene encoding the 25-hydroxylase enzyme and decreased expression of the cytochrome P450 27B1 gene encoding the 1-α hydroxylase enzyme resulted in inhibition of the Vitamin D synthesis process.[31] In addition, sedentary living habits carried out by obese people can also affect the process of Vitamin D synthesis. Someone who is obese tends to avoid exposure to sunlight so that Vitamin D synthesis is inhibited.[13]

Decreased BMI is also associated with insufficient serum Vitamin D levels according to a study by Kim et al. In this study, a sample of refugees from South Korea was used. This condition of insufficiency is thought to be due to inadequate food consumption in underweight people.[24] This is in accordance with a study by Joh et al. in South Korea, which concluded that not only an increase in BMI was associated with Vitamin D, but a decrease in BMI was also associated with a Vitamin D deficiency condition ($p<0.05$).[32]

In contrast to other studies, a study conducted by Wang et al. concluded that there was no relationship between BMI and Vitamin D levels with a p-value of 0.75. The use of BMI criteria according to WHO can cause it. The use of these criteria may lead to a misclassification of BMI in respondents. It can be seen that most respondents had a normal BMI and the percentage of obese respondents was only 7%.[17]

The studies were collected for this systematic review using a cross-sectional design, so it has weaknesses in proving a causal relationship between BMI and Vitamin D levels. Causal analysis requires a clear time sequence so that exposure can be determined that caused an event. In addition, some of the literature used did not control for confounding factors such as age, food consumed, season, and physical activity exposed to sunlight. Researchers also have limited access to paid literature. The methods of measuring Vitamin D are different in each study, so a meta-analysis can't be done.

Table 4. Characteristics of studies

No	First author	Year	Location	Study design	Vitamin D analysis method	Range or Average Age	number of respondents	BMI range or average (kg/m^2)	Average Vitamin D Levels (ng/mL)	Result
1	Moy F-M.	2011	Malaysia	Cross-Sectional	CLIA	48.5	380	27.5	17.8	Significant*
2	Yin[23]	2012	China	Cross Sectional	RIA	49.36	601	25.21	26.91	Significant *
3	Hao[20]	2014	China	Cross Sectional	ECLIA	56.4	567	23.8	15.5	Significant *
4	Fatima[27]	2015	Pakistan	Cross Sectional	ELISA	37.4	132	24.3	9.8	Significant *
5	Kim[24]	2015	South Korea	Cross-Sectional	Gamma Counter	43.7	386	22.7	15.5	Significant *
6	Shafinaz IS[21]	2016	Malaysia	Cross Sectional	ECLIA	30-49	858	25.66	17.97	Significant *
7	Man	2017	Singapore	Cross Sectional	ECLIA	67	1139	24.45	22.1	Significant *
8	Chiang[22]	2018	America	Cross Sectional	RIA	45-84	150	26.35	21.2	Significant *

9	Erkus[28]	2018	Turkey	Cross Sectional	HPLC	19-70	105	38,63 dan 21.92	17 and 20.76	Significant *
10	Suryanarayana[25]	2018	India	Cross Sectional	RIA	66,68	298	25.3	19.3	Significant *
11	Wang[17]	2020	Taiwan	Cross-Sectional	CMIA	26-65	2880	14.4-39.7	28.61	Insignificant +

Table 5. Assessment of the quality of the study

Study	Selection			Comparability	Outcome		Total
Author, Year	Representativeness of the sample	Sample Size	Non-Respondents	factors are controlled	Assessment of the outcome	Statistical test	
Moy, 2011	-	*	*	-	**	*	5
Yin, 2012	*	*	-	*	**	*	6
Hao, 2014	*	*	-	**	**	*	7
Fatima, 2015	-	*	-	*	**	*	5
Kim, 2015	-	*	-	**	**	*	6
Shafinaz, 2016	*	*	*	**	**	*	8
Man, 2017	*	*	-	-	**	*	5
Chiang, 2018	*	*	*	**	**	*	8
Erkus, 2018	*	*	-	-	**	*	5
Suryanarayana, 2018	*	*	*	-	**	*	6
Wang, 2020	*	*	-	*	**	*	6

CONCLUSION

This systematic review concluded that increases and decreases in BMI are associated with decreased serum Vitamin D levels in Asian populations. We suggest further research using clinical trial in obese people and control to compare the metabolism of Vitamin D so the causal analysis can be found.

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AUTHOR CONTRIBUTION

JS, R, and YA designed and conceptualized the study. JS and YA collected and reviewed the data. JS, R, and YA edited the manuscript and reviewed the study proposal. All authors approved the final manuscript.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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