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Association of Vitamin D Status with Metabolic Syndrome and its Components in Bangladeshi Urban Women

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Abstract

Background: The prevalence of metabolic syndrome is on the rise in developing countries like Bangladesh along with decreasing Vitamin D levels. As women are more vulnerable to metabolic syndrome and vitamin D deficiency, and connection among these were reported in various population, this research aims to quantify the association between vitamin D and metabolic syndrome and its components among Bangladeshi women from urban area.

Methods: Necessary data were collected from 233 participants over five months from 2015 to 2016 in Dhaka, Bangladesh. The concentration of Triglyceride, High-Density Lipoprotein (HDL) levels, fasting plasma glucose was measured with kits and vitamin D analysis was performed using High-Performance Liquid Chromatography.

Results: In this study, the prevalence of metabolic syndrome among the population was found to be 59.66%. When the subjects were divided into different quarters according to vitamin D sufficiency levels, subjects in all the quarters had significantly lower odds ratios of having metabolic syndrome compared to the lowest quarter.

Conclusion: The number of metabolic syndrome components were found to be inversely correlated with Vitamin D level and individual components were found to be correlated with Vitamin D, indicating the inverse association between vitamin D and prevalence of risk of metabolic syndrome.

Keywords: Metabolic syndrome • Vitamin D • Urban women • Bangladesh • Vitamin D deficiency

Introduction

Metabolic Syndrome (MS), the strong predictor of the possibility of type 2 diabetes mellitus (T2DM) and cardiovascular disease [1], is a combination of abnormalities [2]. Approximately 20%-30% of the adult population of the world is affected [3] by this global epidemic [2]. T2DM and Coronary Heart Disease (CHD) are increasing in developing countries like those in South Asia [4], and the high frequency of metabolic syndrome in south Asian people is considered as a contributory factor for this [5]. Some causative factors for the development of MS are considered to be elevated economic growth, adoption of western diet and urbanization [6], which can be found increasing in developing a portion of the world like south Asian countries. Among other factors, evidence has been found that Vitamin D deficiency may be a risk factor for MS [7-9]. The prevalence of metabolic syndrome was reported to be higher in women than men in a previous study [10], so gender is also important when it comes to MS. The presence of MS among Bangladeshi rural women was found previously [11,12] but the report about the presence of metabolic syndrome among women from the urban area of Bangladesh is not much available. Also, vitamin D deficiency in Bangladeshi people was reported earlier for which female gender and urbanization were mentioned as important factors [13]. As vitamin D deficiency and MS are interrelated, and female are more susceptible to both of these, it is important to study the onset of metabolic syndrome and its association with vitamin D deficiency in Bangladeshi women since the occurrence of metabolic syndrome among South Asians including Bangladeshis is on the rise [14]. This research on Bangladeshi women will also be important for women from other rapidly developing countries. To our knowledge, this research is the first one to be conducted on the Bangladeshi population to find the relation between MS and vitamin D. This article will focus on the association of vitamin D status with the increasing risk of metabolic syndrome and its different components among Bangladeshi women from urban areas.

Materials and Methods

Population size

A total of 300 women (Aged ≥ 25 years) were approached from Dhaka, Bangladesh in a cross-sectional manner. They were informed of the purpose and nature of the research. Some baseline characteristics were set, like non-pregnancy and not having chronic conditions such as osteoporosis, osteomalacia, Hepatitis, Liver cirrhosis, and HIV. After getting their consent and getting all the baseline conditions accordingly, 233 subjects were selected for different physical measurements and blood sample collection. From November 2015 to March 2016 sample collection was done from the subjects and different assays were done simultaneously.

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Definition of metabolic syndrome and vitamin D sufficiency

According to National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) [15], at least three of the following criteria are necessary to be present for determining metabolic syndrome: Waist Circumference (WC) at least 80 cm or 31.5 inches for women of non-European origin, Triglycerides (TG) at least 150 mg/dl or greater, High-Density Lipoprotein (HDL) Cholesterol below 50 mg/dl for women, Blood Pressure (BP) 130/85 mmHg or greater or on treatment, Fasting Plasma Glucose (FPG) at least 5.6 mmol/L or known diabetes. Along with NCEP ATP III definition, the International Diabetes Federation [16] and modified criteria of NCEP ATP III for Asians recommended by American Heart Association-National Heart Lung Blood Institute (AHA/NHLBI) [17] were used. Serum vitamin D status was categorized based on 25(OH)D levels as following-optimal (75 nmol/L or above), insufficiency (50 nmol/L-74.99 nmol/L), moderate deficiency (25 nmol/L-49.99 nmol/L) and the severe deficiency (25 nmol/L) [18-20].

Biochemical and physical analysis: About 5 mL of venous blood was collected from each participant after 10-12 hours of overnight fast. 2 mL of the blood was transferred to tubes with EDTA (Ethylene diamine tetra acetic acid) (1.2 mg/mL) for plasma collection and the rest were collected in another tube without anticoagulants for serum collection and kept in the icebox for transportation to the laboratory. Using centrifugation at 2000 rotation per minute (rpm) for 15 minutes, the serum and plasma were separated from the designated tubes and stored at -200℃ Then the concentration of TG, HDL levels and FPG were measured using the standard protocol provided with kit (Rendox Reagent). Waist circumference was measured with a non-stretchable tape and Blood pressure (BP) was measured using the standard mercury manometer and cuff. 25(OH)D was measured by High Performance Liquid Chromatography (HPLC). C18 HPLC columns [4.6 × 100 mm (millimeter), 5 µm (micrometer) particle size], HPLC-grade methanol, HPLC-grade n-haxane and 2-propanol were used. The solvent was same as mobile phase (100% methanol). The sample was prepared according to Turpeinen, Hohenthal and Stenman [21]. Run time of each sample was 10 minutes, injection volume was 20 µL and detection was at 265 nm (nanometer). The output was recorded as a series of peaks with each one representing a compound in the mixture passing through the detector. The area under the peak was proportional to the sample amount passed.

Statistical analysis: Statistical Analysis was carried out using IBM SPSS Statistics 24.0 and Microsoft Office Excel 2013 software. For different comparisons and analysis, logistic regression analysis, linear regression analysis, Wald Chi-Square test was carried out. For correlation analysis, Pearson correlation coefficient was considered.

Results

This study was conducted among 233 participants whose vitamin D level and components of metabolic syndrome (MS) were measured from blood samples. HPLC was used to measure vitamin D level and the mean value was found to be 49.75 nmol/L. Metabolic Syndrome components like serum level of TG, HDL and fasting plasma glucose were measured by using commercially available kits. Table 1 represents the data regarding metabolic syndrome components and vitamin D levels that we found from the respective study subjects.

Table 1. Population characteristics regarding metabolic syndrome components and Vitamin D [25(OH)D].

Characteristics	Frequency (n)	%or mean ± sem[1]	lclm[2]	uclm[3]
Waist Circumference (inch)	233	34.37 ± 0.25	33.87	34.86
Systolic Blood Pressure (mm Hg)	233	126.35 ± 1.05	124.28	128.42
Diastolic Blood Pressure (mm Hg)	233	83.94 ± 0.72	82.53	85.34
Triglyceride (mg/dL)	233	150 ± 4.5	141.12	158.87
HDL cholesterol (mg/dL)	233	33.11 ± 0.71	31.71	34.52
Fasting plasma glucose (mmol/L)	233	6.15 ± 0.15	5.86	6.44
Vitamin D (nmol/L)	233	49.75 ± 1.25	47.29	52.22

[1]Standard Error of Mean; [2]lclm: Lower 95% Confidence Limit; [3]uclm: Upper 95% Confidence

Our study population was categorized based on the level of MS components and we found approximately 2.15% of the population have all the values in normal range. Moreover 23.18% of participants have at least three metabolic syndrome components which indicate the possibility of having metabolic syndrome and 13.73% of participants have all the metabolic syndrome components over the normal range (Table 2). Study subjects were also classified upon serum vitamin D level [25(OH)D]. According to the classification of serum vitamin D status-optimal (75 nmol/L or above), insufficiency (50 nmol/L-74.99 nmol/L), moderate deficiency (25 nmol/L-49.99 nmol/L) and the severe deficiency (25nmol/L) [18-20], it was found that about 9.44% population had optimal Vitamin D level whereas 10.73% were classified as severe Vitamin D deficient. Linear regression analysis showed a correlation between metabolic syndrome components and the level of vitamin D where we found an increased level of metabolic syndrome components with the decreased level of vitamin D (F test, r=-0.604, p<0.001) (Table 3 and Figure 1).

Odds ratio (OR) for metabolic syndrome was calculated for the participants having different levels of vitamin D and it was found to be changing with the difference of vitamin D levels. The cutoff values for the quartiles were selected as per different sufficiency levels of vitamin D (Q1: Severe deficiency level; Q2: Moderate deficiency level, Q3: Insufficiency level; and Q4: Optimal level) and it showed that subjects in all the quarters (Q2, Q3, Q4) had significantly lower odds ratios of having metabolic syndrome compared to Q1. Logistic regression analysis was carried out to predict the association of risk of metabolic syndrome by the level of vitamin D. And here we found 6.2% decrease in odds of having metabolic syndrome for each nmol/L increase in vitamin D level (Figures 2 and 3).

Table 2. Metabolic syndrome profile.

Characteristics	Frequency (n)	Percentage %
Age (Years)		
25-34	67	28.76%
35-44	67	28.76%
45-54	47	20.17%
55-64	37	15.88%
65 or above	15	6.44%
No. of Metabolic Syndrome Components Present		
0	5	2.15%
1	33	14.16%
2	56	24.03%
3	54	23.18%
4	53	22.75%
5	32	13.73%
Presence of Metabolic Syndrome		
No	94	40.34%
Yes	139	59.66%

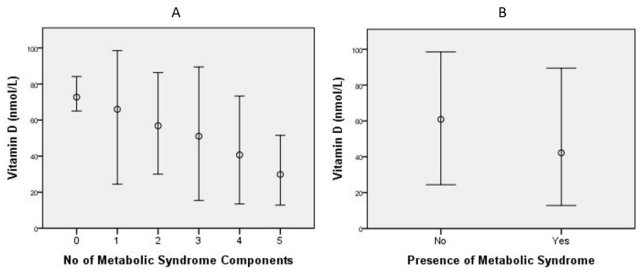

Figure 1. (A): Vitamin D [25(OH)D] level in relation to number of metabolic syndrome components; (B): and to the presence of the metabolic syndrome. With the increase in metabolic syndrome components Vitamin D level was found to be decreasing (Linear regression, F test, r=-0.604, p<0.001). Vitamin D levels are shown in mean, highest and lowest value.

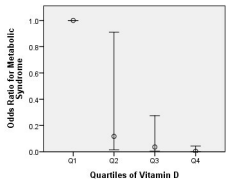

Figure 2. Odds ratio for metabolic syndrome in association with vitamin D [25(OH)D] level. Quartiles of vitamin D are: Q1: 0-24.99 nmol/L; Q2: 25–49.99 nmol/L; Q3: 50-74.99 nmol/L; and Q4: ≥ 75 nmol/L. Subjects in all the quarters had significantly lower OR of having metabolic syndrome compared to Q1 (For Q2: OR=0.117, 95%CI=0.015-0.91, p<0.05, for Q3: OR=0.036, 95%CI=0.005-0.275, p<0.01 and for Q4: OR= 0.004, 95%CI=0.0004-0.044, p<0.0001).

Table 3. Vitamin D profile.

Characteristics	Frequency (n)	Percentage%
Vitamin D level (≥ 50 nmol/L)		
Yes	113	48.5%
No	120	50.5%
Vitamin D level (≥ 75 nmol/L)		
Yes	22	9.44%
No	211	90.56%
Vitamin D level (≥ 25 nmol/L)		
Yes	208	89.27%
No	25	10.73%

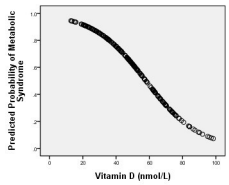

Figure 3. Risk of metabolic syndrome predicted by vitamin D [25(OH)D] levels shown by scatterplot. For each nmol/L increase in vitamin D level is associated with 6.2% lower odds of having metabolic syndrome (OR=0.938, 95%CI=0.921-0.956). For determining this association, logistic regression analysis was carried out between the presence of metabolic syndrome (from Table 2) and vitamin D [25(OH)D] (p<0.001, Wald chi-square test).

Table 4. Correlation among Vitamin D status and different metabolic syndrome components.

Type of Analysis	p-value	Pearson Correlation Coefficient (r)	Interpretation of Pearson Correlation Coefficient (r)
Waist circumference vs Vitamin D	p<0.05	-0.139	Negative linear relationship
Systolic pressure vs Vitamin D	p<0.01	-0.365	Negative linear relationship
Diastolic blood pressure vs Vitamin D	p<0.01	-0.292	Negative linear relationship
Fasting plasma glucose vs Vitamin D	p<0.01	-0.322	Negative linear relationship

We calculated the correlation among different metabolic syndrome components with vitamin D [25(OH)D] level to find out the association of

each component with vitamin D. Our findings showed that all the components, except HDL, have a negative linear relationship with vitamin D levels at different strengths (Table 4).

Discussion

The present research was conducted to examine the relationship between metabolic syndrome and vitamin D among Bangladeshi women from the urban area. To our knowledge, this is the first prospective research to have evaluated the association among these factors in such type of population. An inverse relationship between metabolic syndrome and vitamin D was observed. Negative relationships among vitamin D and metabolic syndrome components, except HDL, were also established.

Women with no metabolic syndrome were found to have higher vitamin D levels compared to women with a metabolic syndrome-like found in a study with urban Indian women [22]. To support this, Vitamin D was found to be decreasing with the increased number of metabolic syndrome components. Individuals in the lowest Vitamin D quartiles had a stronger association with metabolic syndrome compared to the individuals from other quartiles, These manifest that increased Vitamin D levels were linked to a lower risk of having metabolic syndrome in the population.

Although the correlation among each metabolic syndrome components and vitamin D level was weak to moderate in nature, all of them were statistically significant. The inverse relationship among vitamin D and elevated WC, BP, and TG are consistent with previous documentation of similar findings [22]. An inverse relationship among vitamin D and elevated WC, FPG, and TG in Australian adults [23] were also found to be reported earlier.

The association between vitamin D and waist circumference found here was consistent with previous studies [24,25]. It could be due to the inhibition of adipocyte differentiation by vitamin D [26], and could also be the result of activation of lipoprotein lipase by vitamin D in adipocytes [27]. The previously reported association between vitamin D and blood pressure [25,28] can be found here too. As vitamin D suppresses renin gene expression, the absence of vitamin D receptor may cause up-regulation of the renin-angiotensin-aldosterone system and as a result, elevated blood pressure [29]. Also, high parathyroid hormone level causes high blood pressure, and 25(OH)D and parathyroid hormone levels are negatively interrelated [30]. Going out less could be another reason for this association as reduced vitamin photosynthesis in the skin and high melanin content may decrease vitamin D store, thus affect the Parathyroid Hormone (PTH) release [31] and affect blood pressure. The inverse relation between vitamin D and fasting plasma glucose may be due to the inverse relationship between vitamin D and insulin resistance probably caused by immunomodulatory and anti-inflammatory properties of vitamin D [32], which in turn decreases glucose absorption by cells.

Association between vitamin D and triglyceride confirmed in previous reports [33] can be explained by increased calcium absorption mediated by vitamin D [34], which can reduce the formation of hepatic triglyceride [35]. Triglyceride may also increase due to increased PTH activity as PTH concentration is negatively related to post heparin lipolytic activity [36]. The association between vitamin D and HDL, supported by previous studies [33,37,38] could be for the fact that vitamin D maintains apolipoprotein A-I, a component of HDL [33]. Vitamin D showed a positive correlation with apolipoprotein A-I and HDL concentration in the Belgian population [39].

In this research only 22 of the 233 participants had optimal vitamin D level. Although only 94 were free from metabolic syndrome, some of them may also form this syndrome at some point of their life as 56 of them has 2 components positive for metabolic syndrome. A significant number of women were found to have elevated glucose level or diabetes, which can be reduced by dietary modifications and enhanced physical activity [40,41]. Wearing hijab and veils may also cause vitamin D deficiency as they prevent sunlight exposure. Moreover, Bangladeshi housewives prefer staying home for most of the time due to their social views, and also are not much eager in outdoor physical activities. Along with that, mass urbanization in the cities are causing a shortage of open space. So appropriate vitamin D supplementations and opportunities for open-air exercise are necessary for urban women in Bangladesh. As features of hypovitaminosis D are mostly reversible and metabolic syndrome can be controlled also, it is strongly recommended to screen for vitamin D deficiency and abnormalities in metabolic syndrome components for prevention.

The research design has many strong points and prospects. Exclusion of data for osteoporosis, osteomalacia, Hepatitis, Liver cirrhosis, and pregnancy was strongly maintained. Most of the participants were found to be possessing metabolic syndrome and had vitamin D below the optimal level, so a new analysis can be conducted to find out whether the new level of vitamin D and metabolic syndrome components are needed to be determined for this type of population or not. Also, other developing countries can conduct this research too and accumulated results can be used to see the extent of association of MS and vitamin D deficiency with different development works. So this research can be viewed as the first of the many researches. However, some factors were not considered during the analysis, like the amount of sunlight exposure. Although it is shown to be relevant in different associations, PTH (Para Thyroid Hormone) data were not taken which could be strongly related to vitamin D and as shown in some studies, to metabolic syndrome too [42,43].

Conclusion

This research indicates the inverse association between vitamin D status and prevalence of risk of metabolic syndrome among Bangladeshi women from an urban area and correlation among metabolic syndrome components and vitamin D levels. The research demonstrates the necessity for randomized controlled clinical trials to determine the urgency for the replenishment of vitamin D deficiency and associated metabolic syndrome disorder.

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