Original Research Article

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Association between body mass index and immunoglobulin G response before and after coronavirus disease 2019 vaccination

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Abstract

Introduction: Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has had a profound global impact, prompting the rapid development and deployment of vaccines to control the pandemic. Vaccination plays a crucial role in generating protective immunity. Factors such as age, sex, comorbidities, and body mass index (BMI) may influence the strength and duration of vaccine-induced immunity. This study aims to evaluate the association between BMI and anti-SARS-CoV-2 immunoglobulin G (IgG) antibody responses before and after COVID-19 vaccination.

Methods: This prospective analytical study was carried out in the Department of Biochemistry, Dhaka Medical College, Dhaka, Bangladesh, from January, 2021 to December, 2021. The study population comprised medical students from Dhaka city, with 60 participants recruited using a purposive sampling method. Data were analyzed using the Statistical Package for the Social Sciences version 26.0.

Results: About 60% had normal BMI (mean 23.88 ± 4.01), 25% were overweight, 10% obese, and 5% underweight, with no significant gender difference ($P = 0.711$). Post-vaccine IgG levels rose significantly in the normal weight (43.70 → 282.30 AU/mL, $P < 0.001$), overweight (68.60 → 408.90 AU/mL, $P = 0.003$), and obese groups (120.65 → 586.30 AU/mL, $P = 0.028$), but not in the underweight group (0 → 144.70 AU/mL, $P = 0.109$). Correlation analysis showed no significant association between BMI and IgG levels pre-vaccine (r = 0.203, $P = 0.12$) or post-vaccine (r = 0.164, $P = 0.21$).

Conclusion: This study shows that IgG levels significantly increased after two doses of the Sinopharm vaccine in normal weight, overweight, and obese individuals, but not in the underweight group. However, no significant correlation was found between BMI and pre- or post-vaccine IgG levels, suggesting that antibody response is largely independent of BMI.

Keywords: Body mass index, coronavirus disease 2019 vaccination, immunoglobulin G response

Introduction

The coronavirus disease 2019 (COVID-19) pandemic has emerged as a major global public health issue, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a novel positive-sense, single-stranded RNA virus belonging to the beta-coronavirus lineage.[1] The outbreak was first identified in Wuhan, Hubei Province, China, in December 2019, and subsequently spread worldwide, leading the World Health Organization (WHO) to declare it a global

pandemic on 11 March 2020.[2] Approximately 80% of infected individuals remain asymptomatic or develop only mild symptoms such as fever, cough, headache, or dyspnea, while the remaining 20% may experience severe complications including hypoxemia, acute respiratory distress syndrome, shock, and multi-organ failure.[3] Patients at higher risk of critical illness and mortality include the elderly, immunocompromised individuals, and those with underlying metabolic, pulmonary, or cardiovascular comorbidities.[4] Transmission primarily occurs through respiratory droplets within close contact (about one meter), and infection can also occur through contaminated surfaces. To reduce transmission, the WHO advises proper use of personal protective equipment such as masks or respirators, while the centers for disease control and prevention additionally emphasize the importance of maintaining social distancing.[5] Obesity and elevated body mass index (BMI) have been implicated in altered immune responses to SARS-CoV-2 infection and vaccination. Research indicates that individuals with higher BMI (≥25 kg/m^2) exhibit impaired humoral responses following natural infection – including reduced antibody titers at 3 months and decreased avidity and spike-specific B-cell percentages at 1 year – but these differences were not observed around 5 months post-second vaccine dose.[6] However, other studies highlight concerns about vaccine-induced immunity in individuals with obesity. For instance, those with class III obesity (BMI ≥40 kg/m^2) showed notably reduced neutralizing capacity 6 months post-vaccination, with 55% having undetectable neutralizing function compared to only 12% in individuals of normal weight; even though total antibody levels were similar, their quality – and durability – declined more rapidly.[7] Supporting this, large-scale population data revealed that people with severe obesity faced a 76% higher risk of severe COVID-19 outcomes after vaccination, due to more rapid waning of immunity.[8] In addition, BMI appears to interact with sex in shaping post-vaccine immune responses: among recipients of the mRNA BNT162b2 vaccine, increasing BMI corresponded to lower spike immunoglobulin G (IgG) titers in men – but not women – indicating potential sex-specific effects.[9] Conversely, certain investigations, especially long-term follow-up of mRNA vaccine recipients, have found no significant association between BMI and receptor binding domain (RBD)-specific IgG or neutralizing antibody titers at both 50 and 200 days post-vaccination.[10] These conflicting findings underscore the complexity of the BMI–vaccine response relationship. Our study aims to further elucidate this issue by assessing pre- and post-vaccination IgG responses stratified by BMI categories.

Methods

This prospective analytical study was conducted at Department of Biochemistry, Dhaka Medical College, Dhaka, Bangladesh, from January 2021 to December 2021. Medical students of Dhaka city were the study population. A total of 60 students were selected as study subjects by purposive sampling technique. Ethical permission was taken from Ethical Review Committee of Dhaka Medical College. The study included apparently healthy medical students of both genders, aged between 18 and 25 years. Participants with a history of COVID-19 infection, prior COVID-19 vaccination, or any known comorbidities were excluded from the study. Pregnant individuals were also excluded. Anti-SARS-CoV-2 IgG is immunoglobulin produced by immune system to provide protection against SARS-CoV-2.[11] Post-vaccination anti-spike RBD IgG responses were assessed using the Abbott SARS-CoV-2 IgG II Quant antibody test targeting the spike RBD. The assay cutoff is 50 AU/mL, with linear quantification of detected results from 50 to 40000 AU/mL reported by the manufacturer. According to manufacturer's cutoff value-

- ≥50 AU/mL indicates – Positive (Responsive)
- <50 AU/mL indicates – Negative (Non-responsive).[12]

After meticulous checking and rechecking all the data were recorded in a predesigned data collection sheet. Continuous variables were expressed as mean and standard deviation (SD) and compared between groups of subjects by unpaired student's *t*-test in case

of normal distribution or, median and interquartile range (IQR) compared by Mann–Whitney U-test in case of skewed distribution. Categorical variables were compared using a Chi-square test or Fischer's exact test as appropriate and presented as absolute frequencies with percentages. All "*P*" values were two-tailed with significance defined as $P \leq 0.05$ at the level of 95% confidence interval. All analysis has been done using the Statistical Package for the Social Sciences 26.0 package.

Results

All the study subjects (100%) were aged within the range of 18–25 years, whereas the mean ± SD was 20.77 ± 1.99. There was no significant difference between ages of male and female. The mean ± SD of male was 21.13 ± 1.98 and was aged within the range of 19–25 years. The mean ± SD of female was 20.40 ± 1.98 and was aged within the range of 18–25 years. The youngest and oldest study subjects were 18 years and 25 years, respectively [Table 1].

Majority of the subjects (60%) were in normal weight BMI category, with mean ± SD was 23.88 ± 4.01. Among the rest of the subjects was 25% overweight, 10% obese, and 5% underweight BMI category. There was no significant difference among the BMI categories between male and female. The lowest BMI was found 16.56, which was among the male study subjects and the highest BMI was found 34, which was among the female study subjects [Table 2].

This table shows that the antibody level is significantly increased after 2 doses of Sinopharm vaccine among the study subjects of normal weight, overweight, and obese category BMI except underweight BMI category [Table 3].

This figure shows that post-vaccine IgG level decreased in 8% study subjects than their pre-vaccinated IgG level [Figure 1].

The table shows that there is no significant correlation of BMI with pre- and post-vaccine IgG level [Table 4, Figures 2 and 3].

Table 1: Demographic profile of the study subjects (*n*=60)

Age (years)	Male	Female	Total	*P*-value
Mean±SD	21.13±1.98	20.40±1.98	20.77±1.99	0.156
Range	19–25	18–25	18–25	

SD: Standard deviation. Unpaired student's *t*-test was done

Table 2: BMI status of the study subjects (*n*=60)

BMI (kg/m²)	Male (%)	Female (%)	Total (%)	*P*-value
Underweight	2 (6.66)	1 (3.33)	3 (5)	0.711[a]
Normal weight	16 (53.33)	20 (66.66)	36 (60)	
Overweight	9 (30)	6 (20)	15 (25)	
Obese	3 (10)	3 (10)	6 (10)	
Mean±SD	23.94±3.85	23.85±4.21	23.88±4.01	0.928[b]
Range	16.56–32	17–34	16.56–34	-

BMI: Body mass index, SD: Standard deviation. [a]Chi-square test was done. [b]Unpaired Student's t-test was done

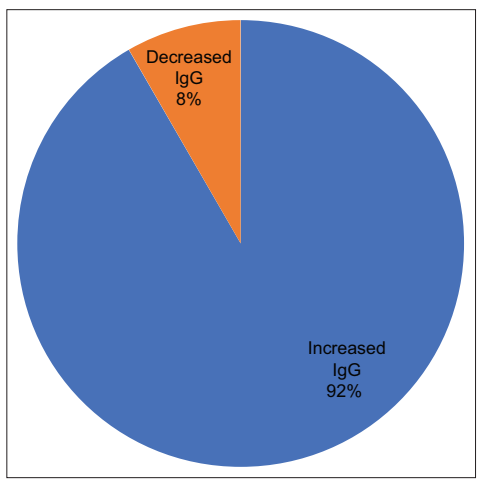

Figure 1: Percentage of study subjects with increased and decreased post-vaccine immunoglobulin G (IgG) than pre-vaccinated IgG level (*n* = 60)

Discussion

In this study, the mean (±SD) age of participants was 20.77 ± 1.99 years, ranging from 18 to 25 years as all were medical students. No previous studies have been conducted exclusively in this age group, since most available research included adults and

Table 3: Pre- and post-vaccine IgG level according to BMI (*n*=60)

IgG (AU/mL)	Pre-vaccine		Post-vaccine		*P*-value
	Median	IQR	Median	IQR	
Underweight	0	0–20.30	144.70	71.70–693.00	0.109
Normal weight	43.70	0–152.63	282.30	157.92–907.07	<0.001
Overweight	68.60	0–198.60	408.90	254.40–1142.00	0.003
Obese	120.65	33.60–348.17	586.30	241.55–1248.00	0.028

IgG: Immunoglobulin G, IQR: Interquartile range, BMI: Body mass index. Wilcoxon signed-rank test was done

Table 4: Correlation of BMI categories with pre- and post-vaccine IgG concentration (*n*=60)

IgG	R	*P*-value
Pre-vaccine - IgG (AU/mL)	0.203	0.12
Post-vaccine - IgG (AU/mL)	0.164	0.21

BMI: Body mass index, IgG: immunoglobulin G. Spearman's correlation test was done

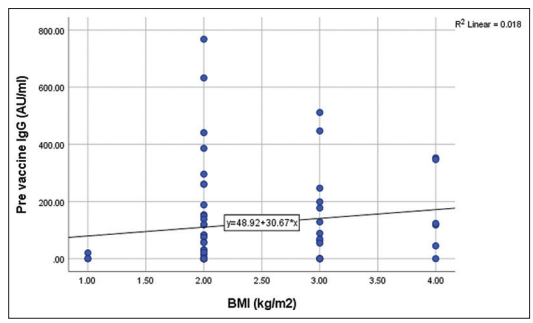

Figure 2: Correlation of body mass index categories with pre-vaccine immunoglobulin G

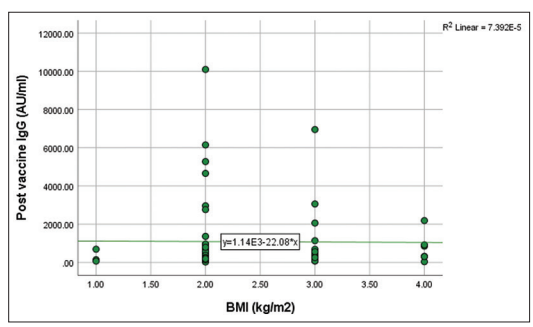

Figure 3: Correlation of body mass index categories with post-vaccine immunoglobulin G

older populations. Regarding BMI, 60% of subjects fell in the normal-weight category (16 males, 20 females; BMI 18.5–24.9). The mean BMI was 23.88 ± 4.01, with 25% overweight, 10% obese, and 5% underweight. BMI values ranged from 16.56 to 34. This distribution aligns with Lombardi *et al*., who reported 46% normal weight, 22% overweight, and 7% obese.[13] This present study found that the anti-spike IgG level was significantly increased after two doses of Sinopharm vaccine irrespective of different BMI status. The post-vaccine IgG level increased significantly among the participants with normal weight (median [IQR]: 43.70 [0–152.63] vs. 282.30 [157.92–907.07] AU/mL; $P \leq 0.001$), overweight (median [IQR]: 68.60 [0–198.60] vs. 408.90 [254.40–1142.00] AU/ml; $P = 0.003$), and obese (median [IQR]: 120.65 [33.60–348.17] vs. 586.30 [241.55–1248.00] AU/mL; $P = 0.028$). However, in case of underweight participants, the IgG level was not significantly increased after vaccination (median [IQR]: 0 [0–20.30] vs. 144.70 [71.70–693.00] AU/mL; $P = 0.109$), it may be due to the smaller number of participants (only three students) were in this group and it needs a large number of underweight participants to conclude about whether it is significant or not. The study also found that there was no significant association of BMI categories with pre- and post-vaccine IgG level (in case of pre-vaccine IgG, r = 0.203; $P = 0.12$ and in case of post-vaccine IgG, r = 0.164; $P = 0.21$). However, Lombardi *et al*., found a positive association between the anti-S1 antibody titers and the BMI. Their multivariable analysis confirmed that <35 years age, overweight/obese, and non-smokers had higher frequency of high titers.[13] Moreover, in a study in Turkey, Özdemir *et al*., detected a weak negative correlation between BMI and antibody levels, but was not statistically significant ($P = 0.281$).[14] The present study demonstrates that after 2nd doses of vaccination,

antibody titers were reduced from titers observed before vaccination in 8% participants. In a study at Dhaka, Bangladesh, they observed that in 40.54% participants, antibody titers were reduced after 2nd dose of vaccination from the titers seen after 1st dose. The proper reason of this reduction in antibody titers is unknown, though it might be, during the study period, high infection rate was prevailing in Dhaka city and the participants might have been exposed with the virus within few days before blood collection after 2nd vaccination. These viruses might have neutralized the antibodies present in their body.[15]

Limitations of the study

This study has certain limitations. The relatively small sample size restricts its applicability to the wider population, and participants were primarily healthy young adults, leaving the vaccine response in pregnant women, children, older adults, and those with chronic illnesses unexplored. Financial constraints prevented measurement of antibody levels after the first dose, which would have enabled comparison between previously infected individuals after one dose and non-infected individuals after two doses.

Conclusion

This study shows that IgG levels significantly increased after two doses of the Sinopharm vaccine in normal weight, overweight, and obese individuals, but not in the underweight group. However, no significant correlation was found between BMI and pre- or post-vaccine IgG levels, suggesting that antibody response is largely independent of BMI.

Recommendation

It is recommended that future studies with larger and more diverse populations be conducted to further explore the impact of BMI on vaccine-induced antibody responses, particularly in underweight individuals, to ensure optimal vaccination strategies across all BMI groups.

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Conflicts of Interest

None declared.

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