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*Article*

# Insight about the Body Mass Index among School Students during COVID-19 Pandemic

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**Abstract: Background:** Several reports indicate that long stay at home for online schools due to the COVID-19 pandemic changed the normal physical activity and body weight of school-age students. Previous studies revealed that almost 50% of school students complained of increased or decreased more than 3 kg of weight due to lower physical activity. This study aims to provide insight about the Body Mass Index (BMI) among school students during COVID-19 pandemic. **Methods:** A retrospective matched-longitudinal study was conducted in 2022 based on previous data about BMI-for-age percentile in school-age students aged 6 to 18 years. These data were collected the year before and during COVID-19 pandemic (2019-2021). **Results:** All the included students were Arabic (N = 53,580) and were not diagnosed with chronic illness. The outcomes showed that the overall percentage of students with normal weight was 54%, 56%, and 53% during the 2019-2021 years, respectively. Overweight among students increased during the COVID-19 pandemic years, as almost 10% of the students were overweight in 2019 compared with 12% in 2020 and 2021 years. Besides, obese students also increased in the 2020-2021 period compared with the 2019 year (15-17% vs. 10%). In contrast, underweight trends among students declined, as 26% reported in 2019 compared to 17-18% in 2020 and 2021. **Conclusion:** There are significant variations in Arabic school-age students regarding their BMI values. Obesity was highly detected among children and adolescents during the COVID-19 pandemic years compared to 2019, while underweight cases declined.

**Keywords:** COVID-19 pandemic; school health; BMI; underweight; overweight; obesity

## Introduction

During the Coronavirus disease-2019 (COVID-19) pandemic in 2020 and 2021, most schools globally have been closed to avoid the transmission of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) among students and their relatives [1]. Instead, online courses were organized and conducted to overcome the new pandemic-related issues [2].

The increase in body mass index (BMI) among children is highly detected in most developed countries [3], and it is described as one of the risk factors for the early onset of type-2 diabetes mellitus (T2DM), hypertension, and coronary vascular diseases [4].

In adults, the overweight and obesity diagnosis is based on fixed criteria, in which BMI  $\geq 25$  is described as overweight, and BMI  $\geq 30$  is recognized as obesity [5]. However, the criteria for diagnosing overweight and obesity are quite different in school-age students, as it depends on the gender, height, weight, and age of the student to calculate BMI and BMI-for-age percentile. School students with BMI-for-age 85th percentile or more are described as overweight, while students with 95th percentile or more are recognized as obese [6].

Several reports indicate that long stay at home for online schools due to the COVID-19 pandemic changed the normal physical activity and body weight of school-age students [7-9].

Palmer et al. reported that almost 50% of school students complained of increased or decreased more than 3 kg of weight [10]. Similarly, Jalal et al. revealed that half of the included students in their study reported that they lost or gained weight during lockdown due to lower physical activity [11]. Weaver et al. showed an increase in students' weight in 2020 compared with previous years [12].

This study aims to provide insight about the BMI among school students during COVID-19 pandemic.

## Subjects and methods

### *Study Design and study population*

A retrospective matched-longitudinal study was conducted to determine and compare BMI-for-age percentile in school-age students aged 6 to 18 before and after COVID-19 pandemic-related schools' lockdown in 2019-2021.

Arabic children and adolescent school students in Saudi Arabia aged 6 to 18 who visited a primary healthcare center (PHC) during 2019, 2020, or 2021 were eligible for this study. The researchers excluded children and adolescents who were documented as non-Arabic, diagnosed with chronic disorders that may affect their body weight (i.e., diabetes mellitus, sickle cell anemia, and kidney disease), and those who use medications for the long term, which may also affect their body weight (i.e., oral corticosteroids, anti-psychotic medications, first-generation anti-histamines, and antiepileptic medications).

### *Data collection and BMI-for-age percentile change measurement*

The required information about the school-age students was gathered from secondary data provided by the Data Management Office (Data Governance Team), Saudi Ministry of Health, Riyadh. The secondary data source is supported by the patients' medical-record data in the health information system (HIS) filled by physicians working in PHCs in different regions of Saudi Arabia.

### *Statistical analysis*

Data analysis was performed using the Statistical Package for Social Sciences (SPSS) version 24. The Association between the different groups in terms of categorical variables was assessed using the Chi-square test. All tests' results were considered significant if the p-value was less than 0.05.

### *Ethical consideration*

The study was reviewed and approved by the Central Institutional Review Board (IRB) committee of the Saudi Ministry of Health (IRB Log Number: 22-29 M). The confidentiality and anonymity of the participants' data were preserved. This study depended on anonymous secondary data; therefore, no consent for participation was needed.

## Results

More than 700,000 school-age students' data were collected during 2019-2021. The study included 53,580 children and adolescents after excluding repeated PHC visit data for the same student, incomplete students' data, and non-Arabic students. The total included students were divided into three groups based on the year of visiting PHC (2019, 2020, and 2021). By simple randomization, each group contains 17,860 students aged 6-18 years and is matched regarding their ethnicity (Arabs) and health status. All the included students were Saudis and were not diagnosed with chronic illness. **Table 1** summarizes the students' characteristics.

The outcomes showed that the overall percentage of students with normal weight was 54%, 56%, and 53% during the 2019-2021 years, respectively. Frequencies of students with optimal BMI increased significantly in 2020 compared to 2019 ( $p < 0.01$ ); however, no statistical significance showed between 2019 and 2021 years in regards to normal body weight trends. Overweight among students increased during the COVID-19 pandemic years (2020-2021), as almost 10% of the students were

overweight in 2019 compared with 12% in 2020 and 2021 years ( $p < 0.01$ ). Besides, obese students also increased in the 2020-2021 period compared with the 2019 year (15-17% vs. 10%,  $p < 0.01$ ). In contrast, underweight trends among students declined, as 26% reported in 2019 compared to 17-18% in 2020 and 2021 ( $p < 0.01$ ) (**Figure 1**).

The included data were subdivided into categories based on students' age (6-9, 10-14, and 15-18 years), gender, and Saudi regions (west, north, south, east, and center regions). The sub-analysis revealed that the frequencies of normal-weight students significantly declined during 2021 when compared to 2019 only among the age groups 6-9 and 15-18 years, while students aged 10-14 years showed no change regarding this BMI category for the same period (**Table 2**).

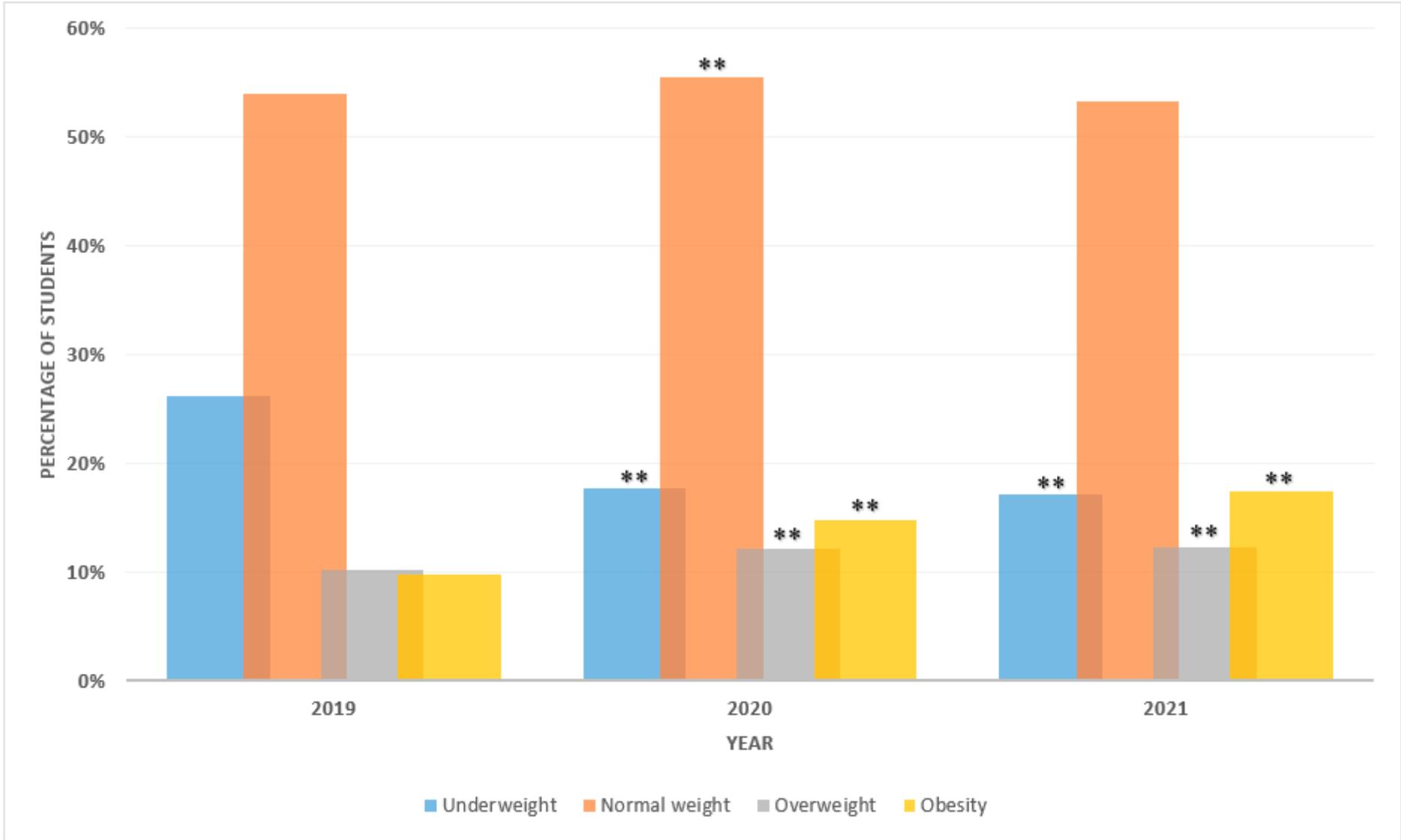
The overweight percentages among 15-18 years old students did not change during 2019-2021, while it increased in students aged 6-14 years. Obesity has been raised among all age groups, however, the highest increase was seen among 10-14 years old students. The frequency of underweight was reduced among all age groups, and hugely reduced among 10-14 years old students (27% in 2019 vs. 11% in 2021) (**Table 2**).

In regards to sex, both male and female students showed increase in the frequencies of overweight and obesity during 2019-2021 (10→12% and 10→17%, respectively among males, and 10→13% and 9→18%, respectively among females). The frequencies of underweight were decreased among both female and male students (26% in 2019 vs. 16-19% in 2021), whereas normal weight frequencies only declined among females (55% in 2019 vs. 54% in 2021). Normal weight in males did not show any change during this period (**Table 2**).

Concerning the geographic variations, all Saudi regions (Center, East, North, South, and West) share the decline in normal weight during 2019-2021, one region was an exception, as there was an increase in this BMI category among students living in the South region. In all Saudi regions, overweight and obesity percentages were hugely elevated in 2021 compared to 2019. By contrast, underweight frequencies were declined during the same period (**Table 2**).

**Table 1.** Characteristics of the included students (2019-2021).

Variable	2019 group (N=17,860)	2020 group (N=17,860)	2021 group (N=17,860)	Total (N=53,580)	
<b>Gender</b>	Male gender	9220 (52%)	7681 (43%)	7603 (43%)	24504 (46%)
	Female gender	8640 (48%)	10179 (57%)	10257 (57%)	29076 (54%)
<b>Age group</b>	6-9 years old students	5257 (29%)	5339 (30%)	6341 (36%)	16937 (31.6%)
	10-14 years old students	7351 (41%)	5954 (33%)	5236 (29%)	18541 (34.6%)
	15-18 years old students	5252 (29%)	6567 (37%)	6283 (35%)	18102 (33.7%)
<b>Region</b>	Students in West Saudi region	2859 (16%)	1539 (9%)	1709 (10%)	6107 (11%)
	Students in North Saudi region	2019 (11%)	1528 (9%)	1289 (7%)	4836 (9%)
	Students in South Saudi region	5878 (33%)	5144 (29%)	4869 (27%)	15891 (30%)
	Students in East Saudi region	1450 (8%)	1759 (10%)	2000 (11%)	5209 (10%)
	Students in Center Saudi region	5654 (32%)	7890 (44%)	7993 (45%)	21537 (40%)



**Figure 1.** The reported percentages of underweight, normal weight, overweight, and obesity among Saudi children and adolescents during 2019-2021. **\*\* Significant difference compared to the documented BMI categories during 2019 period (p<0.01).**

**Table 2.** The frequencies of underweight, normal, overweight, and obesity among Saudi children and adolescents included in the study regarding sub-groups (age category, gender, and Saudi region).

Variable	Year											
	2019 (N total=17,860)				2020 (N total=17,860)				2021 (N total=17,860)			
BMI category	Underweight	Normal	Overweight	Obesity	Underweight	Normal	Overweight	Obesity	Underweight	Normal	Overweight	Obesity
	(<5th percentile)	(5th – 85th percentile)	(85th – 95th percentile)	(>95th percentile)	(<5th percentile)	(5th – 85th percentile)	(85th – 95th percentile)	(>95th percentile)	(<5th percentile)	(5th – 85th percentile)	(85th – 95th percentile)	(>95th percentile)
Total N=53,580	4671 (26)	9636 (54)	1820 (10)	1733 (10)	3149 (18)	9914 (56)	2155 (12)	2642 (15)	3052 (17)	9508 (53)	2198 (12)	3102 (17)
Age category												
6-9 years	N= 5257				N= 5339				N= 6341			
	1723 (33)	2818 (54)	368 (7)	348 (7)	1339 (25)	3091 (58)	422 (8)	487 (9)	1660 (26)	3357 (53)	548 (9)	776 (12)
10-14 years	N= 7351				N= 5954				N= 5236			
	2021 (27)	3848 (52)	806 (11)	676 (9)	926 (16)	3263 (55)	860 (14)	905 (15)	595 (11)	2744 (52)	814 (16)	1083 (21)

<b>15-18</b>	N= 5252				N= 6567				N= 6283			
<b>years</b>	927 (18)	2970 (57)	646 (12)	709 (13)	884 (13)	3560 (54)	873 (13)	1250 (19)	797 (13)	3407 (54)	836 (13)	1243 (20)
<b>Sex</b>												
<b>Male</b>	N= 9220				N= 7681				N= 7603			
	2434 (26)	4921 (53)	916 (10)	949 (10)	1451 (19)	4253 (55)	845 (11)	1132 (15)	1411 (19)	4009 (53)	895 (12)	1288 (17)
<b>Female</b>	N= 8640				N= 10179				N= 10257			
	2237 (26)	4715 (55)	904 (10)	784 (9)	1698 (17)	5661 (56)	1310 (13)	1510 (15)	1641 (16)	5499 (54)	1303 (13)	1814 (18)
<b>Saudi region</b>												
<b>West</b>	N= 2859				N= 1539				N= 1709			
	809 (28)	1501 (53)	269 (9)	280 (10)	283 (18)	854 (55)	198 (13)	204 (13)	304 (18)	884 (52)	212 (12)	309 (18)
<b>North</b>	N= 2019				N= 1528				N= 1289			
	459 (23)	1203 (60)	186 (9)	171 (8)	207 (14)	905 (59)	193 (13)	223 (15)	183 (14)	733 (57)	162 (13)	211 (16)
<b>South</b>	N= 5878				N= 5144				N= 4869			
	1764 (30)	3004 (51)	592 (10)	518 (9)	1146 (22)	2751 (53)	576 (11)	671 (13)	995 (20)	2583 (53)	525 (11)	766 (16)
<b>East</b>	N= 1450				N= 1759				N= 2000			
	335 (23)	825 (57)	138 (10)	152 (10)	262 (15)	985 (56)	211 (12)	301 (17)	298 (15)	1082 (54)	243 (12)	377 (19)
<b>Centre</b>	N= 5654				N= 7890				N= 7993			
	1304 (23)	3103 (55)	635 (11)	612 (11)	1251 (16)	4419 (56)	977 (12)	1243 (16)	1272 (16)	4226 (53)	1056 (13)	1439 (18)

## Discussion

The COVID-19 pandemic during 2020-2021 has led to school shutdowns and quarantine periods in several countries globally. These actions were necessary to minimize the outbreak caused by new coronavirus (SARS-CoV-2) infection among school-age students and their relatives [13]. However, numerous studies revealed that students' weight had significantly changed during the pandemic (2020-2021) due to the changes in usual eating habits and physical activities [10]. Besides, some psychological research showed that anxiety, depression, and minimal social events could ameliorate students' weight [14].

In the current study, the researchers found that the percentage of obese students increased during the COVID-19 pandemic (2020-2021) and reached 17% in 2021. Students aged 10-14 years were more affected by being obese compared to other age groups. In contrast, a high percentage of underweight among school students during the COVID-19 period was recorded by Correia et al., as they revealed that the prevalence of those with BMI less than 5th percentile increased from 2.2% (in 2016) to 10% (in 2020) [15]. Moreover, Azoulay et al. reported that fat tissues decreased among children and adolescents during the COVID-19 pandemic, but muscle tissue increased [16]. However, most published studies showed that BMI values increased among children and adolescents regardless of their school level or age [17-19].

Our outcomes showed that overweight and obesity were increased in female school students during the COVID-19 period. In the same line, Azoulay et al. and Brooks et al. also stated that in females were more overweighted and obese than males.

To the best of our knowledge, this is the first non-self-reported and ethnicity-matched with adequate sample size study conducted in Saudi Arabia to evaluate the BMI changes among healthy school-age students before and during the COVID-19 pandemic. One previous self-reported Saudi study with a sample size of 280 showed that the number of obese school students increased while underweight declined [20]. Other researchers objectively evaluated the BMI changes among 150 diabetic school-age students with a mean age of 12.45. They found that most of them revealed that they had an increased weight during the COVID-19 period compared to the pre-COVID-19 pandemic. However, this increase in weight was clinically insignificant, as the BMI deviation was within normal ranges based on the included participants' mean age [21].

Nevertheless, the current study covered all regions of Saudi Arabia to avoid any bias due to eating habits and subethnicity variations between regions. So far, no differences have been shown among regions, as the prevalence of obesity and overweight increased in the 2021 year in all regions compared to 2019. These changes in BMI among children and adolescents could not only be caused by COVID-19-related factors (e.g., decreased physical activities, food habit change, and social distancing measures) but may also be caused by some diet regimens commonly used nowadays (e.g., keto diet regimen) [22,23]. Although the ketogenic diet is not a new kind of food habit, it is re-applicable to overcome obesity and overweight and to avoid invasive weight-loss surgical options [23].

Despite the fact that global increase in obesity among children during the COVID-19 pandemic could be solved with the return to a normal lifestyle and the end of protective measures, some COVID-19-related routines (e.g., low physical activity) could persist for a longer period. Besides, online courses and several smartphone applications may allow more chances to gain weight. Special programs on how to overcome COVID-19-related obesity should be issued for school-age children and their parents.

### *Limitations*

The study groups were not matched regarding their socioeconomic status as it not found in the provided secondary data.

**Funding:** This paper was not funded.

**Consent for participation:** This study was dependent on anonymous secondary data, therefore, no consent for participation nor publication was needed.

**Consent for publication:** Not applicable.

**Data availability:** The data that support the findings of this study are available from the corresponding authors upon reasonable request.

### List of abbreviation

BMI	Body Mass Index
COVID-19	Coronavirus Disease 2019
HIS	Health Information System
IRB	Institutional Review Board
PHC	Primary Healthcare Center
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
SPSS	Statistical Package for Social Sciences
T2DM	Type-2 Diabetes Mellitus

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