



The Relationship of Food Consumption Patterns to Adult Obesity Status and BMI Changes in the COVID-19 Pandemic: A Longitudinal Study

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Abstract. In Indonesia, the trend of obesity continues to increase consistently, even though the government has targeted to maintain the prevalence of obesity. Obesity is a comorbidity of COVID-19. During the COVID-19 pandemic, there was a change in diet and weight gain. The purpose of this study was to determine the relationship between food consumption patterns to adult obesity and changes in BMI during the COVID-19 pandemic Longitudinal study on 814 cases of obese adults aged 31 years and older who were part of the research subject “The Bogor Cohort Study of Non-Communicable Disease Risk Factors”. The sample is obese cases (BMI 25 and over) which has complete data on BMI in 2019, 2020, and 2021 and consumption data in 2021, while the data is excluded if there is an outlier. The dependent variable is obesity status which is categorized into 3 (obese I, II, and III) and changes in BMI which is the difference between BMI 2020 and BMI in 2019 which is categorized into 3, namely stable, decreasing, increasing based on data distribution and determining cut off based on delta mean BMI changes. The independent variables included consumption patterns of 8 food groups (carbohydrates, meat, fish, eggs, nuts, fruit vegetables, milk, fried snacks), gender, and age. Data were analyzed by the Chi-Square test with a significance of $p < 0.05$. During the COVID-19 pandemic in the city of Bogor (2020–2021), the proportion of obese I was 24.3 percent and BMI increased by 14.2%; obese II was 33.9% and BMI increased by 32.8%, while the proportion of obese III was 41.8% and BMI increased by 53% and significantly according to gender and age. Food consumption which was significantly ($p < 0.05$) related to obesity status was carbohydrate consumption ≥ 22 times/week ($p = 0.006$) and meat consumption > 4 times/week ($p = 0.009$). As for the frequency of consumption pattern which was significantly related to changes in BMI, carbohydrate consumption ($p = 0.006$) and meat consumption was > 4 times/week ($p = 0.048$). The consumption of carbohydrates and meat was associated with obesity status and changes in BMI of obese subjects during the pandemic. An effective educational strategy is needed to provide information on good eating patterns in people who are already obese. In addition, it needs to be accompanied by intensifying health promotion related to physical activity.

Keywords: consumption patterns · obesity · changes in BMI · COVID-19 pandemic

1 Introduction

The trend of obesity has consistently increased worldwide over the past 40 years, the number of men and women with obesity has increased from nearly 100 to almost 700 million, with an increasing impact on children and adolescents [1]. Overweight and obesity are increasing in low- and middle-income countries, especially in urban areas [2]. A substantial increase in obesity is occurring in all South Asian countries [3]. Obesity in Indonesia is considered quite high and the trend continues to increase. Basic Health Survey (Riskesdas) data shows the prevalence of obesity in the adult population of 10.3% in 2007 rose to 15.4% in 2013 and 21.8% in 2018 [4, 5, 6]. Obesity is still the main predictor of the emergence of non-communicable diseases, especially diabetes mellitus [7].

Obesity is a common comorbidity in COVID-19 cases, social isolation can lead to increased fat accumulation. Excessive adipose tissue is a factor that interferes with the function of organs and systems in obese individuals [8]. During the COVID-19 period, children, adolescents, and young adults experience weight gain due to changes in dietary behavior, increased intake, and inappropriate food choices [9] this can exacerbate the childhood obesity epidemic and increase disparities risk of obesity [10].

The prevalence of obesity and overweight increased during the COVID-19 period [11]. The long-term impact of the Covid-19 crisis is the greater prevalence of obesity due to limited physical activity and the increased consumption of processed foods that are high in sugar, salt, and fat [12]. The pandemic evaluation survey of obesity and health care in Canada in 2020 showed that weight gain by more than 5% was 40% and those who gained more than 10% reached 13% during the pandemic [13]. The COVID-19 pandemic has changed the habits or lifestyles of the world's population, including diet. Several studies on consumption patterns during the pandemic were carried out in various countries, Bakhsh et.al reported that more than 40% and 45% of respondents ate and snacked more, causing about 28% weight gain [14].

Each person's dietary pattern is different, and the type of food consumed is also different. Every food consumed contains various nutrients including energy which can accumulate into fat reserves in the body and even different portions of food consumption gave a different effect on the body as increased portions or serving size contribute to the overconsumption of energy and excess body weight [15]. Various works of literature illustrate that isolation and the COVID-19 pandemic have caused changes in food buying behavior, consumption patterns, and changes in body weight [16].

One of the program achievements for the Indonesian Ministry of Health in the 2020–2024 period is still considered difficult and has not been achieved in controlling the prevalence of persistent obesity [17]. To obtain an overview of food consumption patterns and changes in BMI of obese people during the COVID-19 period, therefore further analysis is necessary to determine the relationship between consumption patterns to BMI changes of obese cases during the COVID-19 pandemic.

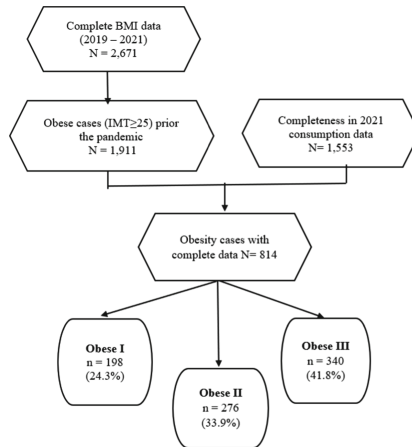


Fig. 1. The flow of data selection for obese cases analyzed in this study

2 Material and Methods

2.1 Design Study

This study was part of a longitudinal study entitled “Cohort Study of Non-Communicable Disease Risk Factors (FRPTM)” in 5 sub-districts (Kebon Kalapa, Babakan Pasar, Babakan, Ciwaringin, and Panaragan) in Central Bogor Regency, Bogor City. The sample of this study was respondents who were categorized obese (have a BMI of 25 kg/m² or more), aged 31 years or older, and have completed data on BMI (the year 2019, 2020 (filling in BMI online), 2021) and complete consumption data in 2021.

2.2 Data Selection

Data selection for further analysis was performed from the total obese population of the FRPTM cohort study. There were 2671 respondents with complete BMI data in 2019, 2020, and 2021. After checking the completeness of consumption data in 2021, there were 814 respondents analyzed in this study (Fig. 1). The sample inclusion criteria were the completeness of the data on the BMI variable and consumption data in 2021, while the exclusion criteria were outlier data.

2.3 Variable Description

The dependent variables were obesity status which had been categorized into 3 (obese I, II, and III), and changes in BMI which had been categorized into 3 (increase, stable, decrease). Classification of obesity according to categories for Indonesia, namely obese I (BMI 25 – 26.9), obese II (BMI 27 – 29.9), and obese III (BMI 30) [18]. Changes in BMI which were defined as the difference between BMI in 2020/2021 and 2019, were then categorized into 3, namely increase, stable and decrease. This categorization was

done based on data distribution. Determination of cut-off using the mean delta changes in BMI [19].

BMI changes were categorized into 3 groups, which are stable (BMI delta $-0.2452 - 0.2452$), decrease (BMI delta < -0.2452), and increase (BMI delta > 0.2452). The main independent variable was the pattern of food consumption which has grouped into 8 consisting: food sources of carbohydrates (cereals, tubers, sugar, and their products); meats (poultry meat, red meat, and their processed products); fish (freshwater fish, marine fish, and their products); eggs and its processed products; peanuts and its processed products; fruits and vegetables; milk and its products and fried snacks [20]. Food consumption was obtained using the Food Frequency Questionnaire (FFQ) which collected individual consumption for a month. Food consumption data were then categorized based on the eating frequency as frequent and rare using the distribution of the average frequency value of consumption in a week based on each food group. The consumption frequency category for each food group was as follows: carbohydrates were categorized as frequent (22 times a week) and rare (< 22 times a week) consumption; the meat and eggs were categorized as frequent (4 times a week) and rare (< 4 times a week) consumption; fish and milk were categorized as frequent (1 time a week) and rare (< 1 time a week) consumption; peanuts and fried snack were categorized as frequent (5 times a week) and rare (< 5 times a week) consumption; fruits and vegetables were categorized as frequent (7 times a week) and rare (< 7 times a week) consumption. Other independent variables included age and gender. Age groups were categorized into 3, which were 32–44 years, 45–54 years, and 55 years and over. Gender was divided into male and female [21].

2.4 Statistical Analysis

The data were analyzed by using the Chi-Square test. The secondary data source has received approval for research ethics permit from the Ethics Commission of the Health Research and Development Agency of the Ministry of Health of the Republic of Indonesia with the number LB.02.01/2/KE.102/2019; HK.02.03/2/2025/2020, LB.02.01/2/KE.169/2021.

3 Result

3.1 Characteristics of Obese Cases Before Pandemic COVID-19

In the period during the COVID-19 pandemic (2020/2021), obese cases which met the sample criteria for this study were 814 cases with the largest order of details in the proportion being 41.6% obese III, followed by obese II cases, as many as 33.9% and then obese I accounted for 24.3%. Level III obesity still has the largest proportion compared to other obese levels and increase proportion from 38.3% to 41,8% (Fig. 1 and Fig. 2).

Based on the age group, the proportion of obese cases was significantly different ($p = 0.001$). In the 31–44 years age group, the largest proportion was in obese III cases (36.6%), in the 45–54 years age group the highest proportion was in obese II cases, while at the age of 55 years and older the largest proportion was in obese I cases (Fig. 1).

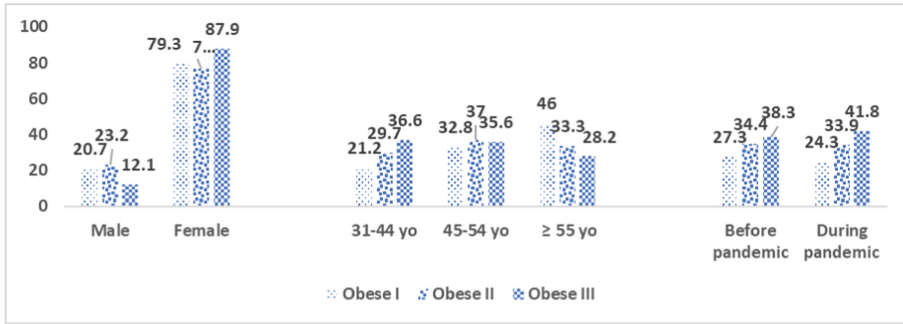


Fig. 2. Characteristic of obese cases by sex, age group, and the number of cases before and during the pandemic

Table 1. The proportion of obese cases according to changes in BMI

BMI	Obesity status (N = 814)			Sig.
	Obese I* n = 198 (24.3)	Obese II* n = 276 (33.9)	Obese III* n = 340 (41,8)	
	n (%)	n (%)	n (%)	
Changes in BMI				0.000
• Increase	45 (14.2)	104 (32.8)	168 (53.0)	
• Stable	85 (28.6)	99 (33.3)	113 (38.0)	
• Decrease	68 (34.0)	73 (36.5)	59 (29.5)	

* Obese I: BMI 25-26.9 kg/m²; Obese II: BMI 27 – 29.9 kg/m²; Obese III: BMI 30 kg/m² and above. Obesity status in the pandemic COVID-19 (2020/2021)

3.2 Changes in BMI in Obese Cases

The proportion of obese cases according to changes in BMI showed a significant difference ($p = 0.000$). The proportion of changes in BMI increased showing a linear pattern of proportions. If observed, the obese group II showed the greatest ability to reduce BMI compared to the obese I and III levels (Table 1).

3.3 Consumption Patterns and Changes in BMI in Obese Cases

The profile description of obese cases according to the consumption patterns of the eight food groups is shown in Table 2.

Of the eight food categories that showed different proportions with obese status I, II, and III were consumption of carbohydrates ($p = 0.006$) and meat ($p = 0.009$). Carbohydrate consumption patterns often appeared higher in cases of obese II and III, which were more than 30%, while the pattern of meat consumption showed the largest proportion in cases of obese III, which is 42% (Table 2). Changes in BMI according to consumption

Table 2. Profile of obesity status according to the consumption patterns during the pandemic COVID-19

Consumption patterns	Obesity status* (N = 814)			Sig.
	Obese I* n = 198 (24.3)	Obese II* n = 276 (33.9)	Obese III* n = 340 (41,8)	
	n (%)	n (%)	n (%)	
Carbohydrates consumption				0.006
Frequently	23.9	39.6	36.5	
Rarely	24.7	29.5	45.9	
Meats consumption				0.009
Frequently	20.9	37.2	42	
Rarely	29.3	29.3	41.8	
Fish consumption				0.066
Frequently	18.4	33.5	48	
Rarely	26	34	40	
Eggs consumption				0.641
Frequently	25.5	33.8	40.8	
Rarely	22.7	34.1	43.1	
Peanuts consumption				0.401
Frequently	26.6	34.7	38.6	
Rarely	23.2	33.5	43.2	
Fruits and Vegetables consumption				0.103
Frequently	24.7	28.4	47	
Rarely	24.2	35.9	39.9	
Milk consumption				0.082
Frequently	25.4	41.3	33.3	
Rarely	24.1	32.6	43.3	
Fried snack consumption				0.627
Frequently	23.4	33.4	43.2	
Rarely	25.5	34.5	40	

* Obese I: BMI 25-26.9 kg/m²; Obese II: BMI 27 – 29.9 kg/m²; Obese III: BMI 30 kg/m² and above. Obesity status in the pandemic COVID-19 (2020/2021)

patterns of 8 food categories showed a significant difference in consumption of carbohydrates and meat ($p < 0.05$). The proportion of decreased BMI showed a significant difference between the obese cases I, II, and III who rarely consumed carbohydrates ($p = 0.006$), and also the proportion of stable BMI showed a significant difference in obese cases I, II, and III who rarely consumed meats ($p = 0.043$) (Table 3.).

Table 3. Changes in BMI according to consumption patterns among obese cases during the COVID-19 pandemic 2020/2021

Consumption pattern	Obese status (N = 814)									
	I	II	III	I	II	III	I	II	III	
	BMI Changes (N = 814)									
	Increase* (%)			Stable* (%)			Decrease* (%)			Sig.
Carbohydrates consumption										0.006
Frequently	16.8	36.5	46.7	23.3	39.8	36.8	36.0	44.2	19.8	
Rarely	12.2	30.0	57.8	32.9	28.0	39.0	32.5	30.7	36.8	
Meats consumption										0.048
Frequently	14.4	34.2	51.4	34.0	35.2	42.4	28.4	44.4	27.2	
Rarely	14.0	31.6	54.4	22.4	31.1	32.6	37.8	31.1	31.1	
Fish consumption										0.181
Frequently	14.9	29.8	55.3	26.9	28.3	44.8	30.5	38.1	31.4	
Rarely	13.6	53.2	51.1	30.3	38.2	31.6	37.9	34.7	27.4	
Eggs consumption										0.476
Frequently	14.2	30.5	55.3	29.6	34.9	35.5	38.6	41.0	20.5	
Rarely	14.2	34.7	51.3	27.6	31.7	40.7	30.8	33.3	35.9	
Peanuts consumption										0.194
Frequently	13.1	32.0	54.9	26.6	34.3	39.2	27.7	37.6	34.7	
Rarely	15.2	33.5	51.2	30.5	32.5	37.0	40.4	35.4	24.2	
Fruits and Vegetables consumption										0.077
Frequently	15.1	29.1	55.9	29.5	30.9	39.6	38.9	31.9	29.2	
Rarely	13.0	37.7	49.3	27.8	35.4	36.7	27.6	42.5	29.9	
Milk consumption										0.062
Frequently	14.1	42.3	43.6	30.1	34.9	34.9	36.4	43.2	20.5	
Rarely	14.2	29.7	56.1	28.0	32.7	39.3	33.3	34.6	32.1	
Fried snack consumption										0.318
Frequently	11.4	32.6	56.1	26.0	34.1	39.8	31.7	42.7	25.6	
Rarely	16.2	33.0	50.8	30.5	32.8	36.8	35.6	32.2	32.2	

* Obese I: BMI 25–26.9 kg/m²; Obese II: BMI 27 – 29.9 kg/m²; Obese III: BMI 30 kg/m² and above. Obesity status in pandemic COVID-19 (2020/2021)

4 Discussion

The findings of this study indicated that obesity cases ($BMI \geq 25$) during the COVID-19 pandemic showed the highest proportion of obese III (41.6%) followed by obese II (33.9%) and the lowest in obese I (24.3%). This proportion was higher than the prevalence of adult obesity based on the Indonesian Basic Health Survey (Riskesmas) which accounted for 21.8% in 2018 [8] and other Asian countries i.e., Malaysia 16.6%, India 10%, China 25%, Thailand 28.3% [22].

Based on gender and age group, the findings illustrated that the proportion of obesity was higher in women than men with an estimated ratio of 3:1. Obesity rates were higher among women, as reported in many other countries [23]. In some developing countries, obesity, especially among women, is regarded as a sign of affluence. Such cultural influence could be related to the higher prevalence among women compared to their male counterparts [24].

Based on age group, the proportion of obesity is more than 30% for obese I and II. In obese I, the proportion of obesity is higher in 55 years and older. In Singapore which is a developed region in Asia, nearly 35% of people aged 18–69 years are overweight, another 14% are obese. This societal problem in Singapore is shown to be associated with its extremely large GDP and economic affluence [25]. A study in Malaysia on 1,045 young adult respondents found that almost half experienced weight gain with an average gain of 4.06 ± 3.23 kg in exactly 15 months since the pandemic [26]. Similar results were reported by a study in America involving 3,473 participants, weight gain was experienced by 48% of participants [27].

Each person's dietary pattern is different, and the type of food consumed is also different. Every food consumed contains various nutrients including energy which can accumulate into fat reserves in the body and even different portions of food consumption gave a different effect on the body as increased portions or serving size contribute to the overconsumption of energy and excess body weight. The COVID-19 pandemic has changed the habits or lifestyles of the world's population, including diet. Several studies on consumption patterns during the pandemic were carried out in various countries. Various works of literature illustrate that isolation and the COVID-19 pandemic have caused changes in food buying behavior, consumption patterns, and changes in body weight [28].

The increase in BMI during the COVID-19 pandemic showed a significant difference, and the findings showed the highest increase in BMI changes in the obese III group. More than half (53%) of obese cases experienced an increase in BMI during the COVID-19 pandemic. The World Health Organization [29] states that consuming energy-dense, high-fat, high-sugar, and low-fiber foods has a higher risk of being overweight and obese. Bakhsh et.al reported that more than 40% and 45% of respondents ate and snacked more, causing about 28% weight gain [14]. Other studies also found a similar situation where a higher proportion of weight gain was experienced in participants with higher BMI/obesity [26].

The dietary profile for carbohydrate consumption and meat consumption in obese cases during the COVID-19 pandemic showed differences between obese levels I, II, and III. Carbohydrate consumption patterns often appeared higher in cases of obese II and III, which was more than 30%, while the pattern of meat consumption showed

the largest proportion in cases of obese III, which was 42% (Table 3). The changes in BMI were significantly related to the consumption of carbohydrates, especially in obese cases in the decreased BMI category, and consumption of meat related to the stable BMI category during the COVID-19 pandemic. A study by Roman et al. found that a high meat/high-fat pattern (a high intake of red meat, processed meat, poultry, potatoes, pasta and rice, eggs, fried food, and fried potatoes) was associated with a higher probability of the presence of obesity (OR 1.2 [95%CI: 1.1–1.4]) than the western pattern (high intake of processed meat, fast-food, snacks, sauces, sweets, nuts, and fruit) and prudent pattern (a high intake of fish, vegetables, legumes, fruits, and soy milk) [31] and in the elderly, obesity also associated with inadequate consumption of whole-wheat grains (PR 1.7 [95%CI: 1.14–2.52]) and adequate consumption of fruit (PR 1.28 [95%CI: 1.06–1.55]) [30]. Consumption of cereal and grain products ($\beta = 0.084$, $p = 0.015$, 95% CI = 0.017–0.160) and consumption of oils and fatty foods ($\beta = 0.123$, $p = 0.001$, 95% CI = 0.059–0.241) were reported to have an association with weight gain during the pandemic [26]. Similar to that study, several factors that influenced weight gain in 4,181 participants in Turkey included consumption of white bread and sweet foods, consumption of foods with an increase in the portion of main meals, and also decreased physical activity [15].

Carbohydrates provide the major source of energy in the diet and hence the type and amount of carbohydrates consumed is an important consideration for weight control. Carbohydrates in the form of cereals, grains, and sugar are quantitatively the most important source of dietary energy for most populations [31]. In Indonesia mean intake of total carbohydrates represents 57,4% of dietary energy. The consumption of energy sources of the Indonesian people mainly comes from starchy foods, which are generally in the form of refined carbohydrates such as rice, processed flours, and tubers [32]. This can be explained by the mechanism that a high-carbohydrate diet with a high proportion of refined carbohydrates will stimulate insulin secretion and thus inhibit fat oxidation and promote fat storage [33]. Refined carbohydrates generally have a high glycemic index. A cross-sectional study showed that the intake of a high Glycaemic Index (GI) diet causes increases in hunger and subsequently leads to an increased intake of food, thus potentially affecting energy balance and body composition [34]. Those findings show that with increased dietary GI or Glycaemic Load, more insulin is produced and more fat is stored, indicating that the type of carbohydrate may be related to the development of overweight and obesity [35]. A recent ecological study based on data obtained from 170 countries suggested that the consumption of meat contributes just as much as sugar to the growing burden of obesity. A meta-analysis study revealed that red and processed meat intake is directly associated with the risk of obesity, and higher BMI and waist circumference. Red meat and its products are categorized as high-energy-density foods, therefore, people who consume more red meat were more likely to be overweight, and even became obese [36].

These studies just assessed the food frequency intake on obesity, without considering the daily intake quantity. The limitation of this study was that it could not show the percentage of energy intake. An increase in food consumption will increase the percentage of energy intake. Obesity is often considered a result of either excessive food intake or insufficient physical activity. When energy intake exceeds energy expenditure, a state

of positive energy balance occurs, and the consequence is an increase in body mass, of which 60% to 80% is usually body fat [38]. Another limitation is that the analysis has not controlled for other variables simultaneously that may affect the relationship between consumption patterns and changes in BMI.

5 Conclusion

The consumption of carbohydrates and meat was associated with obesity status and changes in BMI of obese subjects during the pandemic. This study underscores the importance of paying more attention to the prevention and management of obesity in society. During the pandemic, weight gain was higher in the group that was already obese. An effective educational strategy is needed to provide information on good eating patterns in people who are already obese. In addition, it needs to be accompanied by intensifying health promotion related to physical activity.

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