Original Article

Central Asian Journal of Medical Sciences
CAJMS

Cent Asian J Med Sci. 2023 June;9(2) 3-11 https://doi.org/10.24079/CAJMS.2023.06.002

Association of Anthropometric Parameters and Severity of SARS-COV-2 Infection among Hospitalized Patients in a Tertiary care Center in Western Maharashtra – an Analytical Cross-Sectional Study

Mamta Kishor Shewte[1], Rajeshree Sushil Dhok[2*], Priyanka Narayanrao Pachange[3], Prachi Manohar Suryawanshi[4], Naila Nazir Sayed[5]

[1]Department of community Medicine, BJGMC Pune, India; [2]Department of community Medicine, B K L Walawalkar Rural Medical college, kasarwadi, India; [3]Department of community Medicine, BAV Medical college & Kamla Nehru Hospital, Pune, India; [4]Department of community Medicine, BJGMC Pune, India; [5]Department of community Medicine, BJGMC Pune India.

Submitted: Jan 16, 2023
Revised: Apr 20, 2023
Accepted: June 9, 2023

Corresponding Author
Dr. Rajeshree S Dhok,
(M. D. Community Medicine,
Assistant Professor)
Department of community Medicine, B K L Walawalkar Rural Medical college, Kasarwadi, Post-Sawarde, Taluka – Chiplun, Dist-Ratnagiri-415606, India.

Phone: 919561746269
E-mail: rajeshree.dhok@gmail.com
ORCID: https://orcid.org/0000-0002-5694-2588

Background: On March 11, 2020, the World Health Organization (WHO) confirmed COVID-19 as a pandemic. COVID-19 has infected more than 5.5 million people worldwide, resulting in more than 3,47,000 fatalities. Obese individuals may be more susceptible to infection with SARS-CoV-2. This study was conducted to assess the association between anthropometric parameters and the severity of SARS-CoV-2 infection.

Methodology: This analytical cross-sectional study was undertaken on COVID-19-positive patients admitted to COVID-dedicated wards at a tertiary care center in Pune. The data was collected using a convenient sampling method from 185 COVID-19-positive patients.

Result: Among those Positive for SARS-COV-2, 128 (69.19%) patients had mild COVID-19, and 57 (30.81%) patients were having severe COVID-19 disease. 36 patients (28.13%) with mild COVID-19 disease were average weight, 48 patients (37.50%) were overweight, and 42 patients (32.81%) were obese. Three (5.26%) of the 57 patients with severe COVID-19 disease were overweight, and 54 (94.74%) were obese. 19 (10.2%) patients had previously been diagnosed with hypertension, and 22 (11.8%) patients had both hypertension and diabetes.

Conclusion: Obesity in patients with COVID-19 was associated with severe diseases, particularly pneumonia. Patients having underlying medical illnesses like hypertension and diabetes were found to be at higher risk of severe COVID-19.

Keywords: Anthropometry, COVID-19, Severity of Illness, Hospitalization, Risk Factors.

Introduction

Coronavirus Disease 2019 (COVID-19), an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has developed into one of the century's worst pandemics. On March 11, 2020, the World Health Organization (WHO) confirmed COVID-19 as a pandemic [1]. COVID-19 had infected over 5.5 million people worldwide as of May 26, 2020, resulting in more than 347,000 fatalities [2]. COVID-19's COVID-19's clinical consequences range from asymptomatic to fatal, with various degrees of pneumonia [3]. Obesity is described as an abnormal build-up of body fat. It is commonly quantified by the body mass index (BMI), which is computed as body weight in kilograms divided by height in meters squared (m2) [4]. Additional anthropometric indicators, such as waist circumference and waist-hip ratio, are used to determine Obesity. Globally, the number of obese people is increasing. Adiposity has been linked to unfavorable health outcomes, such as coronary artery disease, stroke, insulin resistance, hypertension, and fatty liver disease [5]. Not only does fat accumulation contribute to mechanical-related health concerns, but the vast adipose tissue also secretes numerous adipokines that contribute to the inflammatory process [6].

Nevertheless, obesity impairs the immune system, particularly in vulnerable individuals with numerous comorbidities [7]. Obese individuals may be more susceptible to infection with SARS-CoV-2 [8]. COVID-19 has a pathogenesis characterized by an impaired immune response that results in injury to various organs, most notably the lower airways [9]. Obesity may be associated with worse outcomes and severity of COVID-19 due to the identical etiology. To our knowledge, there is a lack of evidence on the association between obesity and the severity of SARS-CoV-2 infection. With this context, this study was planned to assess the association between anthropometric parameters and the severity of SARS-CoV-2 infection. The study aimed to evaluate the association between anthropometric parameters, comorbidities present, and the severity of SARS-CoV-2 2 infection.

Materials and method:

Research design: This hospital based analytical cross-sectional study was undertaken on COVID-positive patients admitted to COVID-dedicated wards at B J Medical College and Hospital, a tertiary care center in pune during September and November 2021. At the B.J. Government Medical College, a dedicated COVID-19 building is available for patients diagnosed with COVID-19. There are 4(A&B), 5(A&B), 7(A&B), 8(A&B), and 9(&B) wards for COVID-19-positive patients, and wards 4C, 5C, 7C, 8C, and 9C for intensive care unit (ICU) patients having multiple complications. Wards 27 and 13 are reserved for suspected patients. We collected data from patients admitted to COVID 7B and 8B wards who met the study's inclusion criteria and consented to participate.

A total of 185 COVID-19-positive patients were interviewed during the study period. Patients were included if they were aged 15 years or older, admitted to 7B and 8B wards in the COVID-19 building, had confirmed SARS CoV-2 infection by detecting SARS-CoV-2 RNA in nasopharyngeal or throat swab specimens via real-time RT-PCR amplification and willing to consent to the study. Patients were anthropometrically measured with utmost care, not causing any discomfort to them. Patients with confirmed SARS-CoV-2 infection who refused to consent, patients aged less than 15 years, pregnant females, and patients who could not provide anthropometric measurements were excluded.

Sample size: The sample size was determined using the combined prevalence of abdominal Obesity (18.7) and overweight (11.3) in Maharashtra state as determined by the ICMR-INDIAB Phase I study. Together, they account for 30 % of the population [9]. 95% confidence level on both sides, 80% power, a ratio of controls to cases of 2; a hypothetical proportion of controls with exposure of 30, a hypothetical proportion of cases with exposure of 51.72, the least extreme odds ratio to be detected is 2.50, thus, cases-59 and controls-117 were calculated. The sample size was calculated as 176.

Data Collection: The data were collected by following the COVID-19 appropriate behavior. The complete personal protective equipment was worn at the time of data collection. The data were collected using a convenient sampling method from 185 COVID-19-positive patients with inclusion criteria admitted in 7B and 8B wards in the COVID-19 building. Oral consent was taken due to the high risk of spread of infection, and the case report form was filled out by history taking and collecting all information by pre-tested proforma, which included a predesigned and semi-structured questionnaire. At the time of admission, baseline demographic information like name, age, gender, address, religion, education, socioeconomic status, occupation, and

risk exposures like contact with a known COVID-19 case and COVID-19 vaccination status was recorded. Personal history of currently taking any medication, presence of comorbidities like hypertension, diabetes mellitus, chronic renal disease, chronic lung disease, any malignancy, chronic liver disease, and immune-compromised condition were collected. Body weight, height, waist circumference, and hip circumference were recorded according to standard operating procedures on the admission day. The severity of SARS-CoV-2 infection diagnosed by the physician was noted, and the waist-to-hip ratio was calculated. All the equipment used was appropriately sanitized after each use to avoid further spread of infection. Outcome data related to severity and outcome were collected at the time of discharge.

Operational definitions used in the study: Body mass index categorized into four groups: <18.5 kg/m2 (underweight), 18.5–24.9 kg/ m2 (average weight), 25.0–29.9 kg/ m2 (overweight), and ≥25.0 kg/ m2 (obese), following Asia-Pacific cutoff for underweight, overweight and Obesity [10]. The optimal waist circumference (W.C.) cutoff levels were 85 cm in males and 80 cm in females. The optimal waist-hip ratio (WHR) cutoff values are (0.90) for Asian men and (0.79–0.85) for Asian women [11,12].

Severity status: Participants' severity of SARS-CoV-2 infection was scored using an ordinal scale developed by a unique World Health Organization (WHO) committee as SARS-CoV-2 infection" "mild disease" with scores of three (no oxygen therapy) or four (oxygen by mask or nasal prongs), and "severe disease" for patients with scores of five (non-invasive ventilation or high-flow oxygen), six (intubation and mechanical ventilation), or seven (ventilation plus additional organ support)[13].

Statistical Analysis: The data was entered in Microsoft Excel 2007 and analyzed using SPSS-v.16. All the continuous variables were summarized using mean and S.D., while the categorical variables were summarized as percentages and proportions. To show the association between anthropometric parameters and COVID-19 severity, an odds ratio with 95% CI was calculated. The logistic regression models were designed with dependent variables such as COVID-19 disease severity. These outcomes were predicted based on various factors, including an individual's gender, age, level of education, place of residence, socioeconomic status, Obesity, waist circumference, waist-to-hip ratio, and whether or not they had received the COVID-19 vaccination. These factors were used as variables in the model to help predict the outcome, i.e., COVID-19 severity. Fisher's exact test was applied to show the significant difference between the two categorical variables. P-value <0.05 was considered to be statistically significant.

Ethical consideration:

Approval from the Institutional Ethics Committee was obtained prior to the start of the study (No.0721243-243).

Results:

The study enrolled 185 patients diagnosed with COVID-19 between September 21 and November 21 (Figure 1), with 128 (69.19%) patients having mild COVID-19 disease and 57 (30.81%) patients having severe COVID-19 disease.

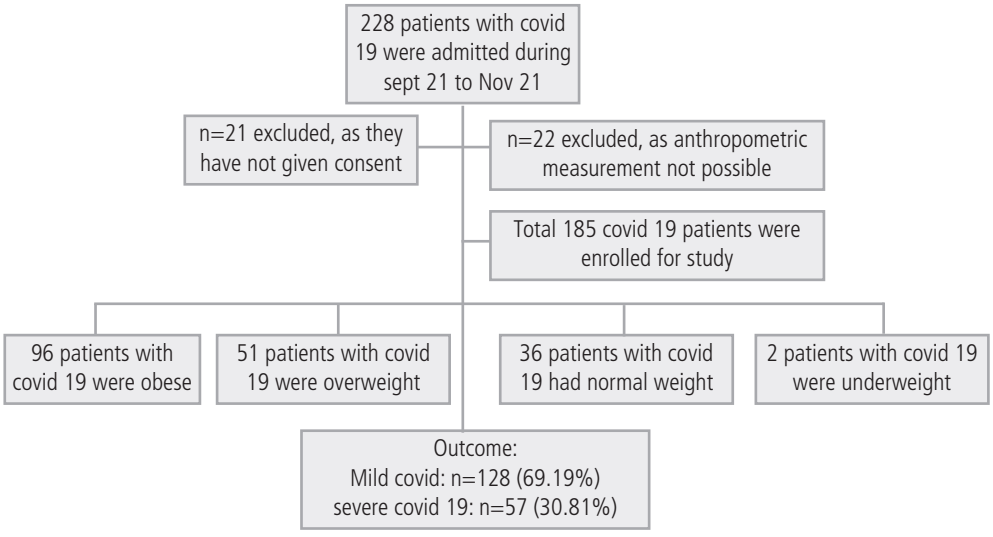

Figure 1: Study participants and their outcome

Out of the 185 study participants, 90 (48.6%) were males, while 95 (51.3%) were females. The mean age of patients with mild COVID-19 disease is 41 ± 20.5 years, and of patients with severe COVID-19 disease is 50 ± 25 years. In this study, 118 (63.7%) patients were urban residents, 109 (59%) were graduates, and 42 (26%) were classified as upper middle class. A maximum of 77 (41.6%) had received a single dose of COVID-19 vaccine, whereas 66 (35.6%) had not received a single dose. Males were disproportionately affected by severe COVID-19, comprising 68.42% of severe cases compared to 39.84% in the mild group, a statistically significant difference with a P-value of 0.0003. Similarly, there is a statistically significant association between age group and the severity of COVID-19. The observed distributions of Mild and Severe COVID-19 cases across the age groups are different than expected under independence. Education level significantly influences the severity of COVID-19, with specific educational backgrounds showing varied risks. On the other hand, factors like place of residence and socioeconomic status did not show a statistically significant impact on the severity of the disease, with P-values of 0.22 and 0.20, respectively. Interestingly, while a more significant proportion of individuals in the severe COVID-19 group had received their first vaccine dose compared to the mild group, the difference is not statistically significant, with a P-value of 0.14. Only 36 (19.4%) of patients reported recent contact with SARS-CoV-2-positive individuals (see Table 1).

Table 1. Basic characteristics of patients with mild and severe COVID-19

Characteristics	Mild COVID 19 (n = 128)		Severe COVID 19 (n = 57)		P-value
	No.	%	No.	%	
Gender					
Male	51	39.84	39	68.42	0.0003*
Female	77	60.16	18	31.58	
Age in years					
15 - 35	58	45.31	6	10.53	0.0001*
36 - 45	24	18.75	14	24.56	
46 - 55	14	10.94	17	29.82	
56 - 65	18	14.06	17	29.82	
66 and above	14	10.94	3	5.26	
Residence					
Rural	50	39.06	17	29.82	0.22*
Urban	78	60.94	40	70.18	
Education					
Illiterate	12	9.38	3	5.26	0.0001*
Middle school	9	7.03	6	10.53	
Higher School	18	14.06	14	24.56	
Graduation to Post-graduation	89	69.53	34	59.65	
Socio economic status					
Upper	14	10.94	6	10.53	0.20*
Upper middle	32	25.00	10	17.54	
Lower middle	38	29.69	10	17.54	
Upper lower	14	10.94	18	31.58	
Lower	30	23.44	13	22.81	
COVID vaccination status					
1st dose	47	36.72	30	52.63	0.14*
2nd dose	31	24.22	11	19.30	
Not vaccinated	50	39.06	16	28.07	

In the present study, 36 (19.4%) patients with mild COVID-19 had an average BMI between 18.5- 24.9, 51 (27.5%) patients were overweight with a BMI between 25.0- 29.9, and 96 (51.8%) patients were obese with a BMI greater than 25. (See Table 2). Out of 128 patients diagnosed with mild COVID-19, thirty-six patients (28.13%) had average weight, 48 patients (37.50%) were overweight, and 42 patients (32.81%) were obese. Among 57 patients with severe COVID-19, three (5.26%) were overweight, whereas 54 (94.74%) were obese. It is observed that the severity of COVID-19 disease was associated with body mass index in this study. Thirty (52.63%) of the 39 male patients with severe COVID-19 disease had a waist circumference greater than 85 cm and a waist-hip ratio greater than 0.9. Similarly, 12 (66.6%) of 18 female patients with severe infection had a waist circumference greater than 80 cm and a waist-hip ratio greater than 0.85. The study findings suggest an association between the severity of COVID-19 infection and waist circumference as well as waist-hip ratio, as seen in Table 2.

Table 2. Anthropometric parameters of patients with mild and severe COVID-19

Anthropometric parameters	Mild COVID-19 (n = 128)		Severe COVID-19 (n = 57)		Odds Ratio	95% CI	P-value
	No.	%	No.	%			
Body Mass Index							
Underweight# (n=2)	2	1.56	0	0	NA		-
Normal weight# (n=37)	36	28.13	1	1.75	1		-
Overweight# (n=51)	48	37.5	2	3.51	1.5	0.13-17.1	<0.05
Obesity# (n=96)	42	32.81	54	94.74	46	6.09 – 351	<0.001
Waist Circumference							
Males							
< 85 cm	46	35.94	9	15.79	1		
> 85 cm	5	3.91	30	52.63	28.9	9.36 – 100	<0.001
Females							
< 80 cm	72	56.3	6	10.53	1		
> 80 cm	5	3.9	12	21.05	28.8	7.5 - 109.4	<0.001
Waist/Hip ratio							
Males							
< 0.90 cm	46	35.94	9	15.79	1		
> 0.90 cm	5	3.91	30	52.63	30.9	9.36 - 100.4	<0.001
Females							
< 0.85 cm	72	56.3	6	10.53	1		
> 0.85cm	5	3.9	12	21.05	28.8	7.5 - 109.4	<0.001

Body mass index categorized according to Asia-Pacific cut-off for underweight, normal, overweight and obesity [10]

Table 3 describes the comparison of mean Body Mass Index (BMI) and waist circumference between patients with mild and severe COVID-19. The comparisons are made based on statistical analysis (t-tests), and the p-values are reported to indicate the significance level of the differences observed.

1. Body Mass Index (BMI): Patients with severe COVID-19 had a significantly higher mean BMI (32.59 kg/m^2) compared to those with mild COVID-19 (27.45 kg/m^2). The p-value is 0.0025, which is less than the typical cutoff 0.05, indicating that the difference is statistically significant. This suggests that a higher BMI may be associated with a more severe form of COVID-19.

2. Male Waist Circumference: Among males, those with severe COVID-19 had a significantly larger mean waist circumference

(88.9 cm) compared to those with mild COVID-19 (79.1 cm). The p-value is 0.04, which is also less than 0.05, indicating that this difference is statistically significant.

3. Female Waist Circumference: Among females, those with severe COVID-19 had a significantly larger mean waist circumference (84.2 cm) compared to those with mild COVID-19 (71.3 cm). The p-value is 0.026, which is also less than 0.05, indicating that this difference is statistically significant.

Table 3. Comparison of BMI and waist circumference between the mild and severe COVID-19 cases

Variables	Mild COVID-19 (n = 128) Mean ± SD.	Severe COVID-19 (n = 57) Mean ± SD.	P-value (t-test)
Mean BMI (Kg/m2)	27.45 ±10.2	32.59 ± 11.3	0.0025
Male Mean Waist circumference (cm)	79.1 ± 21.3	88.9 ± 22.4	0.04
Female Mean Waist circumference (cm)	71.3 ± 22.7	84.2 ± 22.1	0.026

Table 4 shows the distribution of COVID-19 patients according to severity and comorbidities. In terms of comorbidities, 20 (10.8%) patients had previously been diagnosed with hypertension, and 22 (11.8%) patients had both hypertension and diabetes. Severe COVID-19 disease was found in a more significant proportion of patients with hypertension and diabetes than mild COVID-19 disease. Only one male patient had chronic renal failure and was classified as having a severe case of COVID-19. The presence of hypertension and diabetes mellitus showed a statistically significant association with the severity of COVID-19 (P-value < 0.05).

Table 4. Distribution of COVID-19 patients as per severity and co-morbidities present

Co-morbidities *	Mild COVID-19 (n = 128)		Severe COVID-19 (n = 57)		P-Value#
	No.	%	No.	%	
Hypertension	7	5.5%	13	22.8%	0.001
Diabetes mellitus	4	3.1%	18	31.6%	0.001
Chronic renal disease	0	0.0%	1	1.8%	0.06

* Presence of co-morbidities is not mutually exclusive, # Fisher exact test was used to calculate P-value

Discussion

Of 185 study participants, 69.19% of patients had mild COVID-19 disease, and 30.81% had severe COVID-19 disease. Most patients were in their middle age. Amongst the study participants, a quarter of the patients had severe COVID-19 diseases, and more than half of the patients had mild COVID-19 diseases. Even after accounting for age, sex, diabetes, and hypertension, a higher BMI (obesity) was significantly associated with severe pneumonia. According to the current investigation, higher BMI levels were found to be associated with an increased severity of COVID-19 disease. Additionally, COVID-19 patients who were obese (BMI > 25 kg/m2) had a higher risk of developing severe pneumonia than COVID-19 patients who had a BMI in the normal range. Our investigation established the dosage response association between increased BMI and severity of COVID-19 with a focus on severe pneumonia, much like a prior study [14]. Pathogenesis, such as immunological dysregulation, comorbidities, and a compromised respiratory system, has been linked to severe COVID-19 and Obesity [15]. Increased inflammation and a compromised host immune response are associated with adiposity. Interleukin (IL)-1, IL-6, IL-8, IL-10, tumor necrosis factor-, C-reactive protein, and resin can be secreted by macrophages when fat cells, particularly visceral adipocytes, are present. During the COVID-19 pandemic, the overproduction of these pro-inflammatory cytokines, known as a cytokine storm, also contributes to multiorgan failure and lung injury [16, 17]. It is possible that persistent inflammation in obese individuals is linked to more severe inflammation and contributes to worsened COVID-19 outcomes. Conversely, obese

people have less ability to produce an immune response against microorganisms. Therefore, SARS-CoV-2 and other microbial contaminants may spread and increase more quickly in this population. The presence of hypertension and diabetes mellitus showed a statistically significant association with the severity of COVID-19 in the current study. Some studies suggest that patients may be more likely to develop severe COVID-19 if they have underlying medical conditions (such as extreme heart conditions, diabetes, chronic kidney disease, etc.) [18, 19]. Development of diabetes mellitus, hypertension, and cardiovascular disease are all increased by obesity [20]. In conclusion, the present study supports the hypothesis that anthropometric parameters, particularly Obesity, play a significant role in determining the severity of COVID-19 outcomes. Ruan et al. (2022) [21] showed that anthropometric parameters could predict disease severity in COVID-19 patients, while Sanchis-Gomar et al. (2021) [22] emphasized the detrimental impact of obesity on COVID-19 outcomes due to the collision of two epidemics. Petersen et al. (2021) [23] conducted a systematic review and meta-analysis, highlighting the influence of body mass index (BMI) on COVID-19 severity. Hajifathalian et al. (2020) [24] found that obesity was associated with worse outcomes in COVID-19, based on data from New York City. Finally, Korakas et al. (2020) [25] suggested that the immune and metabolic derangements in Obesity might be the link to adverse clinical outcomes in COVID-19. These studies collectively emphasize the importance of considering anthropometric parameters as significant factors in COVID-19 severity and the need for further research in this area.

Future Direction: Given the strong association observed in this study between Obesity and severe COVID-19, future research should continue to explore the underlying mechanisms of this relationship. The role of obesity-related comorbidities such as metabolic syndrome, cardiovascular disease, and diabetes and their potential impact on disease severity should be further investigated. Research could also delve into how obesity may affect the immune response to SARS-CoV-2 and whether specific interventions targeted at weight reduction could prove beneficial in mitigating the risk and severity of COVID-19 in obese individuals. Additionally, understanding the role of inflammation in obese individuals, who often present a chronic low-grade inflammatory state, may shed light on the mechanisms that lead to severe COVID-19 manifestations in these patients. Furthermore, it would be beneficial to understand how Obesity impacts the efficacy of COVID-19 treatments and vaccines. There is a need for studies that specifically examine the therapeutic response and vaccine-induced immunity in the obese population.

Additionally, it would be essential to consider social and behavioral aspects that intersect with obesity and COVID-19. Research could assess the impact of socioeconomic status, access to healthcare, diet, physical activity, and other lifestyle factors that contribute to obesity and influence COVID-19 outcomes. These insights could guide public health strategies for managing the pandemic and reducing health disparities.

Strengths of the study: The study is conducted in a tertiary health care setting, and patients from almost all sections of the population are included in the study, thus contributing to a fair representative sample. All the anthropometric measurements were recorded employing standard techniques to ensure accurate results.

Limitation: Although the research did not include the treatment plans, it was assumed that all patients received the recommended and standard care. Due to the patients' restricted access during hospitalization and avoiding the risk of spreading infection, we could not examine the body composition of the study participants.

Conclusion

Obesity in patients with COVID-19 is associated with the severity of disease, particularly severe pneumonia. Patients having underlying medical illnesses (e.g., major heart diseases, diabetes, chronic kidney disease, etc.) are at higher risk of severe COVID-19. Further studies in body composition are warranted to explore the links between adiposity and the severity of COVID-19.

Acknowledgements

We are grateful to our patients for consenting to participate and cooperate during the data collection, even in their illness.

Conflict of interest

None declared.

References

1. Center for Systems Science and Engineering (CSSE) at Johns Hopkins University. Coronavirus COVID-19 global cases. Published 2023. Accessed March 20, 2023. https://coronavirus.jhu.edu/map.html.
2. World Health Organization. Coronavirus disease (COVID-19) situation report-124. Published May 23, 2020. Accessed March 20, 2023. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports.
3. Goyal P, Choi JJ, Pinheiro LC, et al. Clinical characteristics of COVID-19 in New York City. *N Engl J Med.* 2020;382(24):2372-2374. doi:10.1056/nejmc2010419
4. Keys A, Fidanza F, Karvonen MJ, Kimura N, Taylor HL. Indices of relative weight and Obesity. *J Chron Dis.* 1972;25(6):329-43.
5. Ghoorah K, Campbell P, Kent A, et al. Obesity and Cardiovascular Outcomes: A Review. Eur Heart J Acute Cardiovasc Care. 2016;5(1):77-85. doi:10.1177/2048872614523349
6. Nimptsch K, Konigorski S, Pischon T. Diagnosis of Obesity and Use of Obesity Biomarkers in Science and Clinical Medicine. *Metabolism.* 2019;92:61-70. doi:10.1016/j.metabol.2018.12.006
7. Huttunen R, Syrjänen J. Obesity and the risk and outcome of infection. *Int J Obes (Lond).* 2013;37(3):333-340. doi:10.1038/ijo.2012.62
8. Misumi I, Starmer J, Uchimura T, et al. Obesity expands a distinct population of T cells in adipose tissue and increases vulnerability to infection. *Cell Rep.* 2019;27:514-524. doi:10.1016/j.celrep.2019.03.030
9. Pradeepa R, Anjana RM, Joshi SR, et al. Prevalence of generalized and abdominal Obesity in urban and rural India. *Indian J Med Res.* 2015;142(August):139-150. doi:10.4103/0971-5916.164234
10. Wong CK, Lam CW, Wu AK, et al. Plasma Inflammatory Cytokines and Chemokines in Severe Acute Respiratory Syndrome. *Clin Exp Immunol.* 2004;136(1):95-103. doi:10.1111/j.1365-2249.2004.02415.x
11. World Health Organization, International Obesity Task Force (IOTF), International Association for the Study of Obesity (IASO). The Asia-Pacific perspective: Redefining Obesity and its treatment. Published 2000. Accessed March 20, 2023. https://apps.who.int/iris/handle/10665/206936
12. Integrated Disease Surveillance Project (IDSP) NCD Risk Factor Surveillance. Training manual for field workers and field supervisors. Published 2005. Accessed March 20, 2023. https://main.icmr.nic.in/sites/default/files/reports/Phase-1_States_of_India.pdf.
13. World Health Organization. WHO R&D Blueprint Novel Coronavirus COVID-19 Therapeutic Trial Synopsis. Published 2020. Accessed March 20, 2023. https://www.who.int/blueprint/priority-diseases/key-action/COVID-19_Treatment_Trial_Design_Master_Protocol_synopsis_Final_18022020.
14. Pei-Fang Wei. Diagnosis and Treatment Protocol for Novel Coronavirus Pneumonia. *Chin Med J (Engl).* 2020;133(9):1087-1095. doi:10.1097/cm9.0000000000000819
15. World Health Organization Western Pacific Region, International Association for the Study of Obesity, International Obesity Task Force. Appropriate body mass index for Asian populations and its implications for policy and intervention strategies. *Lancet.* 2004;363(9403):157-163. doi.org/10.1016/s0140-6736(03)15268-3
16. Chen C, Lu FC; Department of Disease Control Ministry of Health, PR China. The guidelines for prevention and control of overweight and obesity in Chinese adults. *Biomed Environ Sci.* 2004;17 Suppl:1-36. https://pubmed.ncbi.nlm.nih.gov/15807475/
17. Wang Y, Wang L, Qu W. New national data show an alarming increase in Obesity and noncommunicable chronic diseases in China. *Eur J Clin Nutr.* 2017;71(1):149-150. doi:10.1038/ejcn.2016.171
18. Marie NG, Fleming T, Robinson M, et al. Global, regional, and national prevalence of overweight and Obesity in children and adults during 1980–2013. *Lancet.* 2014;384:766-781. doi:10.1016/s0140-6736(14)60460-8
19. Dietz W, Santosburgoa C. Obesity and its implications for COVID-19 mortality. *Obesity (Silver Spring).* 2020;28:1005-1005. doi:10.1002/oby.22818
20. Hales CM, Carroll MD, Fryar CD, Ogden CL. Prevalence of Obesity Among Adults and Youth: United States, 2015-

2016. *NCHS Data Brief.* 2017;288:1-8. https://www.cdc.gov/nchs/data/databriefs/db288.pdf

21. Ruan Y, Wei L, Liu J, et al. The role of anthropometric parameters in predicting disease severity in COVID-19 patients. *Clin. Infect. Dis.* 2022;25(6):580-589.
22. Sanchis-Gomar F, Lavie CJ, Mehra MR, et al. Obesity and outcomes in COVID-19: When an epidemic and pandemic collide. *Mayo Clin Proc.* 2020;95(7):1445-1453. doi:10.1016/j.mayocp.2020.05.006
23. Petersen A, Bressem K, Albrecht J, et al. The impact of body mass index on the severity of COVID-19: A systematic review and meta-analysis. *Obes. Med.* 2021;24:100317.
24. Hajifathalian K, Kumar S, Newberry C, et al. Obesity is associated with worse outcomes in COVID-19: Analysis of early data from New York City. *Obesity.* 2020;28(9):1606-1612. doi:10.1002/oby.22923
25. Korakas E, Ikonomidis I, Kousathana F, et al. Obesity and COVID-19: Immune and metabolic derangement as a possible link to adverse clinical outcomes. *Am J Physiol Endocrinol and Metab.* 2020;319(1):E105-E109. doi:10.1152/ajpendo.00198.2020