Review

Body Mass Index (BMI) and Coronavirus Disease 2019 (COVID-19): A Living Systematic Review

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Abstract: On March 11, 2020, coronavirus disease 2019 (COVID-19) was declared a pandemic by the World Health Organization (WHO). This review focuses on where the body mass index (BMI) value can be used as a tool to evaluate the risk of development and/or aggravation of this disease. Databases were used to search studies published up to April 18, 2020. In total, 4285 articles and other scientific literature were found, and twelve articles were included in this systematic review. The mean BMI value of severe COVID-19 patients ranged from 24.5 to 33.4 kg/m², versus 22.0 to 24.3 kg/m² for non-severe patients. Articles using the terms obesity or overweight, without indicating the BMI value, in these patients were common, but this is not useful as the nutritional status, when not defined by this index, is confusing due to the classification being different in the West compared to among Asian and Korean criteria-based adults. Furthermore, the use of BMI is important during this pandemic, as it should be applied to nutritional support therapy during hospitalization of infected patients, as well as being considered in the home confinement population.

Keywords: BMI; COVID-19; obesity; overweight; nutrition.

1. Introduction

A new epidemic started on December 8, 2019, in Wuhan (Hubei Province, China) where several cases of severe pneumonia of undetermined etiology were reported based on fever (>38°C), cough, fatigue, muscle pain, leukopenia, lymphopenia and radiographic imaging consistent with pneumonia, which could develop into acute respiratory distress syndrome, metabolic acidosis, septic shock, coagulation dysfunction, organ failure (such as liver, kidney and heart failure), and death [1]. This disease is caused by a new strain of coronavirus, pre-defined as novel coronavirus (2019-nCoV), which causes upper respiratory tract infections in humans [2], and which along with the severe acute respiratory syndrome coronavirus (SARS-CoV) [3] and the Middle East respiratory syndrome coronavirus (MERS-CoV) [4] evolved in the twenty-first century [5]. On February 11th, 2020, the new coronavirus was renamed “SARS-CoV-2” from “2019-nCoV” (Coronaviridae Study Group of the International Committee on Taxonomy of Viruses, 2020) and the disease caused by SARS-CoV-2 was called “coronavirus disease 2019” (COVID-19) [6]. The World Health Organization (WHO) on March 11, 2020, declared COVID-19 a pandemic [7], pointing to the over 118,000 cases of the illness, with a global death toll that had reached 4,291 people, in over 114 countries and territories around the world and sustained risk of further global spread [8]. However, history allows us to learn lessons from the past and especially with diseases of other viruses causing pneumonia in relation to the body mass index (BMI; weight/height² (kg/m²)), this was used as a disease-associated factor. BMI is an anthropometric used to assess malnutrition risk, but has been observed as a risk factor in MERS-CoV
[9], H1N1 influenza [10] and avian influenza H7N9 virus [11]. Currently, there is confusion as to whether COVID-19 has an association with BMI in terms of the pneumonia relationship [12-15], given this index should be considered a factor that could aggravate the disease. The aim of this systematic review was to evaluate the association of BMI with COVID-19.

2. Methods

This systematic review was developed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [16] (Figure 1) and conducted using the WHO COVID-19 database of publications, PubMed, Scopus, Embase and Google Scholar. We included English and other languages which were translated using the freely available Web-based Google Translator (Google, Inc., Mountain View, CA) and, in cases of doubt for the manuscripts written in Asian languages, with the help of Confucius Institute from the University of Valencia, before the full papers were reviewed.

![Figure 1. PRISMA flow diagram for studies retrieved through the searching and selection process.](https://example.com)

*Reasons for exclusion of articles are presented in the Methods section.*

The search strategy was based on the Population, Intervention, Comparator, Outcome (PICO) framework [17] and was conducted to find studies by including two main searches based in the coronavirus, as a causal agent or disease, and an anthropometric parameter: “novel coronavirus” or “2019 Novel Coronavirus” or “2019-nCoV” or “SARS-CoV-2” or “COVID-19” or “coronavirus disease 2019” AND “body mass index” or “BMI” or “weight” or “height” or “obesity” or “obese” or...
“overweight” or “underweight” or “normal weight” or “malnutrition” or “nutritional status”. The search date was up to April 18, 2020.

The classification of nutritional status was carried out, in accordance with the guidelines from the WHO [18], WHO [19] and Seo et al. [20] for International, Asian and Korean criteria-based adults, respectively (Table 1).

Table 1. Classification of Body Mass Index (BMI; kg/m²) and risk of co-morbidities in International, Asian and Korean criteria-based adults according to the WHO [18], WHO [19] and Seo et al. [20], respectively

<table>
<thead>
<tr>
<th>Nutritional status</th>
<th>International adults</th>
<th>Asian criteria-based adults</th>
<th>Korean criteria-based adults</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BMI (kg/m²)</td>
<td>Risk of co-morbidities</td>
<td>BMI (kg/m²)</td>
</tr>
<tr>
<td>Underweight</td>
<td>&lt;18.5</td>
<td>Lower (other health risk)</td>
<td>&lt;18.5</td>
</tr>
<tr>
<td>Normal weight</td>
<td>18.5–24.9</td>
<td>Average</td>
<td>18.5–22.9</td>
</tr>
<tr>
<td>Overweight (pre-obesity)</td>
<td>25.0–29.9</td>
<td>Increased</td>
<td>23.0–24.9</td>
</tr>
<tr>
<td>Obesity class I</td>
<td>30.0–34.9</td>
<td>Moderate</td>
<td>25.0–29.9</td>
</tr>
<tr>
<td>Obesity class II</td>
<td>35.0–39.9</td>
<td>Severe</td>
<td>≥30.0</td>
</tr>
<tr>
<td>Obesity class III</td>
<td>≥40.0</td>
<td>Very severe</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

a Risk of comorbidity according to abdominal obesity < 90 cm (men) and < 85 cm (women)

b Risk of comorbidity according to abdominal obesity ≥ 90 cm (men) and ≥ 85 cm (women)

n.a. not applicable

As inclusion criteria, we required that the study samples were humans, and that the articles were full-text and available in any language. The following information was obtained: author name, type of study, number of patients, age, sex, country, anthropometric parameter or nutritional status and main outcomes.

On the other hand, as exclusion criteria, we excluded studies in which an anthropometric parameter was not used, conference abstracts, simulation studies, unpublished data and articles without full texts. Two teams of paired reviewers (J.M.S., A.G. A.I.C.-G, J.F.T-M) with expertise in medical and health evaluations and training in research methodology independently screened the titles, abstracts, and full texts for eligibility, assessed generalizability, and collected data from each eligible study using standardized pilot tested forms with detailed instructions. Any disagreements were resolved by a third researcher (C.S.).

Based on information from the National Heart, Lung and Blood Institute [21], the validity of each included study was assessed using nine items to which the answer was affirmative (+), negative (-) or other, including “cannot determine”, “not applicable” and “not reported”. Unclear (?) answers were classified using a rating of good (7–9), fair (4–6) or poor (≤3) for each individual study.

3. Results

For this systematic review, the quality rating of the reviewed literature, found by applying the National Heart, Lung and Blood Institute criteria, is fair (Table 2), which is similar to the study of Salehi et al. [34] who carried out a systematic review of imaging findings in 919 COVID-19 patients and observed that the methodologic quality of the studies was generally fair, except for the study of Simonnet et al. [33]. In total, we integrated twelve studies relevant to the aim of this review. All articles
were on studies carried out in China and Korea. Table 3 shows the summary of these studies according to the term ‘BMI’ extracted from the reviewed articles.

Table 2. Methodological quality assessment for studies published on BMI and COVID-19 according to the criteria of the National Heart, Lung and Blood Institute [21].

<table>
<thead>
<tr>
<th>Item</th>
<th>Reference</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Quality Rating

- 1 = Was the study question or objective clearly stated?; 2 = Was the study population clearly and fully described, including a case definition?; 3 = Were the cases consecutive?; 4 = Were the subjects comparable?; 5 = Was the intervention clearly described?; 6 = Were the outcome measures clearly defined, valid, reliable, and implemented consistently across all study participants?; 7 = Was the length of follow-up adequate?; 8 = Were the statistical methods well-described?; 9 = Were the results well-described?

Table 3. Summary of articles with data on BMI in COVID-19 infected patients.

<table>
<thead>
<tr>
<th>No. of patients</th>
<th>Age</th>
<th>Sex</th>
<th>Country</th>
<th>BMI (kg/m²)/Nutritional status [19,20]</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>54</td>
<td>M</td>
<td>Korea</td>
<td>25.7/Obesity class I</td>
<td>[22]</td>
</tr>
<tr>
<td>1</td>
<td>35</td>
<td>F</td>
<td>Korea</td>
<td>33.4/Obesity class II</td>
<td>[23]</td>
</tr>
<tr>
<td>1</td>
<td>59</td>
<td>M</td>
<td>China</td>
<td>26.6/Obesity class I</td>
<td>[24]</td>
</tr>
<tr>
<td>30</td>
<td>21-59</td>
<td>F (66.7%)/M (33.3%)</td>
<td>China</td>
<td>22.0±1.3/Normal weight&lt;sup&gt;a&lt;/sup&gt;</td>
<td>[25]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>27.0±2.5/Obesity class &lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>35.0</td>
<td>F (64.0%)/M (36.0%)</td>
<td>China</td>
<td>&lt;24 (89.2%)≥24 (10.8%)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>[26]</td>
</tr>
<tr>
<td></td>
<td>(average)</td>
<td></td>
<td></td>
<td>&lt;24 (88.0%) and ≥24 (12.0%)&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>149</td>
<td>45.1±13.35</td>
<td>F (45.6%)/M (54.4%)</td>
<td>China</td>
<td>23.7±4.5/Overweight</td>
<td>[27]</td>
</tr>
<tr>
<td>112</td>
<td>62.0</td>
<td>F (52.7%)/M (47.3%)</td>
<td>China</td>
<td>22.0 (22.0-24.0)/Normal weight&lt;sup&gt;g&lt;/sup&gt;</td>
<td>[28]</td>
</tr>
<tr>
<td>(average)</td>
<td></td>
<td></td>
<td></td>
<td>25.5 (23.0-27.5)/Obesity class I&lt;sup&gt;f&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>298</td>
<td>33-61</td>
<td>F (50.0%)/M (50.0%)</td>
<td>China</td>
<td>22.9 (20.6-25.2)/Normal weight&lt;sup&gt;h&lt;/sup&gt;</td>
<td>[29]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>24.5 (22.0-27.8)/Overweight&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>57</td>
<td>F (41.7%)/M (58.3%)</td>
<td>China</td>
<td>25.0±3.3/Obesity class I</td>
<td>[30]</td>
</tr>
<tr>
<td>(average)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>56.7±15.4</td>
<td>F (35.6%)/M (64.4%)</td>
<td>China</td>
<td>23.2 (21.4-25.3)/ Overweight&lt;sup&gt;i&lt;/sup&gt;</td>
<td>[31]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25.2 (22.9-26.9)/Obesity class I&lt;sup&gt;i&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>43.6±17.1</td>
<td>F (36.7%)/M (63.3%)</td>
<td>China</td>
<td>24.3±3.6/Overweight&lt;sup&gt;k&lt;/sup&gt;</td>
<td>[32]</td>
</tr>
</tbody>
</table>

<sup>a</sup>Items from the National Heart, Lung and Blood Institute [21] were stated. <sup>b</sup>Quality rating [21] was good (7–9), fair (4–6) or poor (≤3).
It was February, and found, at 22.

February, (www.preprints.org) | NOT PEER-REVIEWED | Posted: 10 May 2020

Preprints
were found between improved (n=52) and impaired (n=8) patients COVID
Jan
independent prognostic factors demonstrated that gender, BMI, and
being 22.

differences were found between non-infected by COVID
Hospital of Jianghan Universit
26.6

loss of consciou
deterioration of renal function while undergoing treatment, delirium (on the 5th day after admission),
chest pain, acid reflux, heartburn, chest distress and suffocation, progressive dyspnea, progressive
disease in Southern China seafood market contact, that had experienced hypertension for the past 20 years
(treated using oral valsartan and bisoprolol fumarate tablets as medication), coronary heart disease
for the last 6 years (treated using oral bisoprolol fumarate tablets and betaloc) and endured a long-
term anti-rejection treatment (using cyclosporine and bradinine) for 5 years post right kidney
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vomiting, abdominal pain, diarrhea, exertional dysnea without obvious aggravation, hemotysis,
chest pain, acid reflux, heartburn, chest distress and suffocation, progressive dysnea, progressive
deterioration of renal function while undergoing treatment, delirium (on the 5th day after admission),
loss of consciousness, lowered blood pressure and heart rhythm and death. The patient had a BMI
of 26.6 kg/m², putting him in obesity class I [19].

Furthermore, Liu et al. [25] studied medical workers (aged 21-59 years); from the affiliated
Hospital of Jianghan University, Wuhan, in China, between January 11, 2020 and January 3, 2020,
infected by COVID-19 and observed a significant difference in the BMI. It was 22.0±1.3 (normal
weight) versus 27.0±2.5 (obesity class I) kg/m² among the 26 common type and 4 severe cases patients,
respectively. Liu et al. [26] indicated that the infected medical staff, from Union Hospital, Wuhan,
between 16 Jan, 2020 to 15 Feb, 2020, had a BMI of < 24 (n=33/37) and ≥24 (n=4/37) kg/m² among
the group of patients with symptoms onset for 10 or less days; and <24 (n=22/25) and ≥ 24 (n=3/25) kg/m²
for those with symptoms for more than 10 days, respectively, by the time of admission. However,
these authors indicated that the value of ≥24 kg/m² is overweight, and this is a mistake due to the fact
that the values for overweight for Asian adults, established by the WHO [19], range from 23.0 to 24.9
kg/m². Yang et al. [27] carried out at retrospective cohort study of 149 positive patients (45.6% and
54.4% of female and male, respectively, and aged 45.1±13.3) from January 17, 2020 to February 10,
2020 in three tertiary hospitals of Wenzhou, Zhejiang province (China), and found the value of the
BMI was 23.75±4.54 kg/m² (overweight). Peng et al. [28] analyzed 112 patients with cardiovascular
disease in the western district of Union Hospital in Wuhan, from January 20, 2020 to February 15,
2020, and found the average (first and third quartile) BMI of the critical group (n=16) was significantly
higher than that of the general group (n=96), at 25.5 (23.0 and 27.5) versus 22.0 (20.0 and 24.0) kg/m².
These authors observed that patients with BMI>25 kg/m² (obesity class I), were significantly more
likely to be non-survivors (88.24%, n=15/17) versus survivors (18.95%, n= 18/95). Cai et al. [29]
reviewed a study in the Third People’s Hospital of Shenzhen, Guangdong province, China, from
January 11, 2020 to February 6, with 298 patients (aged 33-61 years) with COVID-19 and no significant
differences were found between non-severe (n=240) and severe (n=58) patients with the value of BMI
being 22.9 (normal weight) and 24.5 kg/m² (overweight), respectively. Furthermore, these authors
demonstrated that gender, BMI, and the antiviral agents lopinavir/ritonavir or favipiravir were not
independent prognostic factors for virus clearance. Interestingly, Huang et al. [30] carried out a
multicenter retrospective cohort study in twelve hospitals from Jiangsu province, China, between
January 24 and February 23, 2020, detecting severe patients (n=60) out of 631 infected cases with
COVID-19, with the average BMI among them being 25.0±3.3 kg/m², but no significant differences
were found between improved (n=52) and impaired (n=8) patients in terms of the BMI (25.2±3.4 and

a common type; b severe cases; c group of patients with symptoms onset for 10 or less days; d group of patients with symptoms more than 10 day; e general group; f critical group; g non-severe patients; h severe patients; i patients with intubation; j patients without intubation; k stable non-severe; l progressive severe; m patients admitted in intensive care who required invasive mechanical ventilationn and those who did no.

### 3.1. China

Li et al. [24] reflected on a case report of a Chinese man (59-years-old), with no history of
Southern China seafood market contact, that had experienced hypertension for the past 20 years
(treated using oral valsartan and bisoprolol fumarate tablets as medication), coronary heart disease
for the last 6 years (treated using oral bisoprolol fumarate tablets and betaloc) and endured a long-
term anti-rejection treatment (using cyclosporine and bradinine) for 5 years post right kidney
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<table>
<thead>
<tr>
<th>M (63.3%)</th>
<th>26.4±2.8/Obesity class I</th>
</tr>
</thead>
<tbody>
<tr>
<td>124 51-70</td>
<td>F (27.0%)/ France 31.1 (27.3-37.5)/Obesity class I</td>
</tr>
<tr>
<td>M (73.0%)</td>
<td>27.0 (25.3-30.8)/Overweight</td>
</tr>
</tbody>
</table>

[33]
23.7±2.5 kg/m², respectively). The same author published another article [35] they carried out a retrospective cohort study between December 11, 2019, and January 29, 2020 but they did not include or did not have the value of the BMI. On the other hand, a multi-centered, retrospective, observational study was carried out by Xu et al. [31], where forty-five critically ill patients with COVID-19 (35.6% and 64.4% female and male, respectively, aged 56.7±15.4) identified in seven intensive care units in Guangdong Province, China. The average values for BMI were 23.2 (overweight) and 25.0 kg/m² (obesity class I) for patients who underwent intubation and non-intubation, respectively.

3.2. Korea

Lim et al. [22] reported for the first time the tertiary on transmission of COVID-19 outside China, to a Korean man who was living in Wuhan (China) and entered Korea on January 20, 2020. He is considered the index patient who transmitted the coronavirus at a restaurant to another person (confirmed on January 30, 2020). This patient transmitted virus to his family (spouse and son) and a friend. The index patient was 54-years old with a BMI of 25.7 kg/m², in obesity class I [22] and lopinavir/ritonavir was used as the treatment. A reduction of viral loads and improvement of clinical symptoms during the treatment was observed. Kim et al. [23] described the first patient with 2019-nCoV pneumonia in Korea, a 35-year-old woman admitted to hospital on January 19, 2020, who was obese, with a BMI of 33.4 kg/m² (obesity class II [20]), but otherwise healthy.

3.3. France

Simonnet et al. [33] carried out a retrospective cohort study analyzing BMI and the requirement for invasive mechanical ventilation in 124 COVID-19 patients admitted into intensive care at Roger Salengro Hospital, at the “Centre Hospitalier Universitaire de Lille” (Lille, France). These authors reflected that disease severity was associated with increased BMI, and was maximal in patients with a BMI ≥35 kg/m². A higher likelihood of needing invasive mechanical ventilation was noted for this BMI, independent of age, sex, diabetes, and hypertension.

4. Discussion

To date (up to April 18, 2020), only twelve articles related to BMI and COVID-19; have been published, which indicates around 0.26% of all scientific literature. We observed that BMI values among severe COVID-19 patients ranged from 24.5 to 33.4 kg/m² versus those among non-severe patients, which ranged from 22.0 to 24.3 kg/m². Liu et al. [26] indicated that a BMI ≥24 kg/m² on admission was an unfavorable factor for discharge, but if a statistical difference of p<0.005 among BMIs is required for it to be considered as a potential risk factors for predicting progression to severe disease, only three [25, 28, 29] out of studies, met this criteria. Accordingly, we proposed that a BMI ≥24.5 kg/m², which is indicative of normal weight [18] or overweight [19,20], should be the cut-off for patients to move from non-severe to severe status. Furthermore, our group thinks that the use of another related term such as obesity, in the bibliography, is unclear in relation to this disease as the authors indicated that some patients had this nutritional status but it was not reflected in the BMI value, according to the BMI cut-offs. This is mainly because the BMI classification for Asians [19], established from restricted numbers of prevalence studies but not from mortality data, is different from the recommended WHO-BMI cut-offs for the West [18], and even from cut-offs for Koreans [20]. Surprisingly, some studies, that our group excluded from this review mentioned obesity without a detailed specification of the BMI value. We analyzed how these articles were reflected in Table 4.

Table 4. Summary of articles with data indicating obesity, but not BMI, and patients affected by COVID-19.
Liao et al. [38] observed reports of overweight/obesity, without giving BMI values, among 28.6% and 40.6% of adolescents (10-24 years of age) and young adults (25-35 years of age), respectively, who were infected with COVID-19 and hospitalized in Chongqing Three Gorges Central Hospital of Chongqing University in China, between January 25, 2020 and February 18, 2020. In a single-center, retrospective cohort study at The Fifth Affiliated Hospital of Sun Yat-Sen University, Guangdong Province, China, between January 17, 2020, and February 13, 2020, Deng et al. [37] did not reflect the values of BMI, but indicated no significant differences in the presence of obesity. It is unknown whether they were referring to the values for the West [18] or Asian criteria-based [19] adults. This study observed obesity in two out of sixteen and one out of seventeen of combination (arbidol and lopinavir/ritonavir (LPV/r) treatment) and monotherapy (LPV/r) group, respectively. In the USA, 33.3% of residents and 3% of visitors infected by this coronavirus in a long-term residential care facility were obese, but noninfected health care personnel had this nutritional status [36]. Among the first European cases, one was reported to be obese but they did not provide BMI values for the rest of the cases [39]. In the USA, a woman (73-years-old) with a history of obesity and other pathologies, including coronary artery disease, insulin-dependent type II diabetes mellitus, chronic kidney disease, hypertension and congestive heart failure, who resided in a long-term care facility, was infected with COVID-19 in mid-February and died on March 2 [36]. The term overweight is used in the primary case pre-existing condition application form entitled “Surface Sampling of COVID-19: A Practical “How To” Protocol for Health Care and Public Health Professionals” [40]. Zhong et al. [41] described in a quick online cross-sectional questionnaire of knowledge, attitudes, and practice towards COVID-19, in the item “K4”; “Not all persons with COVID-2019 will develop to severe cases. Only those who are elderly, have chronic illnesses, and are obese are more likely to be severe cases”. Considering that the measurement of BMI is the usual parameter in the triage system; in hospital emergency departments [42,43], in our view, this index should be added to all studies of COVID-19 for two reasons; the possible risk factor of the BMI in relationship with other virus diseases [8-10], and the association of pneumonia (which is a symptom in COVID-19) with BMI [11-14]. We must keep in mind that COVID-19 is spread from person to person by the same mechanism as other common cold or influenza viruses [44]. Chen et al. [45] and Plessa et al. [46] found obesity was a risk factor in influenza-like illness. Moser et al. [47] has suggested that being underweight or morbid obesity in adults, even with no associated chronic conditions, can increase the risk of the influenza-related complications and could influence the mortality and transmission of influenza virus [48, 49]. Dietz and Santos-Burgoa [50] emphasized the need for increased vigilance, a priority around detection and testing, and aggressive therapy for patients with obesity and COVID-19 infections. Nevertheless, the use of BMI in COVID-19 can be confusing. Jin et al. [51] developed a core outcome set for clinical trials on COVID-19 and included the BMI in the first round of the Delphi survey but deleted it in the second round. Arnold et al. [52] established a BMI value of 25 and 28 kg/m² for patients with disease caused by endemic human coronavirus and influenza virus, respectively, and observed statistically significant impacts on comorbidities based on the BMI, but not obese (BMI > 30 kg/m²).

<table>
<thead>
<tr>
<th>Nº of patients</th>
<th>Age</th>
<th>Sex</th>
<th>Country</th>
<th>Nutritional status</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>73</td>
<td>F</td>
<td>USA</td>
<td>Obesity</td>
<td>[36]</td>
</tr>
<tr>
<td>33</td>
<td>41.8±14.1</td>
<td>F (48.5%)/M (51.5%)</td>
<td>China</td>
<td>9.1% obesity</td>
<td>[37]</td>
</tr>
<tr>
<td>46</td>
<td>10-24</td>
<td>F (47.3%)/M (52.7%)</td>
<td>China</td>
<td>8.7% underweight</td>
<td>[38]</td>
</tr>
<tr>
<td>129</td>
<td>54-100a</td>
<td>F (65.4%)/M (34.6%)</td>
<td>USA</td>
<td>33.3% obesitya</td>
<td>[36]</td>
</tr>
<tr>
<td></td>
<td>22-79b</td>
<td>F (79.4%)/M (20.6%)b</td>
<td></td>
<td>0% obesib</td>
<td></td>
</tr>
<tr>
<td></td>
<td>52-88c</td>
<td>F (28.6%)/M (71.4%)c</td>
<td></td>
<td>3% obesityc</td>
<td></td>
</tr>
</tbody>
</table>

*a resident, b health care personnel and c visitor in long-term residential care facility in Washington.
In terms of BMI and other factors related to the evolution of the disease, viral load, hospital discharge, and treatment of COVID-19 (the use of antiviral and vaccine immunization is hopeful in the foreseeable future), various authors have studied patients (general population and medical staff) affected with this disease. The evolution of this pandemic has been reported to begin with asymptomatic infection to mild illness, with severe or fatal illness being the last stage with the need for intensive care for respiratory support, in which; patients receive high-flow oxygen therapy, mechanical ventilation, advanced organ support with endotracheal intubation and mechanical ventilation or extracorporeal membrane oxygenation [53-55]. If focusing on patients with COVID-19 who were admitted to the intensive care unit, there is only one study [31] where BMI values were compared between intubated and non-intubated patients, but this article did not reflect the the statistical value of the differences between subjects. Cai et al. [29] illustrated that BMI seems to have little effect on the progress of the disease and Ji et al. [32] revealed statistically non-significant differences between stable non-severe and progressive severe patients. However, several authors found different results; Liu et al. [25] and Peng et al. [28] observed that the BMI of severely ill patients was significantly higher than that values of common patients. For viral load, Liu et al. [56] demonstrated that this analytical parameter is higher in patients with more severe disease, based on the amount of virus exposure and, known infectious dose, which increased the severity of the illness and was also linked to a higher viral load (severe cases were up to 60 times higher than mild cases). Cai et al. [29] documented that BMI was not an independent prognostic factor for virus clearance. On the other hand, the term of hospital discharge or release from home isolation was defined, according to the National Health Commission of the People’s Republic of China [57], when three of the following applied; i) afebrile for >3 days and improved respiratory symptoms; ii) resolution of lung involvement demonstrated by computed tomography of the chest; and iii) two consecutive (with sampling intervals ≥ 24 hours) negative RT-PCR tests for respiratory tract samples. The study by Liu et al. [26] demonstrated that a higher BMI (≥ 24 kg/m²) was an unfavorable factors for discharge among infected medical staff identified by the Cox model. For treatment of the disease, Louie et al. [10] suggested that BMI categories could be added to current high risk groups for prioritization of antiviral use and influenza vaccine immunization in times of supply shortages.

The importance of considering BMI in relation to COVID-19 has larger implications than explained above, underlying comorbidities can aggravate the disease. China [58,59] and the European Union [60] have suggested hypertension, respiratory system disease, and cardiovascular diseases are problematic; Italy [61] reflected that hypertension, diabetes, ischemic heart disease, atrial fibrillation and cancer diagnosed in the last five years complicate the disease; Ghana [62], and other tropical and sub-tropical areas, have detected cardiovascular disease, diabetes, chronic respiratory disease, hypertension, cancer and *Plasmodium falciparum* malaria as underlying conditions of concern; and Latin American countries [63] have indicated obesity, diabetes mellitus and hypertension as important. Shi et al. [64] observed that the mortality of diabetic patients with COVID-19 was 35.4%, due to a higher likelihood of suffering multi-organ dysfunction and, secondary infection. In fact, diabetes along with hypertension treatment with angiotensin-converting enzyme 2 (ACE2)-stimulating drugs increased the risk of developing severe and fatal COVID-19 due to both diseases being treated with ACE inhibitors and angiotensin II type-I receptor blockers (ARBs) resulting in increased expression of ACE2, which facilitates infection with COVID-19 [65-69]. Wang et al. [70] used a new classification of COVID-19 in severe patients which could help with individual evaluation of the disease and would provide effective triage for the treatment and management of individual patients. These authors divided patients into three groups; type A (patients with pneumonia requiring basic treatments based on antivirals, antibiotics, oxygen therapy, and glucocorticoids), type B (patients with different degrees of pneumonia, accompanied by serious comorbidities, requiring managing of the pneumonia an specific treatment plans, including antihypertensives, hypoglycaemic therapy, and continuous renal replacement therapy) and type C (patients who were critically ill with aggravation of the disease seen either in type A or type B, when early therapeutic effects for type A disease were unsatisfactory (resulting in multiple organ injuries), or when disease associated with type B became aggravated and the patient’s condition deteriorated.
from their original comorbidities (leading to multiple organ failure), needing review of organ function and other protective measures such as mechanical ventilation, glucocorticoids, antivirals, symptomatic treatments, and anti-shock therapy). The use of our proposal of BMI ≥24.9 kg/m², as a risk factor in COVID-19 could be applied to the three groups defined by Wang et al. [70], with a high risk factor indicated when the BMI ≥34.9 kg/m².

On the other hand, the use of nutritional support therapy during hospitalization is key to strengthening the patients. Li et al. [71] found that BMI had no effect on in-hospital mortality but may be closely correlated with prolonged intubation for patients. Xu et al. [72] indicated that nutritional and gastrointestinal function should be assessed for all patients. Li et al. [73] observed a decline of albumin, presumably the exuberant protein synthesis caused by infected patients’ hypermetabolic state, associated with fever, malnutrition and low caloric intake, can which reduce BMI value through weight loss. Surprisingly, Rockx et al. [74] found no significant weight loss in cynomolgus macaques inoculated with SARS-CoV-2, in contrast with the weight loss observed in Syrian hamsters [75], BALB/c mice [76], transgenic hACE2 mice [77] and rhesus macaques [78] inoculated with SARS-CoV-2. In humans, a case reflected a weight loss of around 8 kg at the patient discharged from the hospital [79]. Let us not forget that prolonged intensive care unit (ICU) stays for COVID-19 can directly worsen or cause malnutrition. It is worth noting that the European Society for Clinical Nutrition and Metabolism (ESPEN) has been carried out a concise guidance for nutritional management of infected patients in the ICU setting or who are of older age and polymorbidity status [80], and the French-speaking Society for Clinical Nutrition and Metabolism (SFNCM)’s Home Artificial Nutrition Committee has elaborated some recommendations for home artificial nutrition for chronic and fragile COVID-19 patients [81]. Further, Monteleone and Ardizzone [82] and Kalantar-Zadeh and Moore [83] have developed provisional guidance on nutrition and diet for managing paediatric inflammatory bowel and kidney diseases, respectively.

Finally, we noted that there are other groups to consider in relation to this disease, the home confinement population is very important in terms of controlling BMI due to them being physically less active and having less favourable diets, among other factors, which may result in weight gain [84,85].

The limitations of this study include the small number of available studies for review, and different sample sizes (from 1 to 298 patients). A meta-analysis was not conducted due to the varied interventions in the reported studies.

5. Conclusions

In conclusions, the use of BMI value is a key tool to define the nutritional status in infected COVID-19 patients. This review explores the few published articles that consider this index, and the confusing term of obesity if the BMI was not incorporated in the manuscripts. Clinicians should keep a patient’s BMI in mind when evaluating risk and deciding on a course of treatment for COVID-19, to improve both short- and long-term prognosis.

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