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Obesity and Coronavirus Disease 2019 (COVID-19)

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Coronavirus disease 2019 (COVID-19) is a disease caused by severe acute respiratory syndrome coronavirus (SARS-CoV-2) infection that was first reported on December 31, 2019 in China (Alberca *et al.*, 2020, Yang *et al.*, 2020). This disease behaves variously: from asymptomatic infection to influenza-like symptoms and severe acute respiratory distress syndrome (ARDS) (Földi *et al.*, 2020). In the recent months, COVID-19 has infected millions and killed hundreds of thousands of patients worldwide (Alberca *et al.*, 2020). Human-to-human transmission of this disease happens mainly via direct contact or via droplets spread from an infected person's cough or sneeze (Alberca *et al.*, 2020). The mortality rate and severity of COVID-19 are higher in elderly people and those with diabetes, cardiovascular disease, hypertension, respiratory dysfunctions, and other underlying diseases (Alberca *et al.*, 2020, Yang *et al.*, 2020). In the crisis caused by COVID-19, the probability of publication of invalid data has increased. So, we tried to provide

scientific evidences regarding the association between obesity and COVID-19. Furthermore, we aimed to investigate multiple mechanisms through which obesity may worsen the outcomes of COVID-19 using the published scientific literature.

Obesity is associated with chronic inflammation and metabolic disorders such as dyslipidemia, insulin resistance, and type 2 diabetes mellitus, which can affect the innate and adaptive immune responses. Consequently, it makes the immune system more vulnerable to infections and less responsive to vaccinations, antivirals, and antimicrobial medications (Dhurandhar *et al.*, 2015).

Obesity can impair the memory CD8 T-cell responses to infections such influenza virus infection, increase the rates of mortality and viral titers in lung, and worsen the lung damage (Karlsson *et al.*, 2010). Obesity is also related to vitamin D deficiency that can increase the risk of systemic infections and impair immune system (Bouillon *et al.*, 2019).

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The current evidence indicates that obesity is one of the main risk factors related to hospitalization, intensive care, and mortality among patients with COVID-19 (Földi *et al.*, 2020, Kalligeros *et al.*, 2020, Petrilli *et al.*, 2020, Pranata *et al.*, 2020, Yang *et al.*, 2020). Obesity-related disorders including dysfunction of immune system, chronic inflammation, endothelium imbalance, metabolic dysfunction, and its associated comorbidities may promote pulmonary fibrosis and lead to lung functional failure, as characteristic of severe COVID-19 (Ritter *et al.*, 2020). Furthermore, overweight and obesity can limit diaphragm movement, decrease functional lung capacity, and eventually result in hypoventilation (Dietz and Santos-Burgoa, 2020).

Obesity may also impair motile cilia on airway epithelial cells, disrupt the function of mucociliary escalators, and decrease the clearance of severe acute respiratory syndrome coronavirus (Ritter *et al.*, 2020). In addition, obesity is associated with chronic inflammation and impaired fibrinolysis that increases the risk of developing thrombosis and worsens lung damage (Muscogiuri *et al.*, 2020).

Difficulty in early diagnosis by pulmonary ultrasound due to mechanical issues related to excessive weight is another important factor involved in the increased risk of severe forms of COVID-19 among the patients with obesity. This may lead to a delay in diagnosis and increased mortality rate (Muscogiuri *et al.*, 2020). Moreover, the lack of designed medical or intensive care units for obese patients and the difficulties of intubation and insertion of catheters related to excess of weight may delay the therapeutic processes and worsen the prognosis in obese patients with COVID-19 (Muscogiuri *et al.*, 2020). Therefore, identifying the risk factors related to morbidity and mortality of COVID-19 is important to take appropriate prevention and therapeutic measures. Individuals with overweight and obesity are among the high-risk group related to COVID19 who should be considered more seriously. Furthermore, preventive and curative interventions are required

to decrease the probability of disease development in COVID-19 cases.

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Authors' contribution

Hosseinzadeh M conceived the original idea and designed the scenarios. Zohreh SS collected the data and wrote the draft of manuscript. Hosseinzadeh M critically revised the manuscript and confirmed the final version of it to submit. All authors read and approved the final version of manuscript.

Conflict of interest

The authors declared that there was no conflict of interest.

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