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Impact of COVID-19 pandemic on lifestyle behavior, body weight and physical activity: A review of studies published during 2020

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Abstract
Background and Aims: The lifestyle behavior of individuals for the entire globe has been affected by COVID-19. To evaluate how lifestyle behaviors among adults in developed and developing countries were affected by COVID-19 pandemic.
Methods: This review was carried out to assess lifestyle behaviors including eating habits, body weight and activity level changes among adults in the globe during the pandemic. From the beginning of the pandemic until October 2020 all relevant studies in PubMed were identified.
Results: Adults of both genders in 11 studies were included in the present review. Several changes in lifestyle behavior were caused by COVID-19. The most lifestyle parameters including mental and Psychosocial stress, sleep quantity (average hours) and quality, decline in physical activity and weight gain were prevalent among the participants due to COVID-19.
Conclusion: Dissemination of health education and motivate population through different media styles is essential task during the pandemic.

Keywords: COVID-19, pandemic, lifestyle, Mediterranean diet (MD), DASH diet

Introduction
Coronavirus Disease COVID-19, caused by SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2), initially identified in Wuhan (China), and has spread worldwide nowadays, and up to date, around 3 million cases and 1.5 million deaths have been confirmed [1]. COVID-2019 declared as a pandemic by World Health Organization (WHO) on 11th March 2020 [2]. In addition to physical health of individuals their lifestyle also affected by this pandemic. Physical and mental health may be negatively affected because of changes in mental stress, exercise level, food intake habits and sleep pattern. Several preventive and protective restrictions are needed to reduce/control the dramatic increase in number of (COVID-19) cases.

Lifestyle of people around the world has dramatically and rapidly changed during the COVID-19 pandemic. What we eat and our mental wellbeing have been changed because of changes in social dynamics due to distancing, restricted freedom of movement, social distancing, food providers and exercise resources restriction and psychological adaptations to isolation in order to slow down the transmission of the virus [3]. Food systems at different levels has already affected by COVID-19 pandemic from producers to processors, and consumers [4, 5]. During quarantine and stayed home substantial changes in lifestyle including sedentary lifestyle, sleeping, and eating behavior (stockpiling food and positive energy intake and/ or eating disorder; attitudes and behaviors related to food consumption might adversely affect health. Life become stressful because of boredom or loss of work [6] and media reports on coronavirus during the lockdown [7] people turned to more processed high in energy and low in nutrients convenient foods products due to reduction in variety, and limited access to fresh food [8]. As a result of the COVID-19 lockdown lifestyle and dietary behavior changes were to be expected.

Due to the important role of healthy diet and lifestyle to support health and well-being, several health organizations including the World Health Organization and European Federation of the Association of Dietitians offered several nutritional and lifestyle recommendations to follow during lockdown [9].

Unhealthy behaviors including unhealthy food consumption, sedentary lifestyle and reduce diet quality are common during quarantine [10, 11]. Energy intake is positively increased with sedentary behavior, such as internet use, electronic playing games and TV-viewing because of frequent exposure to advertises of unhealthy food products while watching TV [13-15].

Cytokines levels that can modulate the processes of inflammation and oxidative stress are affected by the consumption of healthy food [16]. One of the healthy and immune supportive diet patterns is Mediterranean Diet (MD) [17, 18]. MD is a high-quality diet based on balance combination between macro and micronutrient nutrients. High levels of antioxidants from fruits and vegetables, availability of monounsaturated fatty acid (MUFA), from fish, nuts, and olive oil makes MD with highly important clinical applications [19]. MD is positively correlated with reduction in type 2 diabetes mellitus, depression, Alzheimer's disease, obesity, cancer, Crohn's disease, and low-grade inflammation [20, 21]. Due to all the above benefits the MD is considered as a fighter against immune-mediated inflammatory responses, such as those occurring in cancer. Energy intake is positively associated with lifestyle changes including online work or education and reduce physical activity during quarantine [22]. "Food craving" is an intense desire for a specific food, mainly rich in simple sugar 'comfort foods' and has a positive effect on mood by encouraging serotonin production and reduce stress [23-25].

Food craving effect of carbohydrates (high glycemic index of foods) is proportional to increase the risk overweight, obesity, cardiovascular diseases, and a chronic state of inflammation of because of COVID-19 [26, 27]. COVID-19 affects negatively the maintaining a healthy and varied diet, as well as a regular physical activity. The consumption of fresh foods, especially fruit, vegetables, and fish, and increase the consumption of highly processed, convenience foods, junk foods, ready-to-eat cereals, and snacks, which tend to be high in fats, sugars, and salt reduced due to limited access to daily grocery shopping.

Dysfunctional eating behaviors risk may increase due to psychological, and emotional responses to the COVID-19 outbreak [28, 29], "emotional eating" is negative emotions can lead to overeating [30, 31].

Finally, lifestyle may be substantially changed due to the containment measures, with the consequent risk of sedentary behaviors, modification in smoking and sleeping habits, increased visceral adipose that could contribute to alter the sleep-wake rhythm may increase the secretion of pro-inflammatory cytokines that cause sleep disturbances. Muscogiuri G *et al*., [32] recently in a cross-sectional study has been reported that good sleepers middle aged adults had higher adherence to the Mediterranean diet (MD) and lower body mass index (BMI) compared to poor sleepers [32]. Body fat and appetite dysregulation have been suggested to interact with low physical activity levels [33]. Obesity is an expansion of the adipose tissue, which produces cytokines and contributes to a proinflammatory milieu [34]. Moreover, regarding pulmonary physiology, subjects with obesity have decreased expiratory reserve volume, functional capacity, and respiratory system compliance. Pulmonary function is further compromised in the supine position by decreased diaphragmatic excursion, making ventilation more difficult in patients with high abdominal fat [35]. The severity of lung disease in COVID-19, which leads to the "cytokine storm" associated with the acute respiratory distress syndrome and multiple organ failure is determined by the inflammatory state. The inflammation in patients with COVID-19, could further exacerbate the inflammatory state characteristics in obese individuals, exposing them to a higher concentration of proinflammatory cytokines compared to normal-weight individuals [36].

2. Methodology search strategy

Search strategy: A comprehensive literature search using the keywords (COVID-19) and (lifestyle), (diet), (physical activity) and (weight change) of articles published on PubMed was conducted from March till December. 2020. Articles published only in the English language were included for the review by applying a selective filtration strategy. The search keywords according to the inclusion and exclusion criteria of the review was done by investigators for data extraction. Key findings such as data for author, year, sample size, study period, study design, and summary were extracted for all included articles.

2.1. Inclusion criteria

- Articles published only in the English language from March till December 2020.
- Studies reporting any of the lifestyle changes: dietary changes, body weight changes and physical activity level during the COVID-19 crisis.

2.2. Exclusion criteria

a. Studies other than the English language.

2.3. Ethical approval

Institutional review board approval was not required for the present review as it based on secondary data.

3. Results

A total of 205 articles from the electronic database list of included studies were achieved. Upon removal of duplicates, from the screened articles, we shortlisted 74 articles. Titles and abstracts of those 74 articles were screened resulting in a yield of 64 relevant articles. Full text for all these 64 relevant articles was downloaded and was further assessed for eligibility. Out of 64 articles, 39 were excluded due to various reasons including insufficient data availability, a study conducted among different age group, studies having different objectives, or not meeting the inclusion exclusion criteria. Hence, in the present review finally, a total of 25 articles were included (Fig. 1).

3.1. Study characteristics

Fig. 1 represents the literature search steps. A total of 13 cross-sectional studies [37-39, 43, 45-48, 53, 56-59], 7 online based [41, 42, 49, 52, 54, 55, 61], 3 retrospective [40, 50, 60], one phone interview [51], and one quantitative descriptive based [44]. With a varying sample size from 27 to 343,104 subjects, conducted between the duration of March to December 2020, were included. All 25 articles (age group 18-70 years, comprising males and females) included in the present review articles were stressed studying about eating or dietary behaviors, weight changes and physical activity or exercise status respectively table 1.

3.2. Dietary and eating behaviors

A mixed result was observed among all the studies conducted. However, in general, an overall change in eating and dietary habits than usual was observed in terms of

overeating, snacking and meal frequency was found to be increased causing weight gain in 18 out of 25 (72%) included articles [38, 41, 42, 44-49, 51, 54-61] table 2.

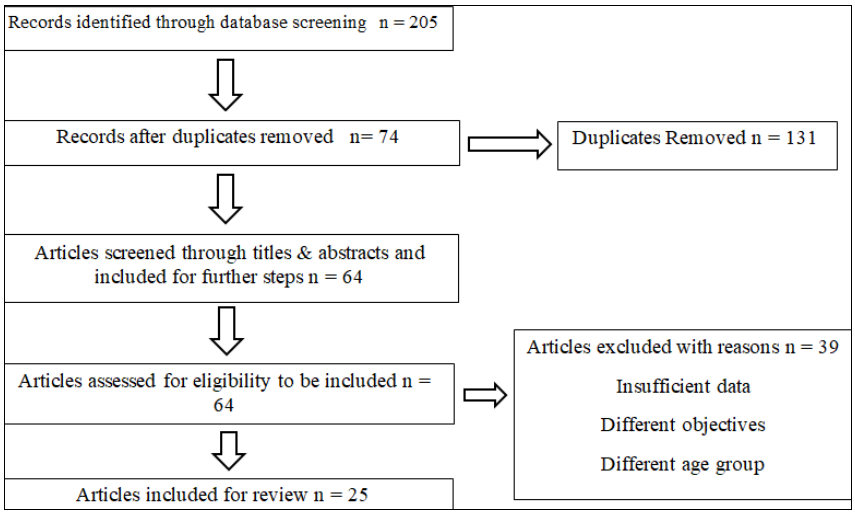

Fig 1: Study flow diagram for study selection required for the review of the literature

3.3. Physical activity

Physical activity level, frequency, and exercise duration reduction among the participants was observed in 16 out of the 25 (64%) included articles (Table 2).

Table 1: A summary of 25 selected articles included in the review and the studied lifestyle behaviors

Sr. No.	Authors and year	Sample size	Study design	Study period	Diet	Physical activity
1.	Nair DR *et al*., 2020 [37]	263	Cross-sectional	April-May 2020	✓	✓
2.	Alomari M *et al*., 2019 [38]	869	Cross-sectional	2019	✓	
3.	M Katsoulis *et al*., 2020 [39]	1844	Cross-sectional	April-May 2020	✓	✓
4.	Rachel *et al*., 2019 [40]	343,104	Retrospective	2019	✓	✓
5.	Edward *et al*., 2020 [41]	27	Online	April-May 2020	✓	✓
6.	Amanda *et al*., 2020 [42]	1230	Online	Mar-June 2020	✓	✓
7.	Javier *et al*., 2020 [43]	4379	Cross-sectional	2020	✓	✓
8.	Zeigler *et al*., 2020 [44]	1200	Quantitative	2020	✓	✓
9.	Guo-Yi Yang *et al*., 2020 [45]	2702	Cross-sectional	2020	✓	✓
10.	Surabhi *et al*., 2020 [46]	727	Cross-sectional	Mar-May 2020	✓	✓
11.	Miguel López *et al*., 020 [47]	675	Cross-sectional	2020	✓	✓
12.	Leila Ismail *et al*., 2020 [48]	1012	Cross-sectional	April-May 2020	✓	✓
13.	Vilma *et al*., 2020 [49]	2447	Online	April-May 2020	✓	✓
14.	Marianna *et al*., 2020 [50]	150	Retrospective	2020	✓	✓
15.	Luigi Barrea *et al*., 2020 [51]	121	Phone interview	2020	✓	✓
16.	Chadia Haddad *et al*., 2020 [52]	407	Online	April-2020	✓	✓
17.	Nagaaki *et al*., 2020 [53]	463	Cross-sectional	2020	✓	✓
18.	Peng Jia *et al*., 2020 [54]	10,082	Online	April-May 2020	✓	✓
19.	Qi Zhu *et al*., 2020 [55]	886	Online	Mar-Apr. 2020	✓	✓
20.	Daniela *et al*., 2020 [56]	700	Cross-sectional	2020	✓	✓
21.	Amélie C *et al*., 2020 [57]	205	Cross-sectional	2020	✓	✓
22.	Gürkan Özden *et al*., 2020 [58]	1,011	Cross-sectional	2020	✓	✓
23.	Adrian Brown 2020 [59]	543	Cross sectional	2020	✓	✓
24.	Shujuan Yang 1 2, *et al*., 2020 [60]	10 000	Retrospective	May-2020	✓	✓
25.	Dimitrios I *et al*., 2020 [61]		Online	April-May 2020	✓	✓

Table 2: Key points summarizing weight, and physical activity changes

Ser. No.	Author	Weight changes	Physical activity changes
1.	Alomari M *et al*., 019 [38]	Increased	Decreased by 42%
2.	Edward *et al*., 2020 [41]	Increased	Decreased
3.	Amanda *et al*., 2020 [42]	Increased	Decreased
4.	Zeigler *et al*., 2020 [44]	Increased	Decreased
5.	Guo-Yi Yang *et al*., 2020 [45]	Increase by 25.0%	Decreased by 54.3%
6.	Surabhi *et al*., 2020 [46]	Increase by 40%	----------
7.	Miguel López *et al*., 2020 [47]	Increase by 38.8%	Decreased by 44.7%

8.	Leila Ismail *et al*., 2020 [48]	Increase by 31%	Decreased by 38.5%
9.	Vilma *et al*., 2020 [49]	Increase by 31.5%	Decreased by 60.6%
10.	Luigi Barrea *et al*., 2020 [51]	Significant increase in BMI	Decreased by 53.5%
11.	Peng Jia *et al*., 2020 [54]	Increase by 24.6%	Decreased significantly
12.	Qi Zhu *et al*., 2020 [55]	Increase by 30.6%	Decreased by 31.5%
13.	Daniela *et al*., 2020 [56]	Significant increase in Bwt.	Decreased significantly
14.	Amélie C *et al*.,2020 [57]	Increase by 47.9 %	Decreased by 67.4%
15.	Gürkan Özden *et al*., 2020 [58]	Increase by 46.9%	Decreased by 56.7%
16.	Adrian Brown *et al*., 2021 [59]	Increase by 55%	Decreased by 61%
17.	Shujuan Yang *et al*., 2020 [60]	Significant increase	Decreased significantly
18.	Dimitrios I *et al*., 2020 [61]	Increase by 25.1%,	Decreased significantly

Discussion

To our knowledge, this is the first review of its kind summarizing the key findings of the cross-sectional, Online, Phone interview, and Retrospective surveys and attempted to highlight the changes in body weight and physical activity due to the COVID-19 pandemic. This review article assessed and provides a snapshot about eating habits and lifestyle changes particularly body weight and physical activity among participants worldwide, via an online, cross-sectional, and retrospective and telephone surveys during the COVID-19 pandemic between March and December 2020. The results indicate that the COVID-19 pandemic and the subsequent lockdown resulted increase in caloric intake and indicated weight gain in about three-fourth of the included studies [38, 41, 42, 44-49, 51, 54-61]. Gaining weight during COVID-19 pandemic caused by important and highly modifiable dietary and lifestyle behaviors that are considered essential for optimal somatic and psychological health. These behaviors include number of meals consumed per day and reduction in the percentage of skipping meals particularly breakfast during the pandemic has been reported in most studies [41-42, 44, 56, 58-59]. Closer to "unhealthy" dietary patterns, characterized as high in energy but with low nutrient density; and distanced from the Mediterranean diet principles also has been indicated in several studies [41, 44-46, 48-49]. This combination considered as a detrimental for immune status. It has been suggested that the negative alterations in eating behaviors could be due to anxiety or boredom [62], lack of motivation to maintain healthy habits [63], or reduced availability of goods and limited access to food due to restricted store opening hours [64]. Most of the surveyed participants in this review did not consume fruits, vegetables, and dairy products on daily basis. Instead, more than half of the surveyed participants reported consuming sweets and desserts at least once per day and over two third consumed salty snacks daily. This transition towards a Westernized diet was reported in most included studies, where the consumption of fresh fruit and vegetables and of milk and dairy products was found low. An important source of fiber, vitamins, minerals, and antioxidants mainly are fruits and vegetables. The Mediterranean diet and Dietary Approaches to Stop Hypertension (DASH) diet) are rich in antioxidants and they are vascular protective. The Mediterranean diet is focusing on high consumption of plant foods, low red meat, and dairy and moderate consumption of monounsaturated fat sources such as olive oil and recognized as an anti-inflammatory dietary pattern, [65]. Evidence suggests that the Mediterranean diet is associated with better health status, lower risk of chronic disease and inflammation as well as increased immunity [66-68].

The Mediterranean diet is not only a healthy dietary pattern but is also a sustainable diet that has a lower environmental impact than the typical Western diet [69]. Moreover, mounting evidence indicates that the Mediterranean diet has a favorable effect on diseases related to chronic inflammation, including visceral obesity, type 2 diabetes mellitus and the metabolic syndrome [70-74]. Knowing that the prevalence of cardiovascular disease is high worldwide, and rates of dyslipidemia are strikingly elevated, makes it imperative that diets such as the Mediterranean diet should be encouraged to minimize and prevent the potentially negative effect of quarantine on dietary habits and overall health. Management of viral infections and prevention is essential, a balanced nutrition, which can help in maintaining and boost immunity against viral infections [75]. As COVID-19 has no pharmacological therapies, healthy diet rich in micronutrient (e.g. trace elements, probiotics, nutraceuticals, and vitamins) may be beneficial especially for vulnerable populations, such as the elderly [75]. Considering that During the COVID-19 lockdown, the sense of hunger and satiety changed for more than half of the population: The increased sense of hunger and the consequent change in eating habits could justify the perception of weight gain observed in 72% of the included studies. In fact, more than half of included studies have been reported a reduction of the consumption of fresh food, accompanied by vitamins and minerals deficiency, including vitamin C and vitamin E and beta-carotene with antioxidants and anti-inflammatory properties during the quarantine. Obesity and impaired immune responses are associated with the deficiency of these micronutrients thus making more susceptible to viral infections [76, 77]. However, during the lockdown, many of the nutritional organizations have paid attention to Mediterranean diet, MD could represent one of the best food models to restore innate and adaptive immunity and might be one of the best therapeutic choice of COVID-19.

Conclusions

In this review, we have provided for the first-time data on the population eating habits and lifestyle changes including weight and physical activity during the COVID-19 pandemic. Weight gain was observed in 72% of the population, whereas decreased physical activity has been reported in 64% of the included studies. Meanwhile, the entire world is struggling to discontinue the chain reaction of COVID-19, and to optimize its growing burden, it is imperative to keep balance in our lifestyle and behavior. Monitoring, counseling, correct and appropriate knowledge dissemination to public is very crucial during the crisis.

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