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Lifestyle Behaviors Predict COVID-19 Severity: A Cross-Sectional Study

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Abstract

Background: The COVID-19 pandemic has put immense pressure on global health systems, especially developing countries with weaker health systems.
Objectives: In the present study, we were looking to see if lifestyle behaviors could predict the severity and recovery duration of COVID-19.
Methods: A total of 1192 participants between the ages of 18 and 70 years participated voluntarily in a web-based survey. Food pattern and physical activity levels were respectively evaluated using the Food Frequency Questionnaire (FFQ) and the Rapid Assessment of Physical Activity (RAPA). The Pittsburgh Sleep Quality Index (PSQI) was also used to evaluate sleep disorders. Analysis of variance, chi-square test, and multinomial logistic regression were used to analyze the data. The significance level was $P \leq 0.05$.
Results: The findings suggested that patients with lower levels of physical activity, sleep disorders, and unhealthier dietary patterns were affected by more severe COVID-19 and longer recovery time ($P \leq 0.05$). We found that physical activity and sleep quality predicted the severity of COVID-19, and physical activity and dietary patterns predicted the recovery time from COVID-19 ($P \leq 0.05$).
Conclusions: In conclusion, lifestyle behaviors, such as unhealthy diets, inactivity, and sleep quality disturbance, affect the severity and duration of COVID-19.

Keywords: Eating Disorder, Sleep Disorder, COVID-19 Pandemic, Exercise, Lifestyle

1. Background

Home quarantine and psychological distress caused by the coronavirus disease 2019 (COVID-19) pandemic led to changes in lifestyle behaviors (1-3). Lifestyle behaviors are everyday activities that result from values, knowledge, and norms and are highly affected by the environment, individual, and tasks (4-6). Improper psychological and physical environments influence daily tasks and can lead to unhealthy behaviors, such as overeating, sedentary behavior, increased alcohol and tobacco use, increased screen time, and, ultimately, sleep disturbance (1, 7). Inadequate sleep quality, combined with unhealthy eating patterns and poor physical activity levels, threatens people's health and can even affect the immune system (8-10). The first case of COVID-19 was detected in Iran on February 20, 2020, and more than 120 000 confirmed cases and more than 7 000 deaths were reported by the Iranian Ministry of Health and Medical Education by May 6, 2020, indicating the severity and prevalence of the disease (11).

Preliminary reports also suggest that the severity and outcome of COVID-19 largely depend on the patient's age and medical history (11). Two years after the pandemic, researchers no longer limit their reports to specific components and focus more on variable lifestyle behaviors (12). However, factors associated with the severity and length of the recovery period in COVID-19 patients remain unclear. The interaction between nutrition and the immune system is well-known; therefore, any nutritional imbalance affects the competence and integrity of the immune system. One of the most important measures in maintaining health and preventing infectious diseases is proper nutrition and adequate sleep (10). Studies show that some dietary patterns may affect the inflammatory markers associated with low-grade systemic inflammation. Low-grade inflammation appears to be associated with a ratio of interleukin-17 to interleukin-10, and interleukin-17 plays an important role in the host's

defense against infections by absorbing neutrophils and producing antimicrobial peptides (11).

Although home quarantine is an effective way to slow the spread of infectious diseases, it can have negative effects on mental health and lifestyle behaviors, including social participation, physical activity, and mental status (10). Indeed, recent studies have shown that COVID-19 home quarantine increases the number of people with low physical activity (15.2%), unhealthy eating behaviors (10%), and poor sleep quality (12.8%) (8-10). Therefore, an unhealthy diet, sedentary lifestyle, and poor sleep quality may adversely affect the host's immune function and may impact the severity and length of recovery of COVID-19 (10, 12, 13).

According to clinical classifications of COVID-19 provided by the National Health Commission of China, patients with mild symptoms (such as fever, upper respiratory infection, and no sign of pneumonia on imaging) were classified as mild. Changes in chest radiology were classified as moderate (lesion progression in chest images within 24 - 48 h $<$ 50%). Severe illness included a significant increase in the respiratory rate, hypoxia, and lung involvement on CT scans (above 50%). Besides, short recovery periods were classified as short ($<$ 7 days), normal (10-14 days), and long ($>$14 days) (11, 14). Overall, the important factors mentioned above appear to have potential effects on the incidence, severity, and length of recovery.

2. Objectives

Therefore, in the present cross-sectional study, lifestyle behaviors of patients with COVID-19 and the effects of these behaviors on the severity and length of recovery period were investigated.

3. Methods

3.1. Study Design

The research design was cross-sectional, and data collection was performed from January 5, 2022, to March 3, 2022, using a questionnaire. A web-based questionnaire was sent to volunteers on social media (Instagram, Telegram, and WhatsApp). The questionnaire consisted of 4 sections: sociodemographic information (Table 1), food frequency, sleep quality, and physical activity level. For this purpose, 1 228 volunteers in 4 geographical parts of Iran were selected via cluster sampling. People aged 18-80 years who had COVID-19 once were included. Exclusion criteria were: (1) patients with any severe immune system conditions, (2) patients with any severe cardiovascular and respiratory conditions, and (3) refusal to fill out the questionnaire. The research design flowchart is shown in Figure 1.

3.2. Questionnaire

Food pattern and physical activity levels were respectively evaluated using the Food Frequency Questionnaire (FFQ) and the Rapid Assessment of Physical Activity (RAPA). The Pittsburgh Sleep Quality Index (PSQI) was also used to evaluate sleep disorders.

The FFQ questionnaire with 168 items was designed based on the structure of the Willett questionnaire and was modified based on Iranian food items. It contains questions about the average frequency of consumption of food items according to the standard serving size or the amount more familiar to the population. In this questionnaire, individuals could report their consumption per day (such as bread), week (rice and meat), month (such as fish), year (such as viscera), or never. The validity and reliability of this questionnaire had been evaluated (15). The food intake was analyzed using the Nutrition 4 v. 3.5.2 software. This software contains Iranian food items, such as Iranian breads and rice (16).

The RAPA questionnaire was validated in other publications. The APA is divided into 2 categories: RAPA 1, aerobic exercise intensity (scored from 1 to 7), and RAPA 2, the type of exercise (muscle strength, flexibility, or both). For the purpose of this study, only RAPA 1 was evaluated. Based on the answers to the questions, the level of physical activity is divided into 3 categories: sedentary or light (Q: 1-3), moderate (Q: 4-5), and vigorous physical activities or active every week (Q: 6-7) (17).

The PSQI is a self-report questionnaire that assesses the quality of sleep and sleep disorders in 1 month. Nineteen items create 7 component scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The rating based on the Likert scale is from 0 to 3, and the overall score is 0 to 21, with a score of 6 or higher indicating poor sleep quality (18). The validity of this questionnaire has been confirmed many times (19).

3.3. Statistical Analysis

Before performing the data analysis, the normality of distribution was tested using the Kolmogorov–Smirnov test. The data analysis was performed using IBM SPSS v. 19.0 (IBM Corp., Armonk, NY, USA). The figures were created by GraphPad Prism v. 6.0 (GraphPad Software, USA). Frequency and percentage were used as descriptive

Table 1. The Participants' Social-Demographic Details

Individual Characteristics	Severity of COVID-19			Total
	Mild	Moderate	Severe	
No. (%)	54 (4.53)	312 (26.7)	826 (69.3)	1192 (100)
Sex (%)				
Male	36.1	11.1	0.8	48.0
Female	33.2	15.1	3.7	52.0
Age (y), mean ± SD	34.2 ± 16	33.7 ± 17.4	36.6 ± 18.4	34.2 ± 17.3
Height (cm), mean ± SD	170.9 ± 9.6	168.3 ± 9.7	166.1 ± 6.9	170 ± 9.6
Weight (kg), mean ± SD	73.2 ± 11.1	69.6 ± 12.7	78.9 ± 11.1	72.2 ± 11.7
History of COVID-19 (%)				
No	0.0	0.0	0.0	17.9
Once	11.7	8.6	1.1	21.5
Twice	4.2	3.9	1.1	9.1
Three times and more	0.9	0.5	0.1	1.5
COVID-19 infection (%)				
No	37.8	0.8	0	38.6
Yes	31.5	25.3	4.5	61.4
Convalescence (%)				
1 week	54.7	1.17	0	55.9
10 to 14 days	10.9	12.8	0.2	23.8
More than 14 days	3.7	12.2	4.4	20.3
The severity of pain during COVID-19 (%)				
No	45.3	1.3	0	46.6
1 - 3	15.8	1.5	0	17.3
4 - 6	5.5	16.6	0	22.2
7 - 10	2.3	6.7	4.5	13.9
Education (%)				
High school diploma and sub-diploma	22.3	10.2	3.2	35.7
Bachelor's degree	27	11.6	0.8	39.4
Master's degree or higher	20	4.4	0.5	24.8
Marital status (%)				
Single	27.4	8.7	0	36.1
Married	42	17.5	4.5	63.9
Smoking and drug use (%)				
No	58.1	19.3	3.7	81
Drugs	0	1.3	0	1.3
Alcohol	2	3.5	0	5.5
Cigarettes	6.5	1.3	0	7.8
Cigarettes and drugs	0.2	0.2	0	0.4
Transmission (%)				
Family	50	7.7	1.5	57.2
Relatives and acquaintances	7.2	9.4	1.9	18.5
Workplace or outdoors	14.1	9.1	1.2	24.3
Residence (%)				
Urban	55.5	20.5	4.4	80.4
Suburban	13.8	5.7	0.2	19.6
Occupation (%)				
Unemployed	10.6	4	0	14.6
Homemaker	13.2	7.6	3.7	24.5
Employed	45.5	14.3	0.8	60.7
Retired	0	0.3	0	0.3
Observance of social distancing (%)				
No	1.3	2	18.2	43.5
Yes	24.8	2.5	29.2	56.5
Wearing a mask (%)				
No	12.8	0.5	0.5	13.8
Yes	56.5	25.7	4	86.2

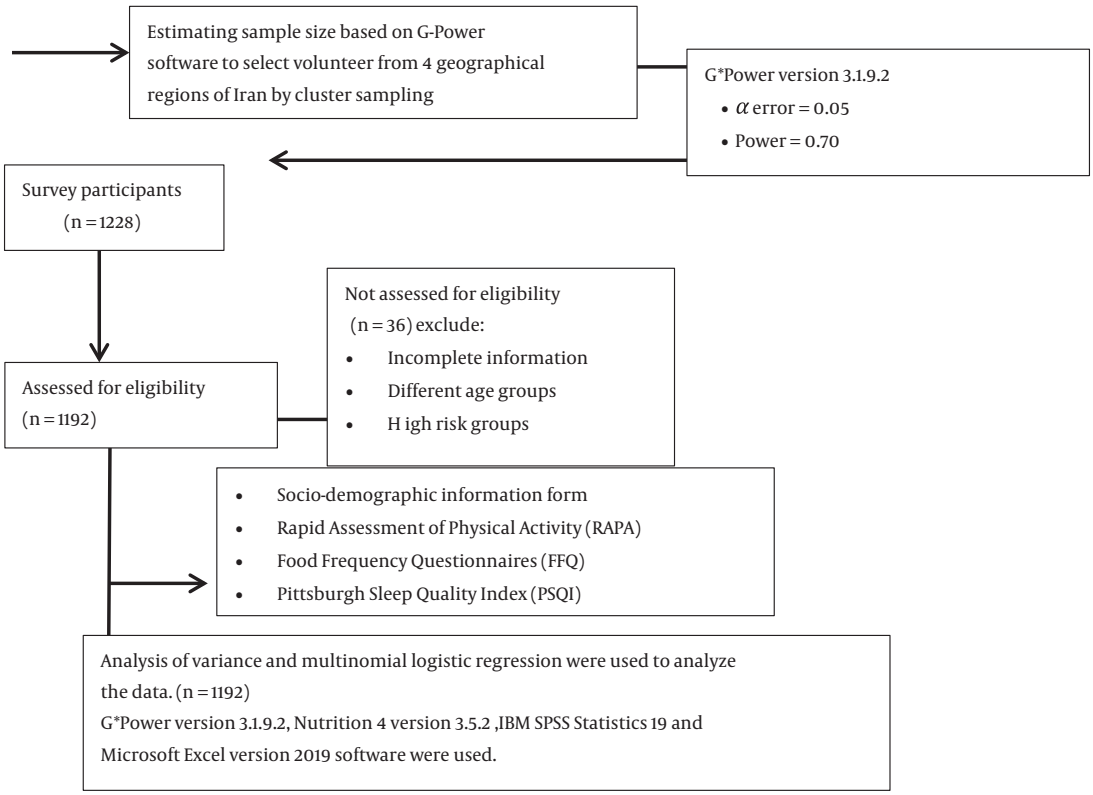

Figure 1. Flowchart of the study

statistics. Analysis of variance, chi-square test, and multinomial logistic regression were also used to analyze the data. Statistical significance was set to alpha = 0.05.

4. Results

In this cross-sectional study in January 2022, 1192 volunteers (48% male and 52% female) aged 34.2 ± 10.3 years participated. The findings showed that 21.5% had a history of COVID-19 at least once. Also, 61.4% had COVID-19 and 55.9% had convalescence for 1 week (Table 1). According to Table 1, most of the 57.2% stated that they were infected by a family member. There were people who lived in urban areas. Most of the patients were employed and were among those who observed social distancing and wore masks.

Figure 2 shows the severity and convalescence of COVID-19 and sex. COVID-19 produces more severe symptoms among women than men. Moreover, women have a longer convalescence.

The results of the chi-square test are presented in Figure 3 for the severity and convalescence of COVID-19 and physical activity level. The results showed a significant difference between the expected frequencies and the observed ones in severity of COVID-19 and physical activity levels ($\chi^2(4) = 34.93$; $P < 0.001$), and convalescence of COVID-19 and physical activity levels ($\chi^2(4) = 31.26$; $P < 0.001$). Active patients are more likely to have mild to moderate COVID-19 and have a 1-week duration of convalescence.

The results of the analysis of variance showed that there was a significant difference between the score of sleep quality, the severity of COVID-19 ($(F2,1189) = 10.85$; $P < 0.001$), and the convalescence length ($(F2,1189) = 3.84$; $P = 0.022$). The results of the post-hoc test are given in Figure 4. The results showed that COVID-19 patients with sleep disorders were more likely to have severe symptoms and a longer convalescence duration ($>$ 10 days) (Figure 4).

The results of the analysis of variance showed that there was a significant difference between the macronutrients, the severity of COVID-19 ($P < 0.001$), and the convalescence ($P < 0.001$). The results of the post-hoc test in Figure 5 demonstrated that people who received more carbohydrates had more severe symptoms ($P <$

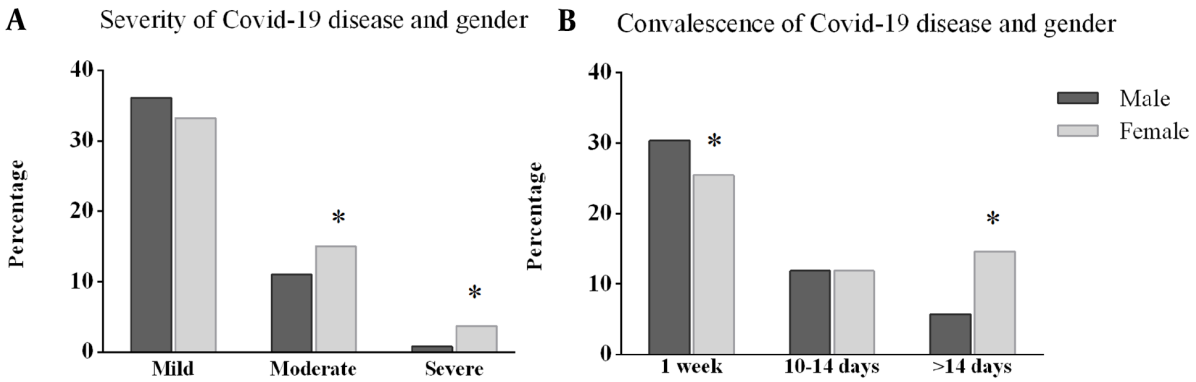

Figure 2. Severity and convalescence of COVID-19 and sex. * Significant difference with the male group at P ≤ 0.01.

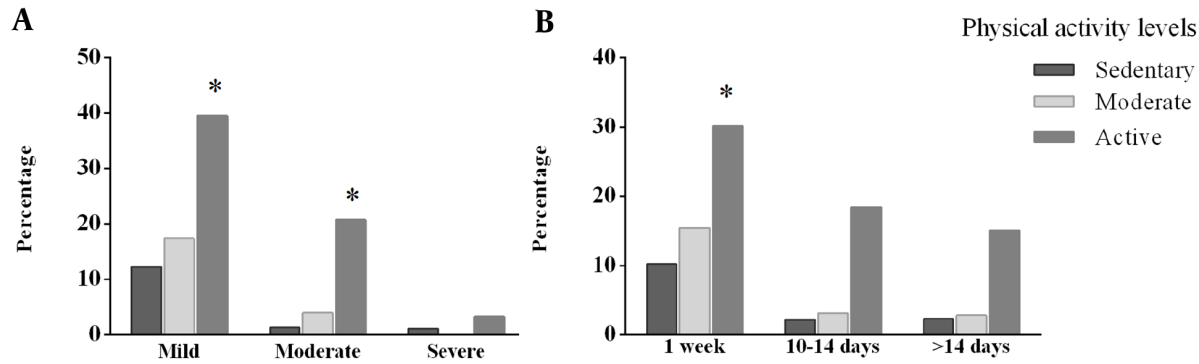

Figure 3. Chi-square independence test for severity and convalescence of COVID-19 and physical activity levels. * Significant difference at P ≤ 0.01.

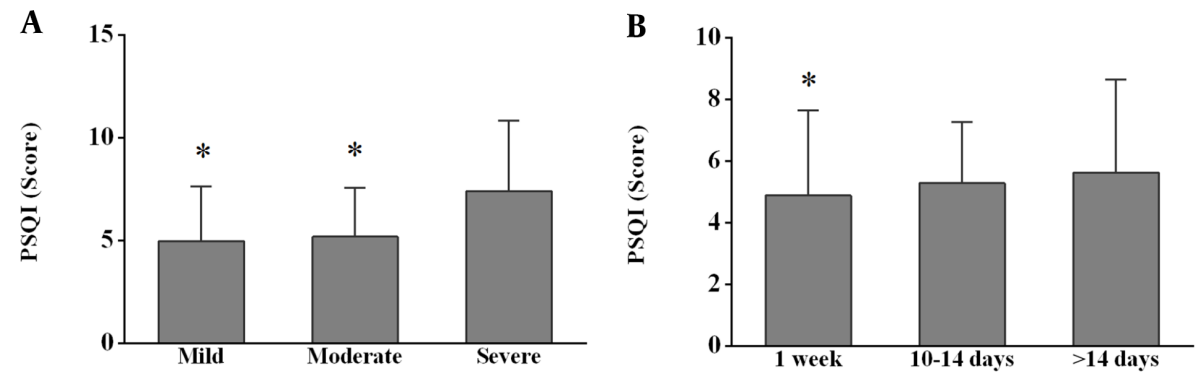

Figure 4. The results of the post-hoc test for severity and convalescence of COVID-19 and sleep quality score. * Significant difference at P ≤ 0.01.

0.05) and longer convalescence duration (P < 0.001). Also, people with more protein intake appeared to have milder symptoms (P < 0.01) and shorter convalescence (P < 0.001). Finally, people with more fat intake appeared to have milder symptoms (P < 0.01) and longer convalescence duration (P < 0.01).

Multiple logistic regression assumptions (i.e., an adequate sample size, linearity of the predictors and

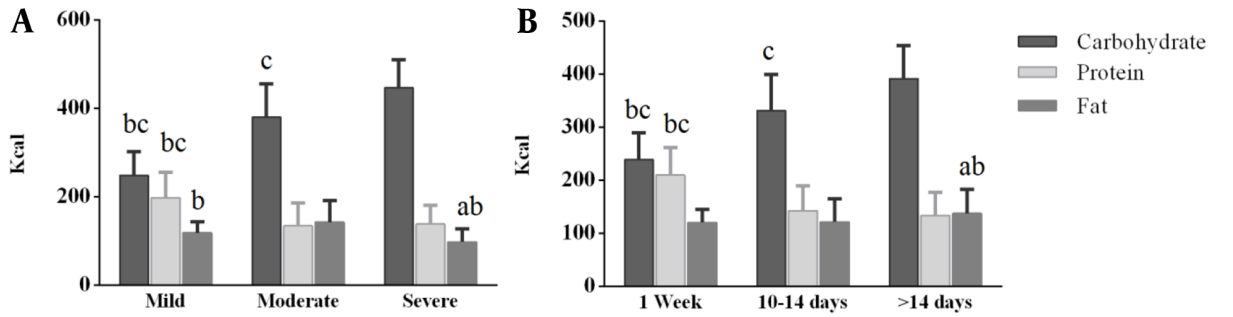

Figure 5. The results of the post-hoc test for severity and convalescence of COVID-19 and macronutrients. a: $P \leq 0.01$ significant difference with mild COVID-19. b: $P \leq 0.01$ significant differences with moderate COVID-19. c: $P \leq 0.01$ significant differences with severe COVID-19.

the logit-transformed outcome, and absence of outliers) were established. A logistic regression model with the 3 predictors was significant for disease severity χ^2 (6, N = 1192) = 86.45, $P < 0.001$, with a Nagelkerke pseudo-R2 of 0.85 and for disease convalescence χ^2 (6, N = 1192) = 56.10, $P < 0.001$, with a Nagelkerke pseudo-R2 of 0.74. The Hosmer-Lemeshow test also showed the model to be acceptable.

Based on the individual regression coefficients, according to the Wald criterion for disease severity, physical activity and sleep quality were significant ($P = 0.012$ and $P < 0.001$, respectively). The odds ratio for this predictor showed that for every unit of increase in physical activity, individuals were 2.18 times more likely to be in the moderate COVID-19 group, and this value was 0.76 for sleep quality (Equation

Equation Moderate COVID-19 = 0.78 (physical activity) - 0.28 (sleep quality)

Based on the individual regression coefficients, according to the Wald criterion for disease convalescence, physical activity and nutrients were significant ($P < 0.001$ and $P < 0.001$, respectively). The odds ratio for this predictor showed that for every unit of increase in physical activity (active), individuals were 0.64 times more likely to be in the 1-week convalescence group, and for every unit of decrease in nutrients (calories), individuals were 0.99 times more likely to be in the 1-week convalescence group (Equation The odds ratio for this predictor showed that for every unit of increase in nutrients, individuals were 1-time more likely to be in the 10 - 14-day convalescence group (Equation

Equation 1-week convalescence of COVID-19 = 0.45 (physical activity) - 0.01 (nutrients)

Equation 10-14-day convalescence of COVID-19 = 0.12 (nutrients)

5. Discussion

COVID-19 and its limitations are among the crises of the present century that have overshadowed the physical and mental health and nutritional status. The results showed that females had more severe COVID-19 with a longer recovery period compared to males. Patients with more active lifestyles had mild-to-moderate COVID-19 with a shorter recovery period (1 week) compared to those with a sedentary lifestyle whose COVID-19 severity was higher. In patients with poor sleep quality and higher carbohydrate intake in the diet, the severity and duration of the disease were higher, and high protein intake reduced the severity and duration of the disease. However, with the consumption of more fat in the diet, although the severity of the disease was reduced, the recovery time was increased. Finally, it can be predicted that with increased physical activity and decreased sleep quality, people are more likely to develop moderate COVID-19. It was shown that with increased physical activity and reduced calories, the possibility of having a 1-week recovery is increased. Finally, as the number of calories increases, the recovery time of the disease increases to 10 - 14 days.

Although various studies have reported higher incidence and mortality among men than women (20, 21), the present study showed that although the incidence is not different in terms of sex, females are more likely to be affected by the severity of the disease and have a longer recovery period. Tavakol et al. (2020) showed that Iranian females have more severe COVID-19 symptoms and a longer recovery period than males (11). This may be due to the state of health care, insurance coverage, and cultural beliefs of Iranian women. On the other hand, the fact that women report more vulnerability to the disease than men is consistent with previous research showing that women are more afraid of pathogens than men (22).

The results of the present study showed that an active

lifestyle and the amount of physical activity are factors that affect reducing the severity (from severe to mild) and length of recovery (below 7 days).

In line with our research, a cross-sectional study of COVID-19 among patients with and without regular physical activity found that patients with regular physical activity were 1.49 times less likely to be hospitalized than those with a sedentary lifestyle. Regular physical activity also reduced the severity of symptoms (23).

In another study, it was stated that physical activity and an active lifestyle can reduce the severity of infection in COVID-19 (24). Many prospective cohort studies have highlighted the role of appropriate physical activity in protecting against serious infections (25, 26). There are biological mechanisms that justify the benefits of immunity through physical activity, such as anti-inflammatory effects and beneficial effects on adaptive immune responses (5, 26). Quarantine and the resulting social isolation can cause major stresses that lead to emotional distress and, eventually, illnesses such as sleep disorders or weakened immune systems (10).

The findings of the present study showed that sleep quality disorders increase the severity of symptoms and the duration of recovery from COVID-19. According to research on COVID-19, the outbreak of the disease has caused anxiety, depression, sleep disorders, and other psychological problems. People with poor sleep quality experienced psychological problems and more involvement with COVID-19, and the symptoms of the disease have been reported to be more severe in these people (19).

Various studies have shown that mental health and sleep enhance immunity. Decreased duration and quality of sleep increase the risk of viral infection (27). Sleep is disrupted by stress, which is induced by activating the hypothalamic-pituitary-adrenal (HPA) axis. Sleep alterations increase such activation and create a vicious cycle between stress and insomnia. Increases in cortisol secretion after HPA activation suppresses pro-inflammatory and antiviral immune responses (19, 28).

Insomnia is associated with increased levels of norepinephrine (which is involved in antitumor responses) and decreased levels of natural killer cells. Insomnia causes abnormal cortisol synthesis, reduces the number and activity of natural killer (NK) cells, and compromises immune function (19, 28). Another factor is nocturnal melatonin levels, which decrease with age. People with poor sleep quality may be more sensitive to COVID-19 because their melatonin levels may be low (9, 27). Disturbances in circadian rhythms increase susceptibility to infection. Chronic stress and sleep deprivation stimulate pro-inflammatory responses and reduce the level and activity of protective immune cells (27). These factors may explain the severity of symptoms and the length of recovery of most patients with poor sleep quality or sleep disorders.

Recent research shows that poor sleep quality and reduced physical activity can disrupt healthy eating patterns (29). Anxiety and boredom due to quarantine are risk factors for consuming more food and lower-quality food compared to standard living conditions. Along with decreased physical activity during the COVID-19 quarantine, eating disorders can lead to disturbed energy balance (30).

Specific nutritional deficiencies may lead to impaired immune function, thereby increasing susceptibility to infectious diseases (30). While no food, nutrient, or dietary supplement can prevent COVID-19, a balanced diet with sufficient amounts of various macronutrients and micronutrients is essential for a well-functioning immune system. High-energy diets and obesity are the main risk factors for a more severe course of COVID-19 (12).

The results of the present study showed that high carbohydrate intake increases the severity of symptoms and the recovery period of COVID-19. Various studies have shown that high-calorie diets can exacerbate pre-inflammatory conditions in patients. Little is known about the relationship between carbohydrates and COVID-19. A high-carbohydrate diet contributes to the prevalence of obesity, insulin resistance, and type 2 diabetes, all of which are risk factors for severe COVID-19 symptoms. High intakes of diets rich in saturated fats, sugars, and carbohydrates activate the innate immune system and impair adaptive immunity, leading to chronic inflammation and impaired host defense against viruses. According to these results, a high-carbohydrate diet may increase the risk of developing COVID-19 symptoms and its length of recovery (31).

Specific nutrients and a combination of nutrients may affect immune function through cell activation and modifying gene expression and the production of signaling molecules. Foods can also affect immune responses through their effects on intestinal microbiota composition (12).

Our research results show that people with a high-protein diet reduce their risk of developing symptoms of severe COVID-19 and a longer recovery period. Little is known about the association between proteins and COVID-19. In one study, mice with protein-calorie malnutrition had lower expressions of IFN-γ, TNF-α, and iNOS in the lung tissue, showing the low ability of the immune system to fight infection and inflammatory diseases (30).

Human research has also shown that protein-energy malnutrition is associated with an increased risk of infectious diseases and a likelihood of increased length of hospitalization, death, and readmission (32). It has been stated that high-protein food sources are highly recommended for people at high risk of infection (33).

In the present study, it was found that the dietary pattern combined with high fat intake reduced the severity of COVID-19 symptoms but increased the length of recovery. Research has shown that consumption of omega-3 fatty acids and short-chain fatty acids, which are metabolic compounds, can reduce the anti-inflammatory effects.

In a study, high-fat ketogenic diets with a carbohydrate restriction (less than 50 grams per day) reduced the severe symptoms of COVID-19 (34).

In the present study, since the type of fat consumed was not considered, it is not possible to provide a suitable analysis of the symptoms of severity and length of recovery from COVID-19. According to the Annual International Congress of the European Society of Clinical Nutrition and Metabolism (ESPEN), it is recommended that patients with COVID-19 have an energy requirement of 27 to 30 kcal per kg of body weight per day, and 1 to 1.3 g per kg of body weight protein should be considered depending on the condition of the disease. The fat-carbohydrate ratio is currently recommended at 30 to 70 for patients without respiratory failure and 50 to 50 for patients with respiratory failure (12, 34).

Reduced physical and social contact and disturbed normal lifestyle (such as less freedom, financial loss, inactivity, sleep disturbance, and unhealthy diet) during the outbreak of COVID-19 have led to changes in lifestyle behaviors. These inappropriate lifestyle behaviors can increase the symptoms of COVID-19 and the length of recovery. In the present study, it was found that physical activity and sleep quality were predictors of COVID-19 severity, and physical activity and dietary patterns were predictors of recovery length among patients with COVID-19.

One of the main limitations of this study is the relatively few participants, which is recommended to be remedied in future studies. Lack of careful monitoring of the subjects' responses to physical activity, dietary behavior, and sleep quality assessment is another limitation that should be considered in future studies. Considering other lifestyle behaviors, such as sociodemographic factors and their relationship with eating, sleeping habits, and the level of physical activity during the pandemic, may prevent the consequences of COVID-19 and help decrease its severity and the length of recovery.

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Footnotes

Authors' Contribution: Fateme Yagmaee and Morteza Taheri are responsible for writing the article, Kahdijeh Irandoust was an assistant editor for the article, and Masoud Mirmoezzi performed the data analysis.

Conflict of Interests: The authors declare no conflict of interest.

Data Reproducibility: Data are available from the first author upon reasonable request.

Ethical Approval: The study was conducted in accordance with the Declaration of Helsinki and approved by the Local Ethics Committee of the Imam Khomeini International University (17628 Imam Khomeini International University).

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Informed Consent: Informed consent was obtained from all the subjects.

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