ORIGINAL ARTICLE

Investigating the Relationship between Nutritional Attitude and Performance with Physical Activity in Patients with COVID-19

Zahra Negarandeh[1], PhD;
Hossein Faramarzi[2], MD;
Siavash Babajafari[3], PhD;
Mohsen Davoodi[4], PhD;
Seyed Ali Hoseini[5], PhD;
Omid Reza Salehi[5], PhD;
Morteza Zare[1], MSc

[1]Nutrition Research Center, Shiraz University of Medical Sciences, Shiraz, Iran
[2]Department of Infectious Diseases, Shiraz University of Medical Siences and Health Services, Shiraz, Iran
[3]Nutrition Research Center, School of Nutrition and Food Sciences, Shiraz University of Medical Sciences, Shiraz, Iran
[4]Department of General Courses, School of Paramedical Sciences, Shiraz University of Medical Sciences, Shiraz, Iran
[5]Department of Sport Physiology, Marvdasht Branch, Islamic Azad University, Marvdasht, Iran

Correspondence:
Hossein Faramarzi,
Depaarment of Infectious Diseases, Shiraz University of Medical Siences, Shiraz, Iran
Tel: +98 9177130387
Email: Hossainfaramarzi@yahoo.com
Received: 14 April 2023
Revised: 16 May 2023
Accepted: 13 June 2023

Abstract

Background: This study aimed to investigate the relationship between nutritional performance and physical activity in patients with COVID-19.

Methods: In this causal-comparative *ex-post facto* study, after obtaining a license from Shiraz University of Medical Sciences, 600 people who volunteered to participate in the present study were selected as the statistical sample. After completing the demographic information and informed consent forms, subjects completed the Nutritional Knowledge Questionnaire and the International Physical Activity Questionnaire (IPAQ). One-sample t-test, Spearman correlation coefficient, Mann-Whitney U and regression tests were used to analyze the data. The data were analyzed using SPSS software version 22, and a significant level of 0.05 for data analysis was considered.

Results: The levels of BMI, nutritional attitude, nutritional knowledge, and nutritional performance of men and women with COVID-19 were unsatisfactory (P≥0.05). Nutritional knowledge scores in women were significantly higher than in men (P≥0.05). With decreasing physical activity, nutritional performance levels increased in women and men; with decreasing nutritional attitudes, physical activity levels increased in men. Also, BMI levels improved with increasing nutritional knowledge scores (P≥0.05).

Conclusion: It seems that lack of proper physical activity, attitude, and poor nutritional performance are the factors affecting the increase in the number of COVID-19 patients; therefore, it is recommended that health centers provide the necessary training on the optimal role of physical activity, attitude, and nutritional performance in the prevention of COVID-19 disease.

Please cite this article as: Negarandeh Z, Faramarzi H, Babajafari S, Davoodi M, Hoseini SA, Salehi OR, Zare M. Investigating the Relationship between Nutritional Attitude and Performance with Physical Activity in Patients with COVID-19. J Health Sci Surveillance Sys. 2023;11(Supplement 3):600-606.

Keywords: Physical activity, Nutritional sciences, COVID-19

Introduction

The amazing spread of acute respiratory disease caused by a new strain of coronavirus (COVID) in late 2019 caused a pandemic of COVID-19 disease.[1] Despite the widespread efforts of health organizations, including the recommendation of personal protective equipment, creating social distance, and personal hygiene, many people still fall victim to the disease worldwide.[2] According to the World Health Organization, 194 million people have been infected with the disease, of which over 4 million have died.[3] According to the first study on patients with COVID-19, the incubation or latency period of the virus was five days on average and ranged from 4 to 7 days. Various health organizations around the world have reported different incubation periods for COVID-19, so the World Health Organization has set a range of 2 to 10 days, the China National Health Commission 10 to 14 days, and the US Center for Disease Control and Prevention 2 to 14 days for this period.[4]

In addition, researchers have pointed out that influencing factors such as age and gender are effective in the incidence and rate of injury caused by the covid-19 disease in such a way that the death rate increases with age, and also men are more likely to die from this disease than women.[5] This study showed that men are more susceptible to contracting and dying from this disease due to differences in lifestyle, smoking, exposure to pollution from hazardous work, and various types of respiratory infections.[5] Many medications have been proposed to treat the patients, each of which has been relatively effective in improving and preventing mortality in these patients depending on age, gender, underlying diseases, and the dose and type of the medication used.[6] According to the researchers, the efficiency of the treatment method and finding the appropriate medication is important in terms of the length of treatment and the ability to prevent death, so the length of medication treatment in these patients under hospitalization and self-care conditions is different, and ranges from 10 to 30 days.[7] Given social changes such as nutritional and physical conditions and restrictions on nutritional counseling in communities, weight gain together with obesity is spreading, which in itself can weaken the immune system and increase the damage caused by this disease.[1] Lymphopenia, a marker of malnutrition, has been reported to be a negative diagnostic factor in patients with COVID-19.[8] It has also been suggested that nutritional interventions can be an important factor in managing COVID-19 patients because most patients experience frequent coughs and dyspnea (shortness of breath) and often require ventilators.[8] Although the nutritional factor is important in these patients, adequate information on the nutritional status of COVID-19 patients in pre-ICU conditions is not yet available.[8] In addition to proper nutrition, researchers believe that regular and moderate physical activity prevents obesity, overweight, and metabolic diseases and creates a positive adaptation in the immune system, making the body resistant to disease and triggering an appropriate response to pathogens. Therefore, the immune system in patients who engage in regular and moderate intensity physical activity has a good efficacy against disease.[9] Although no comprehensive information on the role of nutrition, physical activity, and COVID-19 is available, knowing about the origins of malnutrition and the incidence of metabolic diseases, prevention of obesity and type 2 diabetes, and awareness of proper diet is a very important strategy against the weakening of the immune system.[1] Considering the role of nutrition and physical activity, as well as nutritional knowledge in the incidence of this disease and the lack of sufficient information about the role of these interventions in the treatment of COVID-19, it seems that this study can provide more comprehensive information to improve the patients' conditions. Therefore, this study aimed to investigate the relationship between nutritional performance and physical activity in patients with COVID-19 in Shiraz.

Methods

The present research was conducted as a causal-comparative *ex-post facto* study aiming to investigate the relationship of nutritional knowledge, nutritional habits, and physical activity with the duration of treatment in patients with COVID-19 in Shiraz.

To conduct the research, after obtaining a license from Shiraz University of Medical Sciences, the researcher referred to the hospital managers who were providing services to COVID-19 patients in Shiraz. All the ethical principles of the current research, such as concealment of personal information, voluntary participation in the test, physical and mental ability to complete the questionnaires, etc., were carried out under the supervision of the ethics committee of Shiraz University of Medical Sciences.

After explaining the research steps and obtaining the consent of the managers, the patients' medical records were reviewed, and from among the patients undergoing treatment, 600 people who volunteered to participate in the study were selected as the statistical sample. At the beginning of the research, the authors obtained the written consent from the managers of the referring hospitals and research participants. Due to the difference in the number of people referring to the Shiraz hospitals that were providing treatment services for Covid-19, the sample size in the present study was selected using the stratified sampling method and Morgan's table. Thus the number of samples selected in each hospital depended on the patient population admitted to that hospital. Then, demographic information (age, height, weight, gender, marital status, and …) form and informed consent were delivered to the volunteers. Afterward, their medical records were reviewed, and the drugs' names, doses, amounts of use, and the duration of treatment for each patient, were recorded individually. The Nutritional Knowledge and Nutritional Habits Questionnaires (validity 0.78 and 0.74, respectively) comprising four categories (i.e., demographic information and body composition, knowledge of food groups and their ingredients, attitudes about nutritional issues and related diseases, and nutritional performance in Iran, whose validity and reliability were previously evaluated by Basemi *et al.,* in 2016) were used.[10]

In other words, the first part of the questionnaire evaluated personal information and body composition. The second part contained 31 questions about people's awareness of the classification of food groups and their ingredients. The third part contained 21 questions about the students' attitude to nutritional issues and related diseases, and the fourth part included

eight questions about nutritional practices. Also, the subjects' BMI was obtained by dividing the weight (kilograms) by the square of the height (meters) in terms of kilograms per square meter. Table 1 presents the division of different levels of each component.

Also, the International Physical Activity Questionnaire (IPAQ) was administered among patients and collected after completion. In this research, the physical activity questionnaire, a translation of the short version of the international questionnaire, was used to check the amount of physical activity. This self-report questionnaire consists of seven questions that measure the people's physical activity. This questionnaire considers 3.3 METs of walking, 4 METs of moderate physical activity, and 8 METs of intense physical activity. To calculate the total amount of physical activity per week, the authors added the amount of walking (day×minute×meter) together with the amount of moderate physical activity (day×minute×meter) and of vigorous physical activity (day×minute×meter) per week. According to the formula in the shortened form of the International Physical Activity Questionnaire, MET-min/week, the amount of energy consumption during walking, and moderate and intense activity of the patients were calculated. If the sum of MET-min/week in walking, and moderate and intense activities during seven days were at least 3000 or more, it considered high physical activity, between 600 and 3000 as moderate physical activity, and below 600 as low physical activity. Those who did not report were counted as inactive people.[11] Meanwhile, based on the study of Salikunna *et al.* (2021), the subjects' BMI was divided.[12]

Statistical Analyses

Regarding descriptive statistics, the mean and standard deviation were used to analyze the study data. The authors used the Kolmogorov-Smirnov test to evaluate the normality of the data distribution; along with the Spearman correlation coefficient test as inferential statistics. The Mann-Whitney U test was used to compare data between genders; also, one-sample t-test, one-way analysis of variance with Tukey's *post-hoc* test and Kruskal-Wallis test were used to evaluate the optimal range of variables. The data of this study were analyzed using SPSS software version 22, and a significant level of 0.05 for data analysis was considered.

Results

Table 2 presents the demographic characteristics, mean, and standard deviation of variables in women and men in different age groups. Table 2 presents the frequency and percentage of patients. The results show that 53.5% of patients were male and 47.0% were female; Regarding BMI analysis, it can be stated that 28.1% had a BMI of 25-30 kg/m^2, and 15.5% had a BMI over 30 kg/m^2. Also, 21.5% of patients had low physical activity; interestingly, none of the patients in this study had moderate to high physical activity. Besides, 58.7% of patients had poor nutritional performance, but good nutritional performance was not observed in the subjects. In addition, 99.0% of patients had poor nutritional knowledge. None of the patients had good nutritional knowledge. Also, 3.5% of patients had poor nutritional attitudes, and 95.0% had moderate nutritional attitudes, while none of the subjects in the study had a good nutritional attitude.

Table 1: The score related to the qualitative level of the indicators of nutritional knowledge, nutritional attitude, and nutritional performance

Factor	Good	Medium	Weak
Nutritional knowledge	20-31	11-21	0-10
Nutritional attitude	15-21	8-14	0-7
Nutritional performance	6-8	3-5	0-2

Table 2: Demographic characteristics, mean and standard deviation of the research variables in women and men with COVID-19 in different age groups

		N	Weight (Kg) M±S.D	BMI (Kg/m^2) M±S.D	Physical Activity (Met) M±S.D	Nutritional performance (Score) M±S.D	Nutritional knowledge (Score) M±S.D	Nutritional attitude (Score) M±S.D
Gender	Male	318	70.47±11.28	25.94±12.54	830.65±460.94	2.37±0.84	7.38±1.50	9.22±1.10
	Female	282	71.91±12.57	24.68±3.36	963.83±411.70 ***	2.30±0.85	7.76±1.34 **	9.28±0.92
Age	18-30	153	65.60±11.19	22.75±3.01	1001.88±362.33	2.23±0.94	7.57±1.50	9.16±1.02
	31-45	213	74.53±13.03	25.19±3.01 ***	891.00±493.33	2.41±0.77	7.45±1.53	9.27±0.96
	45-60	90	73.40±8.76	25.66±2.20 ***	851.40±443.43 ##	2.28±0.83	7.83±1.13	9.50±0.78
	61-71	87	70.31±11.72	25.53±3.36 ***	819.31±398.20 ###	2.29±0.86	7.48±1.48	9.08±1.37
	Above 72	15	74.20±9.29	25.75±3.85 ***	693.00±409.89 ###	2.06±0.88	7.63±1.23	9.53±0.76

The results of Tukey's *post- hoc* test showed that the BMI index in all age groups was higher than the age group of 18-30 years ***(P≤0.001). The results of the U Mann-Whitney test showed that the amount of physical activity in women is significantly higher than in men ***(P=0.001) and in the age group of 45-60 ##(P≤0.01), the age group of 61-71 ###(P≤0.001) and 72 and above ###(P≤0.001) are significantly lower than the age group of 18-30. The results of the U Mann-Whitney test showed that the amount of nutritional knowledge in women is significantly higher than that of men **(P≤0.01).

The results of the one-sample t-test showed that BMI levels of men (t=16.07, P=0.001) and women (t=13.40, P=0.001), nutritional performance levels of men (t=-34.30, P=0.001) and women (t=-33.32, P=0.001), nutritional attitude levels of men (t=-20.59, P=0.001) and women (t=-22.08, P=0.001), as well as nutritional knowledge of men (t=-101.78, P=0.001) and women (t=-102.56, P=0.001), were not in the desired range (Table 2).

Also, the results of the Mann-Whitney U test showed that the levels of physical activity in women were significantly higher than in men (Z=-3.29, P=0.001). In addition, the results of the Kruskal-Wallis test showed a significant difference in the levels of physical activity in different age groups (K=17.90, P=0.001). To determine the location of the difference between the age groups, the results of the *post- hoc* test showed that there was no significant difference in the age groups of 18-30 and 31-45 (P=0.07). But in the age group of 45-60 (P=0.007), 61-71 (P=0.001), and above 72 (P=0.003), the levels were significantly less than the age group of 18-30 (Table 2).

The results of the Mann-Whitney U test showed that the scores of nutritional knowledge in women were significantly higher than in men (Z=-3.15, P=0.002). However, there was no significant difference in nutritional knowledge (K=3.45, P=0.48), nutritional performance (K=8.75, P=0.068), and nutritional attitude (K=7.50, P=0.11) in different age groups (Table 2).

Analysis of Nutritional Knowledge, Nutritional Attitude, and Nutritional Performance Based on Physical Activity in Women and Men

The results of the Mann-Whitney U test in Table 3 showed no significant difference in nutritional performance (P=0.90), nutritional knowledge (P=0.88), and nutritional attitude (P=0.32) in men at different levels of physical activity. Also, there was no significant difference in nutritional knowledge (P=0.91) and nutritional attitude (P=0.41) in women at different physical activity levels. However, nutritional performance in women with low physical activity was significantly higher than that of women with moderate activity (P=0.02).

Table 3: Results of nutritional knowledge, nutritional attitude and nutritional performance based on physical activity in women and men

Levels of physical activity	Gender	Nutritional performance	Nutritional knowledge	Nutritional attitude
Low	Male (N=84)	2.38±0.82	7.45±1.28	9.33±0.90
	Female (N=45)	2.53±0.72 **	7.84±1.21	9.32±1.03
	Total (N=129)	2.43±0.78	7.58±1.26	9.32±0.94
Moderate	Male (N=231)	2.36±0.85	7.36±1.57	9.18±1.16
	Female (N=234)	2.25±0.87	7.76±1.36	9.27±0.90
	Total (N=465)	2.31±0.86	7.56±1.48	9.23±1.04

The results of the U Mann-Whitney test showed that nutritional performance in women with low physical activity level is significantly higher than women with moderate physical activity **(P≤0.01).

Table 4: Results of the levels of physical activity and BMI based on nutritional performance, nutritional knowledge, and nutritional attitude in women and men

	Levels	Gender	Levels of Physical activity (Met)	BMI (Kg/m^2)
Nutritional performance	Weak	Male	828.78±472.55	24.91±3.08
		Female	1039.50±406.81 ***	24.82±3.32
		Total	929.64±454.09	24.87±3.20
	Moderate	Male	833.25±446.11	24.53±3.00
		Females	849.32±393.88	24.48±3.42
		Total	840.59±422.27	24.51±3.20
Nutritional knowledge	Weak	Male	828.05±460.83	24.75±3.05
		Female	959.85±403.51	24.63±3.34
		Total	889.69±439.55	24.69±3.19
	Moderate	Males	1485.00±461.59	22.28±3.05
		Females	742.50±1050.05	30.17±1.19
		Total	990.00±857.36	27.54±4.63
Nutritional attitude	Weak	Males	1104.23±411.86 ##	25.87±3.86
		Females	841.50±632.80	23.41±2.50
		Total	1004.14±508.94	24.93±3.55
	Moderate	Males	818.75±459.76	24.70±3.00
		Females	967.19±406.84	24.75±3.39
		Total	889.29±441.31	24.72±3.19

The results of the U Mann- Whitney test showed that the level of physical activity in women with weak nutritional performance is higher compared to women with moderate nutritional performance ***(P≤0.001). It is also higher in men with weak nutritional attitude compared to men with moderate nutritional attitude ##(P≤0.01)

Analysis of the Levels of Physical Activity and BMI Based on Nutritional Performance, Nutritional Knowledge, and Nutritional Attitude in Women and Men

The results of the Mann-Whitney U test in Table 4 showed no significant difference in the levels of physical activity in men with poor and moderate nutritional performance (Z=-0.11, P=0.91); however, the levels of physical activity in women with poor nutritional performance were higher than those with moderate nutritional performance (Z=-4.11, P=0.001).

Also, there was no significant difference in the physical activity levels of men with poor and moderate nutritional knowledge (Z=-1.70, P=0.08). There was no significant difference in the physical activity levels of women with poor and moderate nutritional knowledge (Z=-0.15, P=0.87). Additionally, the levels of physical activity in men with poor nutritional attitudes were significantly higher than in men with moderate nutritional attitudes (Z=-2.48, P=0.01). However, the physical activity levels in women with poor and high nutritional attitudes were not significantly different (Z=-1.12, P=0.26).

Analysis of the Relationship between the Levels of Physical Activity and Nutritional Performance, Nutritional Knowledge, and Nutritional Attitude in Women and Men with COVID-19

The results of the Spearman correlation coefficient test in Table 5 showed a significant and negative relationship between the physical activity levels and nutritional performance in women (P=0.001, r=-0.21).

Also, in general, there was a significant and negative relationship between thephysical activity levels and nutritional performance in men (P=0.003, r=-0.12). The results showed a significant and positive relationship between BMI and nutritional knowledge in women (P=0.04, r=0.12). Also, there was a significant and negative relationship between BMI and nutritional performance (P=0.02, r=-0.09).

Discussion

This study's results showed that BMI levels of 21-25 kg/m^2 and 25-30 kg/m^2 were the most common ones in COVID-19. Notably, people with COVID-19 failed to have moderate to high-intensity physical activity, proper nutritional performance, proper nutritional knowledge, and proper nutritional attitude. Individuals with low and moderate physical activity, nutritional performance, nutritional attitude, and poor and moderate nutritional knowledge comprised the highest number of patients, respectively. According to studies, the US Physical Activity Guide states that 150-minute exercise a week at moderate to high intensity is the best way to keep people healthy. To achieve this goal, people can perform the same exercise duration in different bouts to enjoy its benefits.[13] A sedentary lifestyle and lack of physical activity lead to increased fat mass, impaired metabolism, and increased risk of various diseases.[14, 15] But after the COVID-19 epidemic, the decline in physical activity was incurred due to social distancing policies, leading to physical and mental disorders in human societies.[16] In other words, social quarantine and disorders such as depression, led to changes in people's lifestyles, such as reduced physical activity, unhealthy diet, reduced use of antioxidants, fruits, vegetables, and vitamins, which brought about further problems.[17] According to studies, men seem to be more susceptible to this disease due to being forced to be in workplace with greater sensitivity, and smoke. In addition, it seems that the higher levels of estrogen in women, which is one of the main proteins responsible for the expression of angiotensin-converting enzyme-2 (ACE2), is one of the reasons for less damage in women following this disease; However, due to the new emergence of this disease, more studies are needed in this field.[5, 18] According to the results, the BMI, nutritional attitude, nutritional knowledge, and nutritional performance of men and women with COVID-19 were not optimal. In other words, with increasing age, BMI increased, and physical activity levels decreased. Also, the scores of nutritional knowledge in women were significantly higher than in men. There are studies to confirm this finding; for example, Chesnut *et al*. showed that increasing glucose intake and decreasing physical activity in response to changes in androgen receptors increased the risk of COVID-19-induced mortality and suggested that proper diet along with physical activity by improving glucose homeostasis can reduce the damage caused by COVID-19 disease.[15]

Also, the risk of death from COVID-19 is higher

Table 5: Results of the relationship between the levels of physical activity and nutritional performance, nutritional knowledge and nutritional attitude in women and men with COVID-19

	Gender	BMI	Nutritional performance	Nutritional knowledge	Nutritional attitude
Levels of physical activity	Male	P=0.93, r=-0.005	P=0.63, r=-0.02	P=0.93, r=-0.005	P=0.23, r=-0.06
	Female	P=0.34, r=-0.05	P=0.001, r=-0.21***	P=0.69, r=0.02	P=0.12, r=-0.09
	Total	P=0.97, r=0.002	P=0.003, r=-0.12 **	P=0.48, r=-0.02	P=0.07, r=-0.07
BMI	Male		P=0.06, r=-0.10	P=0.98, r=-0.001	P=0.63, r=-0.02
	Female		P=0.10, r=-0.09	P=0.04, r=0.12 *	P=0.18, r=-0.07
	Total		P=0.02, r=-0.09 *	P=0.18, r=0.05	P=0.57, r=-0.02

Significant Spearman correlation level at ***(P≤0.001), **(P≤0.01), and *(P≤0.05)

in obese people with type 2 diabetes, cardiovascular disease, respiratory disease, and in general, people with underlying disease than in healthy people, so researchers have pointed to the favorable role of physical activity in preventing serious injuries following the disease.[13, 14] Regular exercise, moderate-intensity exercise, and an active lifestyle, by improving body composition, blood fats, and blood pressure can improve cardiovascular health and immune system function and reduce the risk of chronic diseases such as Type 2 diabetes, cardiovascular disease, immune-related diseases, and respiratory infections.[14, 19] On the other hand, the results of Sallis' study showed that the mortality rate of COVID-19 was higher in inactive people and in people with low activity than in those with higher physical activity.[13]

Given the acceleration of the COVID-19 epidemic, limited studies have been conducted on the effects of exercise, diet, and their combination on patients with COVID-19, but in a study, respiratory rehabilitation in patients improved their respiratory function (Aytür, 2020). Another study recommended exercise and an antioxidants-containing diet to prevent COVID-19.[20] In addition, researchers have stated that a regular physical activity and a proper diet improve the quality of people's life with respiratory tract infections (asthma)[21] and cardiovascular patients.[22] Also, the results of the present study showed that the levels of nutritional performance in women with low physical activity were significantly higher than those in women with moderate physical activity.

Physical activity levels were higher in women with poor nutritional performance than in women with moderate nutritional performance. Also, the levels of physical activity in men with poor nutritional attitude were significantly higher than in men with moderate nutritional attitudes. The results showed that by reducing physical activity levels, nutritional performance increased in both men and women. The levels of BMI also improved with increasing nutritional knowledge scores. Therefore, it seems that low awareness of people in the community about the benefits of regular and long-term physical activity as well as their low nutritional knowledge can cause metabolic disorders, reduced antioxidant system efficiency, and reduced immune system function, which is an important factor in the prevalence of epidemics such as COVID-19.

Considering the relationship between physical activity and nutritional performance in women as well as BMI and nutritional performance in men, it seems that failure to evaluate variables such as glycemic indices, fat profile, and inflammatory factors in these patients and the relationship between these factors and the levels of physical activity and nutritional performance are the limitations of the present study. Therefore, it is suggested that the relationship between physiological variables in these patients be evaluated in future studies. Also, given the role of underlying diseases in the rate of damage caused by COVID-19, the lack of evaluation and classification of those (underlying) diseases in the patients involved can be another limitation of the present study. Therefore, it is suggested that in future studies, the relationship between physical activity and nutritional performance should be examined by considering the underlying diseases.

Conclusion

It appears that increasing awareness of the benefits of exercise and proper diet are factors affecting people's health; on the other hand, lack of awareness of the benefits of nutrition and exercise in the community can lead to an increase in the number of deaths and also increase the damage caused by COVID-19.

Acknowledgment

We want to thank all the patients and staff of the hospital who cooperated in conducting the research.

Authors' Contribution

All authors have an equal share in this study.

Conflict of interest: None declared.

References

1 James PT, Ali Z, Armitage AE, Bonell A, Cerami C, Drakesmith H, et al. The Role of Nutrition in COVID-19 Susceptibility and Severity of Disease: A Systematic Review. J Nutr. 2021; 1;151(7):1854-1878. doi: 10.1093/jn/nxab059. PMID: 33982105; PMCID: PMC8194602.

2 Kim H, Rebholz CM, Hegde S, LaFiura C, Raghavan M, Lloyd JF, et al. Plant-based diets, pescatarian diets and COVID-19 severity: a population-based case–control study in six countries. BMJ Nutr Prev Heal. 2021;bmjnph-2021. http://dx.doi.org/10.1136/bmjnph-2021-000272.

3 Yu H, Li J, Bardin S, Gu H, Fan C. Spatiotemporal Dynamic of COVID-19 Diffusion in China: A Dynamic Spatial Autoregressive Model Analysis. ISPRS Int J Geo-Information. 2021;10(8):510. https://doi.org/10.3390/ijgi10080510.

4 Tavakoli A, Vahdat K, Keshavarz M. Novel coronavirus disease 2019 (COVID-19): an emerging infectious disease in the 21st century. ISMJ. 2020;22(6):432–50. DOI: 10.29252/ismj.22.6.432.

5 Ya'qoub L, Elgendy IY, Pepine CJ. Sex and gender differences in COVID-19: More to be learned! Am Hear J Plus Cardiol Res Pract. 2021;3:100011. doi: 10.1016/j.ahjo.2021.100011. Epub 2021 Apr 14. PMID: 34169297;

PMCID: PMC8045422.

6 Bryant A, Lawrie TA, Dowswell T, Fordham EJ, Scott M, Hill SR, et al. Ivermectin for prevention and treatment of COVID-19 infection: a systematic review, meta-analysis and trial sequential analysis to inform clinical guidelines. Am J Ther. 2021; 21;28(4):e434-e460. doi: 10.1097/MJT.0000000000001442. PMID: 34469921; PMCID: PMC8415517.

7 Wang C, Wang Z, Wang G, Lau JY-N, Zhang K, Li W. COVID-19 in early 2021: current status and looking forward. Signal Transduct Target Ther. 2021;6(1):1–14. doi: 10.1038/s41392-021-00527-1. PMID: 33686059; PMCID: PMC7938042.

8 Laviano A, Koverech A, Zanetti M. Nutrition support in the time of SARS-CoV-2 (COVID-19). Nutrition. 2020;74:110834. doi: 10.1016/j.nut.2020.110834. Epub 2020 Apr 2. PMID: 32276799; PMCID: PMC7132492.

9 Chastin SFM, Abaraogu U, Bourgois JG, Dall PM, Darnborough J, Duncan E, et al. Effects of regular physical activity on the immune system, vaccination and risk of community-acquired infectious disease in the general population: systematic review and meta-analysis. Sport Med. 2021;1–14. doi: 10.1007/s40279-021-01466-1. Epub 2021 Apr 20. PMID: 33877614; PMCID: PMC8056368.

10 Basami M, Ebrahim K, Maleki A. The Nutritional Knowledge, Attitude And Practice Of Male Students' Athletes In 2014, Ir- University Games. 2016; 9(1): 1345-1354.

11 Jalili L, Yazdi Zadeh H, Sharifi N, Abedi P, Najar S, Asad Mobini E. The relationship between physical activity and the severity of menopause symptoms in menopausal women in Ahvaz, Iran. Iran J Obstet Gynecol Infertil. 2014;17(98):15–23. DOI: 10.22038/IJOGI.2014.2830

12 Salikunna N, Badaruddin R, Ramadhan M, Hasanuddin H, Towidjojo V. Influence of Jogging on Blood Pressure, Non-Fasting Blood Glucose, Body Mass Index, and Physical Fitness at A Young Age. J Exerc Physiol Online. 2021;24(4):65–74.

13 Sallis R, Young DR, Tartof SY, Sallis JF, Sall J, Li Q, et al. Physical inactivity is associated with a higher risk for severe COVID-19 outcomes: a study in 48 440 adult patients. Br J Sports Med. 2021; 55:1099–1105. doi: 10.1136/bjsports-2021-104080. Epub 2021 Apr 13. PMID: 33849909; PMCID: PMC8050880.

14 Després J-P. Severe COVID-19 outcomes—the role of physical activity. Nat Rev Endocrinol. 2021;1–2. doi: 10.1038/s41574-021-00521-1. PMID: 34112985; PMCID: PMC8191438.

15 Chesnut WM, MacDonald S, Wambier CG. Could diet and exercise reduce risk of COVID-19 syndemic? Med Hypotheses. 2021;148:110502. doi: 10.1016/j.mehy.2021.110502. Epub 2021 Jan 24. PMID: 33529978; PMCID: PMC7830305.

16 Puccinelli PJ, da Costa TS, Seffrin A, de Lira CAB, Vancini RL, Nikolaidis PT, et al. Reduced level of physical activity during COVID-19 pandemic is associated with depression and anxiety levels: an internet-based survey. BMC Public Health. 2021;21(1):1–11. doi: 10.1186/s12889-021-10684-1. Erratum for: BMC Public Health. 2021 Mar 1;21(1):425. PMID: 33781231; PMCID: PMC8006646.

17 Mattioli A V, Sciomer S, Cocchi C, Maffei S, Gallina S. Quarantine during COVID-19 outbreak: Changes in diet and physical activity increase the risk of cardiovascular disease. Nutr Metab Cardiovasc Dis. 2020;30(9):1409–17. doi: 10.1016/j.numecd.2020.05.020. Epub 2020 May 30. PMID: 32571612; PMCID: PMC7260516.

18 Jin J-M, Bai P, He W, Wu F, Liu X-F, Han D-M, et al. Gender differences in patients with COVID-19: focus on severity and mortality. Front public Heal. 2020;152. doi: 10.3389/fpubh.2020.00152. PMID: 32411652; PMCID: PMC7201103.

19 Woods JA, Hutchinson NT, Powers SK, Roberts WO, Gomez-Cabrera MC, Radak Z, et al. Sports Medicine and Health Science. 2020;2(2): 55-64.

20 Trujillo-Mayol I, Guerra-Valle M, Casas-Forero N, Sobral MMC, Viegas O, Alarcón-Enos J, et al. Western dietary pattern antioxidant intakes and oxidative stress: importance during the SARS-CoV-2/COVID-19 pandemic. Adv Nutr. 2021;12(3):670–81. doi: 10.1093/advances/nmaa171. PMID: 33439972; PMCID: PMC7929475.

21 Kuder MM, Nyenhuis SM. Optimizing lifestyle interventions in adult patients with comorbid asthma and obesity. Ther Adv Respir Dis. 2020;14:1753466620906323. doi: 10.1177/1753466620906323. PMID: 32103702; PMCID: PMC7047422.

22 Klimis H, Marschner S, Von Huben A, Thiagalingam A, Chow CK. Predictors of Smoking Cessation in a Lifestyle-Focused Text-Message Support Programme Delivered to People with Coronary Heart Disease: An Analysis From the Tobacco Exercise and Diet Messages (TEXTME) Randomised Clinical Trial. Tob use insights. 2020;13:1179173X20901486. doi: 10.1177/1179173X20901486. PMID: 32063724; PMCID: PMC6987487.