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Symptom Severity and Duration of COVID-19 Are Correlated with the Healthy Eating Index (HEI) Among Hospitalized Elderly Patients

Arezou Khosronia[1], Mehrnaz Morvaridi[2], Naheed Aryaeian[3,4]*, Masoud Roudbari[5]*, Pouya Farokhnezhad Afshar[6]

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Abstract

Background: Coronaviruses belong to a broad group of viruses that can infect both humans and animals, leading to a range of illnesses. To protect the host from pathogenic agents, it is essential to enhance the immune system's efficiency. Proper nutrition of patients reduces the risk of secondary bacterial infections. Therefore, our research aimed to investigate the relationship between the Healthy Eating Index and the severity of symptoms and disease duration in older adults with coronavirus disease 2019 (COVID-19).

Methods: This cross-sectional study was conducted among 200 elderly patients with COVID-19 who were hospitalized at a hospital affiliated with the Social Security Organization in Iran. For patients, the consent form, demographic information, disease-related information, and Food Frequency Questionnaire (FFQ) questionnaire were completed, and diet quality was calculated based on the Healthy Eating Index. Disease symptom severity was also assessed using visual analog scale questionnaires. Descriptive statistics, t tests, chi-square tests, and ordinal logistic regression were used to analyze the data in SPSS 22.0, with $P < 0.05$ indicating statistical significance.

Results: The average age of the study population was 70.3 ± 7.38 years, including 93 women and 107 men. Higher Healthy Eating Index (HEI) scores were significantly associated with greater weight, body mass index (BMI), and nutrient intake, including energy, protein, vitamin D, and riboflavin ($P < 0.05$ for all). Symptom severity varied across HEI quartiles, with significant differences observed in dry cough, sore throat, and headaches ($P < 0.05$). Participants in the highest HEI quartile (Q4) experienced more extended hospitalizations ($P = 0.018$). A sore throat was correlated with weight, BMI, and body circumferences ($P < 0.05$).

Conclusion: Our study found that HEI scores in elderly COVID-19 patients were associated with increased body weight, BMI, and waist circumference, as well as more severe symptoms and longer hospitalizations. This "paradoxical relationship" refers to the unexpected association where better diet quality, despite its known benefits for overall health, was linked to worse COVID-19 outcomes, suggesting that diet quality alone may not mitigate the adverse effects of factors such as obesity and metabolic health in this population.

Keywords: COVID-19, Coronaviruses, Healthy Eating Index, Elderly patients

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Introduction

Coronavirus is one of the main categories of viruses that cause many diseases, including colds of varying severity,

Corresponding authors: *Dr Naheed Aryaeian, aryaeian.n@iums.ac.ir*
Dr Masoud Roudbari, roudbari.m@iums.ac.ir

1. School of Public Health, Iran University of Medical Sciences, Tehran, Iran
2. Department of Nutrition, School of Medicine, Abadan University of Medical Sciences, Abadan, Iran
3. Department of Nutrition Sciences, School of Public Health, Iran University of Medical Sciences, Tehran, Iran
4. Nutritional Sciences Research Center, School of Public Health, Iran University of Medical Sciences, Tehran, Iran
5. Department of Biostatistics, School of Public Health, Iran University of Medical Sciences, Tehran, Iran
6. Department of Gerontology, School of Behavioral Sciences and Mental Health, Iran University of Medical Sciences, Tehran, Iran

↑What is "already known" in this topic:
A healthy diet, as measured by the Healthy Eating Index (HEI), is associated with improved health outcomes and enhanced immune function. However, the relationship between diet quality and coronavirus disease 2019 (COVID-19) outcomes in elderly populations remains unclear.

→What this article adds:
This study demonstrates that elderly patients with higher HEI scores experienced more severe COVID-19 symptoms and more extended hospital stays. Despite the benefits of a healthy diet, factors such as obesity and pre-existing health conditions may exacerbate COVID-19 outcomes. Managing both diet quality and underlying conditions is crucial for improving COVID-19 outcomes in this vulnerable group.

such as Middle East Respiratory Syndrome (MERS) and Acute Respiratory Syndrome (SARS) (1). The World Health Organization (WHO) officially announced the emergence of a novel coronavirus infection, later named SARS-CoV-2, on December 31, 2019, in Wuhan, China (2). Worldwide, this agent has affected vast populations, in some cases, leading to fatalities due to serious complications. In Iran, the prevalence of coronavirus disease 2019 (COVID-19) in the population aged six years and older was estimated at 14.2% from early August 2020 (3).

Typical signs of COVID-19 include elevated temperature, persistent cough without mucus, and exhaustion. Other, less frequent indicators, such as a diminished sense of flavor or aroma, a blocked nose, throat discomfort, and a cranial ache, can impact certain cases (4). The complications of this disease vary in severity among individuals. Lethal outcomes might stem from breathing insufficiency, sudden lung distress syndrome, blood infection with shock, clot formation, or widespread organ breakdown affecting areas like the cardiac, hepatic, or renal systems (5).

The course and severity of COVID-19 are influenced by factors such as demographic characteristics (e.g., age, sex, and ethnicity) and pre-existing health conditions (6). Individuals with comorbidities such as hypertension, diabetes mellitus, and cardiovascular diseases, particularly the elderly, experience markedly higher mortality rates (7). A key concern lies in the elevated death figures for aged persons and individuals with baseline problems such as hypertension, glucose control issues, and vascular disorders. This requires attention to the elderly and those with underlying medical conditions by strengthening the immune system and reducing the risk of infection (8).

Malnutrition and poor nutrition are among the causes of weakening the immune system. Adequate intake of macronutrients (carbohydrates, proteins, and fats), alongside micronutrients (vitamins and minerals), and sufficient hydration contribute to the optimal function of the immune system and may reduce disease severity in viral infections, including COVID-19 (9, 10). Like other body systems, the immune system requires sufficient nutrients to function correctly.

Considering their diverse and vital biological functions, nutrients such as vitamins A, D, E, and C, as well as the B-complex, together with minerals including selenium, zinc, and iron, as well as omega-3 fatty acids, are key contributors to immune enhancement and disease resistance (11, 12). Much evidence shows that diet regulates chronic inflammation (13). Unsaturated fatty acid supplementation positively strengthens the immune system by affecting inflammatory systems such as eicosanoids, pro-inflammatory cytokines, and free radicals (14). Many micronutrients, such as vitamins, calcium, antioxidants, and Q10 supplements, have proven antioxidant properties and reduce oxidative stress, which may exert its beneficial effects by reducing tissue inflammation and damage caused by inflammatory diseases (15). Additionally, diets rich in olive oil, fruits, and vegetables that are high in antioxidants and vitamins are linked to a lower incidence of systemic inflammation and chronic diseases (16). Genetics, living environment, lifestyle, nutrition, and the interaction of these factors significantly influence the immune system's function, and many nutritional studies have been carried out on the function of the immune system (17-20).

According to studies, human immunity and resistance to infection depend largely on nutritional status. Evidence suggests that immune system dysfunction is linked to deficiencies in macronutrients and micronutrients. Therefore, a deficiency or a high intake of all nutrients in the diet can negatively affect immune status (18, 21, 22). Nutritional status significantly impacts the severity and duration of COVID-19 symptoms (23). Adequate energy and protein intake are essential in the human diet to prevent infections and strengthen the immune system. Excessive intake and energy restriction through non-alkaline diets negatively affect the immune system's response to influenza infection. They are associated with a higher risk of viral infections such as influenza and related mortality (24).

In light of the global community's increasing need to mitigate COVID-19 symptoms, disease progression, complications, and mortality, the present study was conducted to investigate the association between the Healthy Eating Index (HEI) and symptom severity and hospitalization in older adults with COVID-19. Given the lack of related studies across different age groups, we specifically focused on elderly patients to examine the association between the severity of COVID-19 symptoms and HEI.

Methods

In compliance with the Declaration of Helsinki, this cross-sectional investigation received ethical approval from the Ethics Committee of Iran University of Medical Sciences (IR.IUMS.REC.1400.1245). The study population consisted of elderly COVID-19 patients who were hospitalized in a hospital affiliated with the Social Security Organization based on predetermined inclusion criteria. At the beginning of the study, we obtained informed consent forms from either the participants themselves or their legal representatives. We ensured the confidentiality of all shared information and allowed participants to withdraw at any point. Additionally, security measures were implemented, such as obtaining signatures and fingerprints on consent forms. The eligibility requirements for participating in the research were outlined as follows: subjects must be older, according to the scientific definition (65 years or older), have a clinical or definitive diagnosis of COVID-19 established by chest CT imaging or PCR testing, and be willing to participate. Participants who suffered from diseases such as cancer, AIDS, etc., people treated with nutritional supplements, answered fewer than 130 questions of the food frequency questionnaire, followed special diets with special restrictions due to the disease, and were unwilling to cooperate were excluded from the study protocol.

Participants were recruited from a single hospital, and inclusion criteria were strictly defined to ensure a representative sample of elderly patients with COVID-19. Those with conditions affecting diet (e.g., cancer, AIDS, or severe dietary restrictions) were excluded to maintain

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homogeneity. The sample size of 200 participants was determined by including all eligible elderly COVID-19 patients hospitalized at the Hospital affiliated with the Social Security Organization during the study period (January–June 2022). This approach ensured the inclusion of all available data, maximizing representativeness and capturing a broad range of dietary patterns and COVID-19 outcomes within the defined population.

Medical records of patients admitted between January and June 2022 were reviewed for data collection. This way, the initial diagnosis, the first nursing assessment of prescribed medications, and paraclinical information were extracted from the files during hospitalization and discharge. During this period, 200 people were eligible to participate in the study. To obtain dietary intake information, a validated semi-quantitative Food Frequency Questionnaire (FFQ) comprising 147 food items was administered by a trained nutritionist to assess participants' usual nutritional habits (25). Reported frequencies were converted into average daily intakes. The energy and nutrient composition (including macronutrients and micronutrients) of Iranian foods was analyzed using the N4 software. A trained nurse measured anthropometric parameters. Weight was recorded with light clothing using a seca digital scale with 0.1 kg accuracy, and height was assessed barefoot with a seca stadiometer, precise to 1 cm, at the time of admission. The body mass index (BMI) was then calculated as the weight in kilograms divided by the height in meters squared.

At the same time as completing the other questionnaires, a questionnaire about the severity of the person's symptoms during the coronavirus infection was completed. The Visual Analog Scale (VAS) was employed for symptom severity, chosen for its simplicity and reliability in elderly populations (26). The VAS assessed symptoms such as dry cough, cough with mucus, chills, sore throat, coryzal symptoms (cold-like symptoms), weakness, muscle pain, headache, and shortness of breath. The scale categorized the frequency of each symptom, allowing for a more nuanced understanding of how often symptoms occurred. The frequency categories typically included: Never (the symptom did not occur), Rarely (the symptom occurred infrequently), Occasionally (the symptom occurred at moderate intervals), Frequently (the symptom occurred regularly), and Very frequently (the symptom occurred very often). For each symptom, participants marked a point on the VAS line to indicate the severity of the symptom they were experiencing at that time. The mark along the scale matched a numerical range spanning 0 to 5, where higher numbers reflected a more vigorous intensity.

The method for measuring diet quality based on the Healthy Eating Index comprises 13 components, calculated in accordance with the central recommendations of the American Dietary Guidelines. HEI was founded in 1955, and the 2015 version is the latest accepted by the world population. The HEI has been validated to identify and assess the association between cumulative diet quality and specific disease outcomes, such as mortality risk from cardiovascular disease. The components of HEI are as follows: The fruit section includes whole fruit and juice portions. Protein sources include red and white meats, poultry, eggs, fish and shellfish, tree nuts, seeds, leguminous plants (such as beans and peas), and soy-based products. Whole grains encompass fractions of legumes, while total vegetable intake includes dark leafy greens and assorted non-starchy vegetables. Fatty acid profiles are determined by the ratio of total polyunsaturated fatty acids (PUFA) and monounsaturated fatty acids (MUFA) to saturated fatty acids (SFA). Added sugars and saturated fatty acids are quantified as a proportion of total energy expenditure, with remaining dietary constituents assessed as density per 1000 kilocalories of energy intake. Five points are awarded for each: Every fruit category (encompassing all fruit varieties), intact fresh fruits (unprocessed), total vegetable groups, leafy greens and legumes, complete protein sources, marine-based proteins, plant-derived proteins, and additional components are awarded 10 points. Nutritional excellence was evaluated using a confirmed semi-quantitative Food Frequency Questionnaire (FFQ), which recorded data on the subjects' habitual dietary intake over the preceding 12 months. Each food group was measured in cups or ounces on the FFQ. This approach enabled us to assess long-term dietary patterns and their relationship with COVID-19 outcomes, rather than focusing on short-term nutritional changes. Although all participants received a standardized hospital diet during their stay, the dietary information analyzed in this study was based on typical pre-hospitalization dietary habits assessed using a validated semi-quantitative FFQ. This method ensured that the HEI reflected long-term nutritional patterns rather than the uniform meals provided in the hospital. To minimize recall errors, participants received assistance from a trained nutritionist during the administration of the questionnaire.

The primary outcomes of this research were the severity of COVID-19 symptoms, as assessed by the VAS, and the duration of hospitalization (in days). The primary exposure was diet quality, quantified using the HEI derived from the FFQ, which reflected dietary intake over the previous year. Predictors included HEI scores and specific components of dietary intake, such as macronutrient and micronutrient levels. Potential confounders accounted for in the analysis included age, sex, BMI, and pre-hospitalization health status. The effect of HEI on COVID-19 outcomes may have been modified by factors such as BMI and pre-existing comorbidities. These factors were identified and controlled for in statistical analyses to isolate the effect of diet quality on outcomes.

Statistical Analysis

Descriptive statistics were presented as mean ± standard deviation for continuous variables and as frequencies with percentages for categorical variables. Group comparisons were made using independent-sample t-tests for normally distributed continuous data and chi-square tests for categorical variables. Symptom severity was classified into five levels (1 = no symptoms, 2 = mild, 3 = moderate, 4 = severe, 5 = very severe). Participants were also categorized according to HEI quartiles. Ordinal logistic regression was used to adjust for confounding factors, including age, sex, BMI, and preexisting health conditions. All documented P values were derived from a two-tailed test, with significance accepted at a threshold of P < 0.05. Statistical computations were executed using SPSS version 22.0 (SPSS Inc). All procedures followed pre-specified frameworks, and datasets underwent dual verification to guarantee precision and uniformity in the presented results.

Results

Two hundred elderly patients with COVID-19 who met the eligibility criteria were enrolled in the study. Completed questionnaires were analyzed to investigate associations between the HEI and both symptom severity and length of hospital stay. The mean age of the participants was 70.3 years (SD = 7.38); the sample consisted of 93 women and 107 men (53.5%). The average BMI was 25.4 ± 4.74 kg/m², and the mean waist circumference was 98.9 ± 16.82 cm. Most participants (68.7%) were married, and the majority had an education level of high school or below (56%). The participants were distributed in the following order in terms of symptoms: 157 people (78.5%) dry cough, 124 people (62%) cough with mucus, 174 people (87%) sore throat, 178 people (89%) weakness, 169 people (89%) had coryzal symptoms (84.5%), 147 people had chills (73.5%), 32 people had muscle pain (16%), 48 people (24%) had headaches, 27 people (13.5%) had shortness of breath.

Table 1 presents the general variables of participants categorized by quartiles of the HEI, showing significant differences across several measures. Participants in the highest HEI quartile (Q4: 70.97-90.21) had significantly higher weight (76.3 ± 11.43 kg, *P* = 0.001), body mass index (BMI, 27.9 ± 4.32 kg/m², *P* = 0.001), waist circumference (106.8 ± 17.36 cm, *P* = 0.001), and hip circumference (105 ± 16.39 cm, *P* = 0.006) compared to those in lower quartiles. Table 2 highlights significant variations in dietary intake among participants categorized by quartiles of the HEI. Participants in the highest quartile (Q4: 70.97-90.21) showed significantly higher intake of energy (3100 ± 980 kcal/day, *P* = 0.01), protein (37.4 ± 5.85 g/day, *P* < 0.001), monounsaturated fatty acids (MUFA, 13.2 ± 3.2 g/day, *P* = 0.04), cholesterol (192.80 ± 150.13 mg/day, *P* < 0.001), and various vitamins and minerals, including vitamin D (0.9 ± 0.68 µg/day, *P* = 0.007), riboflavin (0.9 ± 0.24 mg/day, *P* < 0.001), pyridoxine (0.9 ± 0.13 mg/day,

Table 1. General variables of participants based on the quartiles of healthy eating index

Variable	Quartiles of healthy eating index				*P*-value
	Q1 (37.90-59.34)	Q2 (59.34-65.37)	Q3 (65.37-70.97)	Q4 (70.97-90.21)	
Age, years	70.5 ± 8.18	70.6 ± 33.7	71.9 ± 7.23	68.1 ± 6.37	0.073
Weight, kg	66.1 ± 14.04	67 ± 16.74	68.7 ± 13	76.3 ± 11.43	0.001
Height, cm	164.5 ± 10.60	165.4 ± 9.18	165.5 ± 9.03	165.6 ± 7.38	0.922
Body mass index, kg/m²	24.3 ± 3.99	24.3 ± 5.16	25.1 ± 4.61	27.9 ± 4.32	0.001
Waist circumference, cm	94.4 ± 11.71	95.5 ± 18.02	98.9 ± 17.04	106.8 ± 17.36	0.001
Hip circumference, cm	96.4 ± 9.52	97.7 ± 13.8	98.2 ± 12.26	105 ± 16.39	0.006

Data are presented as mean ± standard deviation.
The statistical test used for continuous variables is ANOVA.
A p-value of less than 0.05 was considered statistically significant.

Table 2. Energy-adjusted dietary intake of participants based on healthy eating index quartiles

Variable	Quartiles of healthy eating index				*P*-value
	Q1 (37.90-59.34)	Q2 (59.34-65.37)	Q3 (65.37-70.97)	Q4 (70.97-90.21)	
Energy, kcal/day	2400 ± 890	2860 ± 970	3020 ± 1650	3100 ± 980	0.011
Carbohydrate, g/day	146.2 ± 19.81	142.56 ± 17.49	142.82 ± 22.27	137.1 ± 16.11	0.124
Fat, g/day	34.7 ± 8.07	35.91 ± 7.97	35.81 ± 7.14	36.9 ± 6.61	0.541
Protein, g/day	30.5 ± 5.99	32.2 ± 6.14	35.91 ± 7.13	37.4 ± 5.85	<0.001
SFA, g/day	10.7 ± 3.2	10.8 ± 2.39	11.00 ± 3.39	11.6 ± 3.17	0.545
MUFA, g/day	11.4 ± 3.35	12.1 ± 3.41	12.7 ± 3.27	13.2 ± 3.2	0.041
PUFA (omega-6), g/day	7.6 ± 2.93	8.1 ± 3.36	7.5 ± 2.1	7.61 ± 2.35	0.643
PUFA (omega-3), g/day	0.4 ± 0.26	0.5 ± 0.24	0.5 ± 0.21	0.5 ± 0.22	0.441
Cholesterol, mg/day	100.67 ± 47.08	117.80 ± 97.68	136.51 ± 103.58	192.80 ± 150.13	<0.001
Caffeine, mg/day	43.3 ± 45.19	44.5 ± 42.19	47.8 ± 40.88	56.2 ± 44.62	0.432
Vitamin C, mg/day	61.2 ± 34.41	68.8 ± 40.12	77.9 ± 42.03	75.2 ± 32.61	0.125
Vitamin A, µg/day	234.8 ± 190.75	285.3 ± 194.98	330.3 ± 199.63	399.5 ± 165.31	<0.001
Vitamin E, mg/day	5.7 ± 2.16	5.9 ± 2.5	5.7 ± 1.7	5.7 ± 2.03	0.971
Vitamin D, µg/day	0.5 ± 0.4	0.6 ± 047	0.9 ± 0.68	0.8 ± 0.49	0.007
Thiamine, mg/day	0.8 ± 0.15	0.7 ± 0.13	0.8 ± 0.15	0.7 ± 0.12	0.032
Riboflavin, mg/day	0.7 ± 0.21	0.8 ± 0.21	0.8 ± 0.22	0.9 ± 0.24	<0.001
Niacin, mg/day	9.3 ± 1.71	9.2 ± 1.88	9.7 ± 1.8	9.6 ± 1.84	0.456
Pyridoxine, mg/day	0.7 ± 0.17	0.8 ± 0.17	0.8 ± 0.18	0.9 ± 0.13	<0.001
Folic acid, µg/day	237 ± 44.95	232.1 ± 45.15	229.5 ± 53.32	236.6 ± 42.27	0.821
Iron, mg/day	7 ± 2.02	8 ± 6.7	10.2 ± 7	16.2 ± 10.87	<0.001
Calcium, mg/day	420.9 ± 134.34	451.6 ± 155.28	487.1 ± 140.26	577.00 ± 199.67	<0.001
Potassium, mg/day	1424.2 ± 277.84	1610.2 ± 455.63	1791.7 ± 438.77	2070.1 ± 491.91	<0.001
Magnesium, mg/day	138.5 ± 29.35	151.7 ± 31.65	173.2 ± 38.35	197.00 ± 32.21	<0.001
Zinc, mg/day	4.0 ± 0.95	4.4 ± 1.04	5.2 ± 1.29	5.7 ± 1.07	<0.001

Data are presented as mean ± standard deviation.
The statistical test used for continuous variables is ANOVA.
A p-value of less than 0.05 was considered statistically significant.
Abbreviations: SFA (Saturated fatty acids), MUFA (Monounsaturated fatty acids), PUFA (Polyunsaturated fatty acids)

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Table 3. Severity of participants' COVID-19 symptoms based on quartiles of healthy eating index

Variable		Quartiles of healthy eating index				*P*-value
		Q1 (37.90-59.34)	Q2 (59.34-65.37)	Q3 (65.37-70.97)	Q4 (70.97-90.21)	
Dry cough	Never	27%	24.3%	29.7%	18.9%	0.048*
	Rarely	33.3%	21.1%	33.3%	12.3%	
	Occasionally	23.9%	31.3%	13.4%	31.3%	
	Frequently	17.2%	20.7%	27.6%	34.5%	
	Very frequently	0%	20%	30%	50%	
Cough with mucus	Never	18.4%	23.7%	28.9%	28.9%	0.671*
	Rarely	26.2%	27.9%	19.7%	26.2%	
	Occasionally	26.2%	23.8%	26.2%	23.8%	
	Frequently	46.7%	20%	20%	13.3%	
	Very frequently	33.3%	33.3%	33.3%	0%	
Chills	Never	24.5%	26.4%	22.6%	26.4%	0.964*
	Rarely	24.5%	22.6%	30.5%	22.6%	
	Occasionally	23.6%	25%	23.5%	27.9%	
	Frequently	33.3%	25%	25%	16.7%	
	Very frequently	0%	50%	0%	50%	
Sore throat	Never	34.6%	15.4%	34.6%	15.4%	0.022*
	Rarely	26.4%	27.8%	22.2%	23.6%	
	Occasionally	24.6%	30.8%	29.2%	15.4%	
	Frequently	20.7%	13.8%	17.2%	48.3%	
	Very frequently	0%	25%	12.5%	62.5%	
Coryzal symptoms	Never	32.3%	22.6%	25.8%	19.3%	0.183*
	Rarely	20.5%	27.7%	24.1%	27.7%	
	Occasionally	28.1%	21.1%	19.3%	31.6%	
	Frequently	26.9%	30.8%	30.8%	11.5%	
	Very frequently	0%	0%	100%	0%	
Weakness	Never	50%	27.3%	13.6%	9.1%	0.052*
	Rarely	25%	26.9%	17.3%	30.8%	
	Occasionally	23.2%	21.7%	31.9%	23.2%	
	Frequently	15.4%	28.8%	30.8%	25%	
	Very frequently	40%	0%	0%	60%	
Muscle pain	Never	40.6%	28.1%	21.9%	9.4%	0.223*
	Rarely	35.7%	19%	23.8%	21.4%	
	Occasionally	19.6%	25.5%	25.5%	29.4%	
	Frequently	14.9%	25.4%	28.4%	31.3%	
	Very frequently	25%	37.5%	12.5%	25%	
Headache	Never	44.2%	4.7%	25.6%	25.6%	0.007*
	Rarely	19%	33.3%	28.6%	19%	
	Occasionally	27.9%	32.6%	23.3%	16.3%	
	Frequently	12.2%	26.8%	22%	39%	
	Very frequently	20%	20%	20%	40%	
Shortness of breath	Never	44.4%	25.9%	22.2%	7.5%	0.039*
	Rarely	30.8%	25%	26.9%	17.3%	
	Occasionally	21.4%	28.6%	25.7%	24.3%	
	Frequently	10.8%	21.6%	27%	40.5%	
	Very frequently	20%	20%	20%	40%	
Hospitalization days		6.86 ± 1.79	7.64 ± 2.76	8.02 ± 1.94	8.2 ± 2.45	0.018#

Data are presented as percentages.
*The statistical test used for categorical variables is the Chi-square test.
#The statistical test used for continuous variables is ANOVA.
A p-value of less than 0.05 was considered statistically significant.

P < 0.001), iron (16.2 ± 10.87 mg/day, *P* < 0.001), calcium (577.00 ± 199.67 mg/day, *P* < 0.001), potassium (2070.1 ± 491.91 mg/day, *P* < 0.001), magnesium (197.00 ± 32.21 mg/day, *P* < 0.001), and zinc (5.7 ± 1.07 mg/day, *P* < 0.001).

Table 3 presents the severity of COVID-19 symptoms among participants categorized by quartiles of the HEI. Significant differences (*P* < 0.05) are observed in several symptoms across these quartiles. The frequency of dry cough varied significantly among HEI quartiles (*P* = 0.048). The highest frequency was observed in Q4 (70.97-90.21), with 50% of participants experiencing dry cough "very frequently." There was a notable difference in sore throat occurrences across HEI quartiles (*P* = 0.022). Q4 had the highest percentage (62.5%) of participants reporting frequent sore throat. The incidence of weakness showed borderline significance (*P* = 0.05). Q4 participants reported the highest frequency (60%) of experiencing weakness "very frequently." The occurrence of headaches significantly differed across quartiles (*P* = 0.007). Q4 showed the highest frequency, with 40% of participants experiencing headaches "very frequently." There was a significant variation in shortness of breath (*P* = 0.039). The highest frequency was observed in Q4, with 40.5% reporting frequent shortness of breath. Participants in higher HEI quartiles had longer hospitalization durations, with a significant difference (*P* = 0.018). Q4 participants had the longest average hospitalization, at 8.2 days.

Table 4 presents correlations between clinical symptoms and anthropometric measures. Dry cough showed no sig-

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Table 4. The relationship between COVID-19 symptoms and anthropometric measurements

Variable		Weight	Height	BMI	WC	HC
Dry cough	ρ	0.092	0.026	0.046	0.136	0.101
	P-value	0.195	0.717	0.519	0.055	0.155
Cough with mucus	ρ	-0.210	-0.028	-0.167	-0.141	-0.133
	P-value	0.003	0.694	0.018	0.046	0.061
Chills	ρ	0.128	0.061	0.085	0.075	0.064
	P-value	0.070	0.391	0.232	0.291	0.368
Sore throat	ρ	0.153	-0.001	0.181	0.146	0.153
	P-value	0.030	0.992	0.010	0.039	0.031
Coryzal symptoms	ρ	-0.004	0.004	0.007	-0.034	-0.068
	P-value	0.957	0.959	0.927	0.631	0.336
Weakness	ρ	0.120	0.031	0.089	0.063	-0.015
	P-value	0.091	0.664	0.211	0.372	0.835
Muscle pain	ρ	0.045	0.067	0.020	0.022	0.001
	P-value	0.531	0.343	0.778	0.756	0.993
Headache	ρ	0.063	0.008	0.063	0.071	0.060
	P-value	0.373	0.914	0.376	0.320	0.399
Shortness of breath	ρ	-0.020	-0.111	0.026	0.008	0.076
	P-value	0.778	0.118	0.719	0.908	0.283

Spearman's rho (ρ) denotes the Spearman rank correlation coefficient.
P-value indicates the significance level of the correlation.
A p-value of less than 0.05 was considered statistically significant.
Abbreviations: BMI (Body mass index), WC (Waist circumference), HC (Hip circumference)

Table 5. Multivariable ordinal logistic regression analysis of the association between COVID-19 symptoms and quartiles of healthy eating index

Variable	Quartiles of healthy eating index				P for trend
	Q1 (37.90-59.34)	Q2 (59.34-65.37)	Q3 (65.37-70.97)	Q4 (70.97-90.21)	
Dry cough					
Model 0	Ref.	0.45 (-0.25, 1.16)	0.11 (-0.59, 0.81)	0.09 (0.36, 1.81)	0.008
Model 1	Ref.	0.41 (-0.29, 1.12)	0.09 (-0.61, 0.80)	1.05 (0.30, 1.80)	0.062
Cough with mucus					
Model 0	Ref.	-0.43 (-1.14, 0.28)	-0.58 (-1.29, 0.12)	-0.77 (-1.49, -0.05)	0.022
Model 1	Ref.	-0.41 (-1.13, 0.30)	-0.50 (-1.22, 0.21)	-0.61 (-1.36, 0.14)	0.033
Chills					
Model 0	Ref.	-0.05 (-0.76,0.65)	-0.10 (-0.81, 0.60)	-0.11 (-.82, 0.59)	0.737
Model 1	Ref.	-0.08 (-0.79, 0.62)	-0.17 (-0.89, 0.53)	-0.23 (-0.97, 0.50)	0.603
Sore throat					
Model 0	Ref.	0.36 (-0.35, 1.07)	0.14 (-0.56, 0.86)	1.01 (0.29, 1.74)	0.010
Model 1	Ref.	0.35 (-0.36, 1.07)	0.08 (-0.63, 0.80)	0.91 (0.16, 1.66)	0.039
Coryzal symptoms					
Model 0	Ref.	0.004 (-0.53, 0.89)	0.17 (-0.53, 0.89)	0.36 (-0.35, 1.07)	0.201
Model 1	Ref.	0.02 (-0.69, 0.74)	0.22 (-0.49, 0.94)	0.38 (-0.35, 1.13)	0.569
Weakness					
Model 0	Ref.	0.47 (-0.23, 1.18)	0.88 (0.16, 1.60)	0.75 (0.03, 1.46)	0.015
Model 1	Ref.	0.47 (-0.24, 1.19)	0.83 (0.11, 1.56)	0.65 (-0.08, 1.39)	0.058
Muscle pain					
Model 0	Ref.	0.79 (0.08, 1.50)	0.78 (0.77, 1.49)	1.15 (0.43, 1.87)	0.002
Model 1	Ref.	0.76 (0.05, 1.48)	0.77 (0.05, 1.48)	1.19 (0.44, 1.94)	0.034
Headache					
Model 0	Ref.	1.00 (0.29, 1.72)	0.49 (-0.21, 1.20)	1.01 (0.30, 1.73)	0.041
Model 1	Ref.	1.06 (0.34, 1.78)	0.42 (-0.28, 1.14)	1.09 (-0.04, 0.06)	0.058
Shortness of breath					
Model 0	Ref.	0.58 (-0.12, 1.29)	0.67 (-0.03, 1.39)	1.61 (0.87, 2.34)	<0.001
Model 1	Ref.	0.65 (-0.06, 1.37)	0.73 (0.01, 1.45)	1.71 (0.94, 2.48)	0.001
Hospitalization days					
Model 0	Ref.	0.47 (-0.26, 1.21)	0.90 (0.15, 1.65)	1.04 (0.29, 1.79)	0.002
Model 1	Ref.	0.47 (-0.26, 1.22)	0.90 (0.14, 1.65)	1.20 (0.41, 1.98)	0.004

Model 0: Ordinal logistic regression analysis without adjustment.
Model 1: Ordinal logistic regression analysis with age, sex, and body mass index.
A p-value of less than 0.05 was considered statistically significant.

nificant association with weight, height, BMI, waist circumference, or hip circumference (all $P > 0.05$). By contrast, productive cough (cough with mucus) was inversely correlated with weight (ρ = −0.210, $P = 0.003$), BMI (ρ = −0.167, $P = 0.018$), and waist circumference (ρ = −0.141, $P = 0.046$). In contrast, correlations with height (ρ = −0.028, P = 0.694) and hip circumference (ρ = −0.133, $P = 0.061$) were not statistically significant.

There was no significant relationship between chills and any anthropometric variable ($P > 0.05$). Sore throat demonstrated small but significant positive correlations with weight (ρ = 0.153, $P = 0.030$), BMI (ρ = 0.181, $P = 0.010$), waist circumference (ρ = 0.146, $P = 0.039$), and hip circumference (ρ = 0.153, $P = 0.031$); height was unrelated to sore throat (ρ = −0.001, $P = 0.992$). Finally, coryzal symptoms, generalized weakness, myalgia, headache, and shortness of breath showed no significant associations with weight, height, BMI, waist circumference, or hip circumference (all $P > 0.05$).

The multivariable ordinal logistic regression analysis

(Table 5) found associations between HEI quartiles and various COVID-19 symptoms and hospitalization duration. A dry cough showed a positive association with higher HEI quartiles in the unadjusted model (Ptrend = 0.008), but this association became borderline after adjustment (*P* trend = 0.062). Cough with mucus had a significant inverse trend across HEI quartiles, which remained after adjustment (*P* trend = 0.033). Sore throat and muscle pain were positively associated with higher HEI quartiles in both models (*P* trend < 0.05). Shortness of breath and hospitalization duration also showed positive associations with higher HEI quartiles (*P* trend < 0.05). No significant trends were found for chills, coryzal symptoms, weakness, or headache after adjustment.

Discussion

In this study of 200 elderly patients with COVID-19, we investigated the relationship between the Healthy Eating Index (HEI) and symptom severity and hospitalization duration. Participants in the highest HEI quartile displayed higher weight, BMI, waist circumference, and hip circumference than those in lower quartiles. These individuals also had significantly greater intakes of energy, protein, monounsaturated fatty acids, cholesterol, and several essential vitamins and minerals. Notably, those in the highest HEI quartile reported more frequent and severe symptoms, including dry cough, sore throat, weakness, headaches, and shortness of breath, and experienced more extended hospital stays. Specific symptoms such as sore throat and cough with mucus were associated with higher body weight, BMI, and waist circumference. Overall, while higher HEI scores were linked to greater symptom severity and more extended hospitalization, the relationships between dietary intake, physical measurements, and COVID-19 outcomes underscore the complex interaction of these factors in elderly patients.

Hospitalization Duration

Several studies have shown that diet significantly impacts the length of stay in these patients in the intensive care unit (ICU) (27-31). One of the key findings of our study was the significant association between the number of days of hospitalization and HEI in elderly patients. Parastouei et al carried out a cross-sectional analysis among military personnel infected with COVID-19. Their results suggested that adherence to HEI-2015 was inversely associated with ICU admission and hospital stay duration, although the associations did not reach statistical significance (32). Similarly, research examining the dietary inflammatory index (DII) in relation to COVID-19 severity found a positive association between the empirical DII (EDII) and C-reactive protein (CRP) concentrations, as well as a significant relationship with disease severity. Patients adhering to a pro-inflammatory dietary pattern demonstrated a higher risk of COVID-19 (33). The extended hospital stays observed in participants with higher HEI scores and larger body measurements suggest that while a higher-quality diet may contribute to better general health, it does not necessarily confer protection against severe COVID-19 outcomes in the elderly. This is consistent with studies showing that obesity and related comorbidities are significant risk factors for prolonged hospitalizations and increased severity of illness (34-36).

Symptom Severity and Dietary Intake

The observation that those in the highest HEI quartile reported more frequent and severe symptoms, such as dry cough, sore throat, weakness, headaches, and shortness of breath, aligns with findings that suggest a complex interaction between nutritional status, immune function, and disease progression (21). While good nutrition is crucial for maintaining immune function, excessive intake of specific nutrients, especially in individuals with obesity, may exacerbate inflammatory responses, potentially worsening symptoms (37). Merino et al. conducted a study to examine the relationship between diet quality and the severity of COVID-19, as well as their interaction with socioeconomic disadvantage. The results were consistent with our findings, showing that a healthy diet, including vegan foods, is associated with a lower risk and lower severity of COVID-19. Furthermore, this association may be particularly evident among people living in areas of higher socioeconomic deprivation (38). Another investigation on prediagnosis dietary patterns in patients who had recovered from COVID-19 revealed that unhealthy dietary habits were significantly correlated with more severe illness, longer hospitalization, and delayed recovery (39). These findings align with our results, underscoring the significance of dietary quality in influencing disease outcomes. In addition, Singh et al. reported that diets rich in saturated fats, sugars, and refined carbohydrates impaired innate immune function, whereas balanced dietary patterns played a protective role against COVID-19 complications. For this reason, it has been found that people who are obese and consume saturated fats and sugars are at risk of infection and the severity of symptoms (40).

Although the precise mechanisms remain unclear, evidence suggests that healthy dietary patterns are inversely associated with inflammatory biomarkers, whereas Western-style diets exhibit the opposite trend. For instance, lower CRP levels are consistently observed in individuals with healthier diets (41-44). A higher DII score has been linked with increased COVID-19 severity, most likely due to the pro-inflammatory effects of such diets on systemic inflammation (45). Nutrients with anti-inflammatory potential, such as vitamins C and E, and carotenoids, are associated with lower DII values and may act by modulating transcription factors like NF-κB (33). Taken together, anti-inflammatory foods appear to be a practical strategy for mitigating the severity of COVID-19 infection, given their low DII scores, antioxidant activity, and potential antimicrobial and immunomodulatory properties.

Elevated inflammatory cytokines, particularly CRP, represent an important biological mechanism explaining the direct association between pro-inflammatory diets and adverse COVID-19 outcomes (46, 47).

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Dietary Quality, Specific Symptoms, and Anthropometric Measurements

Participants in the highest HEI quartile had higher weight, BMI, waist circumference, and hip circumference. This finding is consistent with previous research, which indicates that better dietary quality is often associated with higher overall energy intake and larger body size (48-50). The increased intake of energy, protein, monounsaturated fatty acids, cholesterol, and essential vitamins and minerals among these individuals could reflect a more nutrient-dense diet. However, it is also possible that higher body weight and related measurements in these participants contributed to the severity of COVID-19 symptoms and longer hospitalization durations, given the well-documented links between obesity and adverse COVID-19 outcomes (51).

The association of specific symptoms, such as sore throat and cough with mucus, with higher body weight, BMI, and waist circumference further highlights the potential role of obesity in COVID-19 symptomatology. These symptoms may be more pronounced in individuals with higher body fat, which can influence respiratory function and inflammatory status (52).

Implications for Elderly COVID-19 Patients

The complex relationship between dietary intake, anthropometric measurements, and COVID-19 outcomes underscores the need for a tailored approach to nutrition in elderly patients, particularly those with higher BMI and related health issues. Interventions that focus on improving dietary quality and managing weight and related metabolic factors may be essential for mitigating severe COVID-19 symptoms and reducing hospitalization durations in this vulnerable population. It has been suggested that public education during the COVID-19 pandemic should encourage older adults to consume healthier foods—such as vegetables, fruits, and vegetable oils, particularly olive oil—and to reduce the intake of fast food, sweets, simple sugars, and saturated fats. Foods with a lower inflammatory index may play a positive role in reducing the severity of symptoms and shortening the recovery period from COVID-19. There is a need to design prospective and interventional studies on the inflammatory effects of nutritional supplements on the severity of COVID-19 symptoms, prevention, reduction of complications, and treatment of the disease.

Strengths and Limitations

To the best of our knowledge, the present research is the first to specifically evaluate the relationship between HEI, symptom severity, and length of hospitalization in an elderly population with COVID-19. One limitation of this study was the use of the FFQ questionnaire, which was time-consuming and difficult for participants to complete, resulting in reports that contained errors. To minimize errors, the research team consulted a trained nutritionist. Furthermore, due to the limited financial resources allocated to the research project, several laboratory indices were not measured, including immunoglobulins, albumin, prealbumin, and inflammatory markers. Additionally, symptom severity was assessed using the VAS, which, although simple and suitable for elderly patients, may lack the standardization of other validated tools, such as NEWS or COVID-GRAM. Although comorbidities and physical activity levels can influence COVID-19 outcomes, they were not included as primary variables in this analysis to maintain a focused investigation on the direct relationship between diet quality (HEI) and anthropometric measurements. Future studies should consider the potential impact of comorbidities and physical activity levels on these relationships.

Conclusion

Our study revealed that individuals with higher HEI scores exhibited increased body weight, BMI, and waist circumference, as well as higher energy intake, protein, and specific nutrients. Unexpectedly, this group also experienced more severe COVID-19 symptoms and longer durations of hospitalization. Symptoms such as sore throat and cough were mainly associated with higher body weight and BMI. These findings highlight a paradoxical relationship between high dietary quality, as measured by the HEI, and adverse COVID-19 outcomes in elderly patients. This suggests that although proper nutrition is crucial, it must be complemented by effective weight management and overall metabolic health to achieve optimal outcomes. These findings underscore the need for tailored nutritional strategies and weight management in clinical and public health interventions to improve outcomes for elderly patients during pandemics. Future research should delve deeper into these interactions to develop tailored nutritional strategies for elderly populations during pandemics.

Authors' Contributions

A.K.: data collection; M.M.: manuscript drafting; N.A.: project supervision and substantial contribution to study conception; M.R.: project supervision, data analysis, and interpretation; P.F.A.: contribution to study conception.

Ethical Considerations

This study was approved by the Research Ethics Committee of Iran University of Medical Sciences (IR.IUMS.REC.1400.1245) in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants, and participants were assured that their personal information would be kept confidential.

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Conflict of Interests

The authors declare that they have no competing interests.

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