Adherence to Healthy Eating Index-2015 and severity of disease in hospitalised military patients with COVID-19: a cross sectional study

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ABSTRACT

Introduction Proper nutrition can play an important role in preventing and improving disease progression in patients with COVID-19. The Healthy Eating Index-2015 (HEI-2015) is one of the most common measures used to assess overall nutritional quality. This research aimed to identify the relationship between the HEI-2015 score and disease severity in hospitalised military patients with COVID-19.

Methods This cross-sectional study was conducted in 295 hospitalised military patients (retired military and military reserve) with COVID-19. A validated food frequency questionnaire was used to assess food intake. To evaluate the quality of the diet, the HEI-2015 score was calculated. A multiple logistic regression analysis was performed to measure the association between HEI-2015 scores and disease severity (intensive care unit (ICU) admission and length of hospital stay greater than 4 days) in hospitalised military patients with COVID-19.

Results The mean HEI-2015 score was significantly higher in non-ICU patients than in ICU patients (58.39±15.02 vs 53.54±15.65, p=0.01). After adjusting for possible confounding factors including age, sex, comorbidities, calorie intake, body mass index and physical activity, adherence to HEI-2015 inversely related to ICU admission (OR 0.98; 95% CI 0.95 to 1.00) and length of hospital stay of more than 4 days (OR 0.99; 95% CI 0.97 to 1.00) in hospitalised military patients with COVID-19, although statistically not significant.

Conclusions According to the results of the study, adherence to HEI-2015 inversely related to both ICU admission and length of hospital stay in hospitalised military patients with COVID-19, although it was not statistically significant.

INTRODUCTION

COVID-19 is a highly contagious disease caused by a new coronavirus which has different variants with various transmission rate.1 The severity of COVID-19 can be influenced by several factors such as age, sex, ethnicity and comorbidities.2 The clinical signs of COVID-19 range from asymptomatic infections to severe acute respiratory syndrome and death.3 Approximately 30% of patients with COVID-19 are admitted to the intensive care unit (ICU).4 The mortality rate for hospitalised patients with COVID-19 is around 15%, and for patients admitted to the ICU, it is 37%.5 The risk of death is higher in older people with comorbidities such as diabetes mellitus, high blood pressure and kidney disease.6 Although treatment strategies for COVID-19 disease are very important, the most important way to prevent the spread of COVID-19 is through an effective and safe vaccine that is widely available.7 An increased function of the immune system is of crucial importance for defence against viral infections of the respiratory tract.8 Maintaining a healthy eating pattern that includes all essential nutrients is vital for health. The importance of a healthy diet to boost immunity and reduce disease has been known for many years. Nutritional status and some nutrients have a positive effect on patients with COVID-19.9

Few studies were performed on diet quality in patients with COVID-19. To our knowledge, this is the first study to examine the association between the Healthy Eating Index-2015 (HEI-2015) score and severity of illness in hospitalised military patients with COVID-19.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ To our knowledge, this is the first study to examine the relationship between the Healthy Eating Index-2015 (HEI-2015) score and severity of illness in hospitalised military patients with COVID-19.

WHAT THIS STUDY ADDS

⇒ The mean HEI-2015 score was significantly higher in non-intensive care unit (ICU) patients than in ICU patients.

⇒ Adherence to HEI-2015 inversely related to ICU admission and length of hospital stay of more than 4 days in hospitalised military patients with COVID-19, although it was not statistically significant.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ It appears that a diet rich in fresh fruits and vegetables, whole grains, protein foods, dairy products and healthy fats could be effective in reducing the severity of COVID-19 disease.

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disease (ICU admission and length of hospital stay) in hospitalised military patients with COVID-19.

METHODS

Study population
This cross-sectional study was conducted from May to November 2020. Patients participating in the present study were retired military and military reserve. All (295) hospitalised military patients with COVID-19 at Valiasr Hospital in Tehran during the mentioned period were entered into the study by census. The inclusion criterion was hospitalisation due to COVID-19 (confirmed by PCR) and the exclusion criteria were: not completing the questionnaires, and patients whose reported energy intake was ≤500 kcal/day or ≥5000 kcal/day.

Personal data were collected via a questionnaire and information on the disease (length of hospital stay, signs and symptoms, comorbidities and admission to ICU) was extracted from the patients’ records.

At the beginning of the study, the participants received a description of the research purpose and written consent was obtained from all.

Anthropometric and physical activity measurements
Weight was measured with the Seca digital scale (Seca, Germany) with minimal clothing, no shoes and an accuracy of 100 g. Height was measured with the Seca stadiometer (Seca) with a precision of 0.5 cm. Body mass index (BMI) was calculated dividing the weight (kg) by the height (m²).

To assess physical activity, all patients completed a reliable and valid scaled questionnaire, which was divided into nine multiple metabolic equivalents (MET) levels.

Diet assessment
A valid semiquantitative food frequency questionnaire (FFQ) including 147 foods was applied to gather common nutritional information from patients. The frequency of consumption of each item (daily, weekly, monthly and yearly) was obtained by a trained nutritionist through interviews and then converted into the average daily intake. Dietary energy intake, as well as macronutrient and micronutrient intake were determined with the modified nutritionist IV for Iranian foods (First Databank Inc., San Bruno, CA, USA).

Nutritional quality was computed in terms of HEI-2015, which included 13 components. The HEI-2015 as the latest version globally recognised is a measure to evaluate overall nutritional quality and adherence to dietary guidelines for Americans. Items are divided into two categories based on classification: total fruits (whole fruits and fruit juice), whole fruits, total vegetables, greens and beans, total protein foods, and seafood and plant proteins (seafood, nuts, seeds, legumes (beans and peas) and soy products) (five points each) and dairy, whole grains and fatty acids (polysaturated fatty acids+monounsaturated fatty acids/saturated fatty acids), refined grains, sodium, added sugars and saturated fats (score 10 points each). Therefore, the total score ranges from 0 to 100. Various food groups obtained through FFQ translate into cup and ounce equivalents.

All food components except fatty acids, added sugars and saturated fats have been converted to represent food and nutrient intake in cups/ounces or grams per 1000 kcal intake. Added sugars and saturated fats were measured as a percentage of total energy intake.

Statistical analysis
Continuous variables were expressed as mean±SD, while categorical variables were expressed as numbers and percentages.
The assumption of normality for continuous variables was examined with the Shapiro-Wilk test. The independent-samples t-test (or Mann-Whitney U test) as well as the χ² test were then used to compare variables between dependent variable classes. Multiple logistic regression analysis was performed to adjust for possible confounding variables including age, sex, comorbidity, calorie intake, BMI and physical activity. Length of hospital stay was dichotomised based on median (≤4 days). The crude and adjusted ORs were estimated with a 95% CI. Statistical significance was set at the level of p<0.05. HEI-2015, Healthy Eating Index-2015; ICU, intensive care unit.

**RESULTS**

The study recruited a total of 295 military patients with COVID-19 who had been referred to Vali Asr Hospital in Tehran from May to November 2020. The mean age and BMI of the patients were 55.35±17.07 years and 27.28±3.63 kg/m², respectively. There were 193 (65.4%) men. The most frequent symptoms in the patients were fever (51.5%), dyspnoea (41%) and cough (38.6%). The most frequent comorbidities in the patients were diabetes mellitus (19.3%), hypertension (14.6%), cardiovascular diseases (9.5%) and asthma (4.1%) or kidney diseases (2.4%). Eighty-six patients (29.15%) were admitted to the ICU.

The characteristics of the military patients with COVID-19 are provided by the ICU admission and length of hospital stay in Table 1. Non-ICU patients had lower age (p=0.06) and BMI (p<0.001) than ICU patients.

According to Table 2, the mean HEI-2015 score was significantly higher in non-ICU patients than in ICU patients (p=0.01). Also, the mean HEI-2015 score was higher in patients who were hospitalised for ≤4 days (p=0.17). ICU patients intake more calories (p=0.004), protein (p=0.01), fat (p=0.02), carbohydrate (p=0.06), vitamin D (p=0.21), vitamin E (p=0.31), vitamin B₁₂ (p=0.62), vitamin B₆ (p=0.27), vitamin B₃ (p=0.25), zinc (p=0.03) and iron (p=0.44) than ICU patients.

Compared with non-ICU patients, ICU patients intake less total fruits (p=0.17), greens and beans (p=0.11), whole grains (p=0.16), dairy (p=0.06), total protein foods (p=0.75), seafood and plant proteins (p=0.002) and healthy fats (p=0.05) as well as more refined grains (p=0.58), sodium (p=0.09) and added sugar (p=0.43). Also, patients who were hospitalised for more than 4 days intake less total fruits (p=0.06), greens and beans (p=0.01), whole grains (p=0.08), dairy (p=0.4), total protein foods (p=0.29), and seafood and plant proteins (p=0.08) as well as more sodium (p=0.20), added sugar (p=0.68) and saturated fats (p=0.94) than patients who were hospitalised for 4 days or less (not shown in the table).

Table 3 indicates the crude as well as adjusted ORs with 95% CI, for the association between HEI-2015 and both ICU admission and length of hospital stay among military patients with COVID-19. According to the adjusted model 1 (age, sex, comorbidity), there was a statistically significant negative relationship between HEI-2015 score and odds of ICU admission (OR 0.97; 95% CI 0.96 to 0.99). After adjustment for calorie intake, BMI and physical activity (MET), there was a non-significant negative relationship between HEI-2015 score and odds of ICU admission (OR 0.98; 95% CI 0.95 to 1.0). Although not statistically significant, an inverse relationship has been observed between the HEI-2015 score and odds of length of hospital stay (>4 days) according to the crude (OR 0.98; 95% CI 0.97 to 1.00) and adjusted model 2 (OR 0.99; 95% CI 0.97 to 1.00).

### Table 2 Distribution of dietary intakes of macronutrients and micronutrients and HEI-2015 score of military patients with COVID-19 by the ICU admission and length of hospital stay

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>ICU admission</th>
<th>Length of hospital stay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes (N=86)</td>
<td>No (N=209)</td>
</tr>
<tr>
<td>Total calories (kcal/day)</td>
<td>2518.1±672.37</td>
<td>2791.3±742.62</td>
</tr>
<tr>
<td>Total protein intake (g/day)</td>
<td>84.09±27.48</td>
<td>96.2±42.70</td>
</tr>
<tr>
<td>Total carbohydrate intake (g/day)</td>
<td>318.3±104.21</td>
<td>340.9±92.81</td>
</tr>
<tr>
<td>Total fat intake (g/day)</td>
<td>106.1±44.11</td>
<td>118.9±45.24</td>
</tr>
<tr>
<td>Vitamin D (µg/day)</td>
<td>1.75±1.51</td>
<td>1.95±1.16</td>
</tr>
<tr>
<td>Vitamin E (mg/day)</td>
<td>4.11±1.64</td>
<td>4.40±2.36</td>
</tr>
<tr>
<td>Vitamin C (mg/day)</td>
<td>45.37±44.29</td>
<td>39.6±34.88</td>
</tr>
<tr>
<td>Vitamin B₁₂ (µg/day)</td>
<td>1.56±0.71</td>
<td>1.59±0.52</td>
</tr>
<tr>
<td>Vitamin B₆ (µg/day)</td>
<td>253.7±138.57</td>
<td>275.0±158.70</td>
</tr>
<tr>
<td>Vitamin B₉ (µg/day)</td>
<td>4.53±2.47</td>
<td>5.67±9.03</td>
</tr>
<tr>
<td>Zinc (mg/day)</td>
<td>10.09±3.78</td>
<td>11.1±4.46</td>
</tr>
<tr>
<td>Selenium (µg/day)</td>
<td>0.14±0.13</td>
<td>0.13±0.07</td>
</tr>
<tr>
<td>Iron (mg/day)</td>
<td>14.19±6.06</td>
<td>14.7±4.80</td>
</tr>
<tr>
<td>HEI-2015 score</td>
<td>53.5±15.65</td>
<td>58.3±15.02</td>
</tr>
</tbody>
</table>

*Statistical significance was set at the level of p<0.05.

**HEI-2015, Healthy Eating Index-2015; ICU, intensive care unit.**

### Table 3 ORs and CIs for the association between HEI-2015 score and ICU admission as well as length of hospital stay in military patients with COVID-19

<table>
<thead>
<tr>
<th>ICU admission</th>
<th>Length of hospital stay (&gt;4 days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude</td>
<td>OR (95% CI)</td>
</tr>
<tr>
<td></td>
<td>0.98 (0.96 to 0.99)</td>
</tr>
<tr>
<td>Model 1*</td>
<td>0.97 (0.96 to 0.99)</td>
</tr>
<tr>
<td>Model 2†</td>
<td>0.98 (0.95 to 1.00)</td>
</tr>
</tbody>
</table>

Significant results are shown in bold. Data are presented as a (%) or mean±SD, unless stated otherwise. The χ² was used for comparison of categorical variables and the t-test was used for comparison of continuous variables.

*Adjusted for age, gender and comorbidity.
†Adjusted for age, gender, comorbidity, total calorie intake, BMI and physical activity.

BMJ, Body mass index; HEI-2015, Healthy Eating Index-2015.
DISCUSSION

In recent years, nutritional standards and nutritional quality indices have been used to determine the relationship between diet and health since foods are ingested in a mixed way and nutrients are metabolised together so that one food or nutrient can be influenced by another food or nutrient. HEI is one of the most common measures for assessing overall nutritional quality.14

To our knowledge, this is the first study to examine the relationship between the HEI-2015 score and severity of illness in hospitalised military patients with COVID-19. The HEI-2015 score was significantly higher in non-ICU patients than in ICU patients. After adjusting for age, sex, comorbidities, BMI, physical activity and total caloric intake, it was found that HEI-2015 score was negatively associated with odds of ICU admission and length of hospital stay of more than 4 days, although this was not statistically significant.

It appears that the correct response of the immune system is the main factor in the progression of the COVID-19 disease and the decrease in the function of the immune system leads to a cytokine storm, increasing the severity of the disease.15 Studies have also shown that there is an imbalance between pro-oxidants and antioxidants in patients with COVID-19,16 that generates oxidative stress, which could be very important for SARS-COV-2 replication. Adequate nutrition (adequate intake of all micronutrients) plays an important role for optimal immune response.8

On the other hand, patients with severe COVID-19 have been found to lack more than one nutrient. Therefore, nutritional deficiencies can contribute to the COVID-19 outbreak and increase the severity of the disease. According to the result of our study, ICU patients intake fewer calories, protein and fat, carbohydrate, vitamin D, vitamin E, vitamin B_6, vitamin B_12, zinc and iron than non-ICU patients; this difference was statistically significant for calories, protein and fat intake.

Several studies were conducted on the effects of vitamin D, vitamin C and zinc supplementation in patients with COVID-19, but no definitive results have been found on the benefits of these supplements. This may suggest that evaluating overall nutritional quality is better than evaluating the effects of each nutrient individually.15

Since the high HEI-2015 value shows a higher intake of fruits and vegetables, protein, whole grains, greens and beans, dairy, and healthier dairy products, and a lower intake of sodium, added sugars, refined grains and saturated fat, compliance with HEI-2015 indicates better nutritional quality.14 In our research, ICU patients intake more sodium, added sugars and refined grains, as well as fewer fruits, greens and beans, whole grains, dairy, protein foods, seafood and plant proteins and healthy fats than non-ICU patients, although this difference was statistically significant only for seafood and plant proteins intake.

It is recommended to follow a diet rich in fruits, vegetables, whole grains, low-fat dairy products and healthy fats (olive oil and fish oil), and low in sugary drinks, high-calorie foods and salty foods, during COVID-19 pandemic.18 Fruits and vegetables contain vitamins (especially vitamin C and vitamin E), carotenoids, glutathione and polyphenols with antioxidant properties.19 Fruits, vegetables and whole grains are also rich in fibre, which increases the amount of anti-inflammatory cytokines (through the fermentation of the intestinal microbiota and the formation of metabolic compounds such as short-chain fatty acids)20 and lowers fasting blood sugar.20 Therefore, eating plenty of fruits, vegetables and whole grains can support the immune system and reduce the severity of COVID-19 disease. In the present study, non-ICU patients intake more seafood and plant proteins than ICU patients (p=0.002). Polysaturated fatty acids, especially omega-3 fatty acids in fish and nuts, can reduce the severity of COVID-19 disease through anti-inflammatory effects and by strengthening the immune system.21 Low protein intake lowers protein levels, which can increase the risk of infection. In our study, non-ICU patients intake a higher total protein than ICU patients (p=0.01). High-quality protein intake (such as eggs, fish, lean meats, poultry, and fat-free or low-fat dairy products) is important for optimal antibody production.22 Some amino acids such as branched chain amino acids, arginine and glutamine modulate the immune system.23 Yoghurt (especially fortified with probiotics), cheese and milk contain macronutrients (such as protein), micronutrients (such as zinc and vitamin A) and bioactive components (such as casein, whey proteins and associated peptides) that have anti-inflammatory, antioxidant and antiviral effects.24 On the other hand, the ingestion of refined grains, added sugars and saturated fats can cause an increase in inflammation and reduce the immune response.25

Since the Vali Asr Hospital is a reference centre for military personnel in the metropolis of Tehran, the results of this study could be generalised to military personnel with COVID-19 in urban areas of Iran. There were some limitations to this study. Due to the cross-sectional design of the present study, initially it is not possible to find a causal relationship, so prospective cohort studies are necessary. Another limitation of the present study is the small sample size, so it is suggested that future studies be conducted with a sufficient sample size. Although validated FFQ was used, due to relying on people's memory to recall exposure information in the past, the accuracy of the obtained results may be partially affected, although by using a trained nutritionist to conduct the interviews, we tried to minimise this error. Because of financial limitations, we were unable to measure inflammatory factors or biomarkers of oxidative stress and antioxidant status in patients.

CONCLUSIONS

According to this study's results, the HEI-2015 score was significantly lower in military patients admitted to ICU. Although statistically not significant, adherence to HEI-2015 inversely related to both ICU admission and length of hospital stay among hospitalised military patients with COVID-19. It appears that a diet rich in fresh fruits and vegetables, whole grains, protein foods, dairy products and healthy fats could be effective in reducing the severity of COVID-19 disease. More longitudinal studies are required in order to complete the results of this study.

Contributors KP, SSJ, MSep, SA, MSam, GHM and MT studied the concept and designed the study. KP, SSJ and MT collected data. KP, SSJ, MSep, SA, MSam, GHM and MT analysed and interpreted of data. MT drafted the manuscript. KP, SSJ, MSep, SA, MSam, GHM and MT are responsible for the overall content as guarantor of the manuscript. All authors are in agreement with the manuscript and declare that the content has not been published elsewhere.

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Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by the ethics committee for Research at Baqiyatallah University of Medical Sciences (IR. Bmsu.REC.1399.185). Participants gave informed consent to participate in the study before taking part.

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Data availability statement Data are available on reasonable request.

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**REFRENCES**