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Introduction

Coronavirus disease 2019 (COVID-19) is an infectious disease that caused patients a wide range of physical and psychological problems [1]. Some studies noticed COVID-19 patients experience psychological and psychiatric problems after infection such as insomnia, anxiety, depression, delirium, memory loss, and loss of concentration [2, 3]. These psychological symptoms may continue after convalescence from COVID-19 and harm the mental health of recovered patients. Impaired mental health reduces the quality of life [4], so it should be considered during hospitalization and recovery. These patients suffer from psychological sequelae after COVID-19, so it is essential to follow up patients that recovered from COVID-19 [5]. Li et al. reported that 35% of COVID-19 patients have severe to moderate psychological symptoms [6]. A systematic review found anxiety and insomnia to occurred in 35.7% and 41.9% of patients with acute SARS, falling to 12.3% and 12.1% at follow-up [4].

Dietary interventions with relatively moderate effect sizes can significantly reduce the mental and neurological disease burden through food and nutrient-based approaches [7, 8]. ND is a “plant-based” dietary pattern that recommends protein intake from plant sources. It also recommends consumption of fruits and vegetables, whole grains, seeds, and nuts [9]. To increase protein intake, ND recommends increased the consumption of legumes and fish [9]. Along with all these recommendations, there is a limit on the use of red meat and processed foods [10]. Some studies have shown that ND has beneficial effects on psychological symptoms [10, 11].

Therefore, it is essential to assess the diet of COVID-19 recovered patients based on their symptoms. Nutritional interventions are increasingly being used in psychiatric practice [5]. Jacka et al. demonstrated impressive effects of a 3-month dietary intervention on moderate-to-severe depression with a 32% remission in the intervention group [12]. Another study of the Nordic diet reported better improvement in depression in the ND group compared to the control group [13].

Recovered COVID-19 patients faced a severely stressful experience that challenged their psychological health. It is necessary to follow up these people and control their diet to improve their impaired mental health. Considering a healthy diet can improve psychological symptoms after COVID-19. Few studies have been performed to analyse the Nordic diet on psychological disorders. In this case-control study, we attempted to investigate the association between adherence to the ND and psychological responsibility in both recovered COVID-19 patients and healthy people.

Method

Study design

The present case-control study was performed between November 2020 to January 2021 at the clinic of Qaem Hospital, Mashhad, Iran. Adult subjects aged ≥ 30 years old who were affected by COVID-19 within the last 1 month. Participants had a negative CT scan or PCR test for COVID-19 when the interview was started. Also, we randomly selected the control group from adults > 30 years who did not have a COVID-19 history. These participants were referred to the nutrition clinic of the Qaem Hospital. Subjects who had a history of depression treatment in the last 6 months, autoimmune diseases, cancer, renal or hepatic failure, and metabolic bone disease were excluded. Adherence to a special dietary pattern such as a vegetarian diet was another exclusion criteria.

In the control group, subjects with a history of COVID-19 according to CT scan or PCR test, renal or hepatic failure, autoimmune diseases, having a history of depression treatment in the last 6 months, cancer, and adherence to a special diet were excluded. We enrolled one matched control subject for every case. Also, the case and control groups corresponded according to age and gender (± 5 years). In the present study, 246 subjects who had the eligibility criteria were recruited, of which a total of 240 subjects (120 cases and 120 controls) were encompassed in the last analysis. The mean energy of two cases and four controls were outside ± 3 standard deviation (SD), so they were excluded. All cases and control filled out noticed written agreement, and all methods were performed based on related guidelines and regulations or the Helsinki declaration.

General and anthropometric characteristics

Demographic and anthropometric features, such as age, gender, height, weight, and education level were carried out by an expert nurse. Weight was measured by a calibrated personal scale. The fixed measuring tape was used to find out the height. Body weight (kg)/ (body height (m))² was applied for calculating body mass index (BMI).

Dietary intake assessment

The food intake of patients was determined by a reliable and valid 68-item semi-quantitative food frequency questionnaire (FFQ) [14, 15]. The FFQ was completed through face-to-face interviews. Food analysis was undertaken using Nutritionist IV software (N-Squared Computing, Cincinnati, OH, USA). Healthy Nordic Food Index (HNFI) scores were assessed based on the method of Olsen et al. [16]. To calculate the HNFI, we consider six groups with the same micronutrient amount. Daneshzad et al. [17] validated the modified ND score for the Iranian population, including (a) fish (fish conserved in oil and salt and other fish), (b) legumes (soybeans, beans, and

lentils), (c) whole grains, (d) fruit (fresh and dried fruits, fruit juice) (e) root vegetables (onion, garlic, and potato) and (f) cabbages and vegetables (lettuce, tomato, cucumber, spinach, and leafy vegetables). We calculated below- and above-average intake for every item. Each group was classified based on the score obtained (scoring 0–1 points shows “low adherence”, scoring 2–3 points “medium adherence”, and scoring 4–6 points “high adherence”). ND was not given to any individuals and agreement to ND was assessed.

Depression anxiety stress scales (DASS)

Depression anxiety stress scales (DASS) are among the most valid and exact tools to analyze mental conditions [18]. It is a questionnaire that generally includes three subscales, seven questions, and 21 items. Each question score ranges from 0 to 3 on a four-point scale to recognize the severity of mental disorders, consisting of

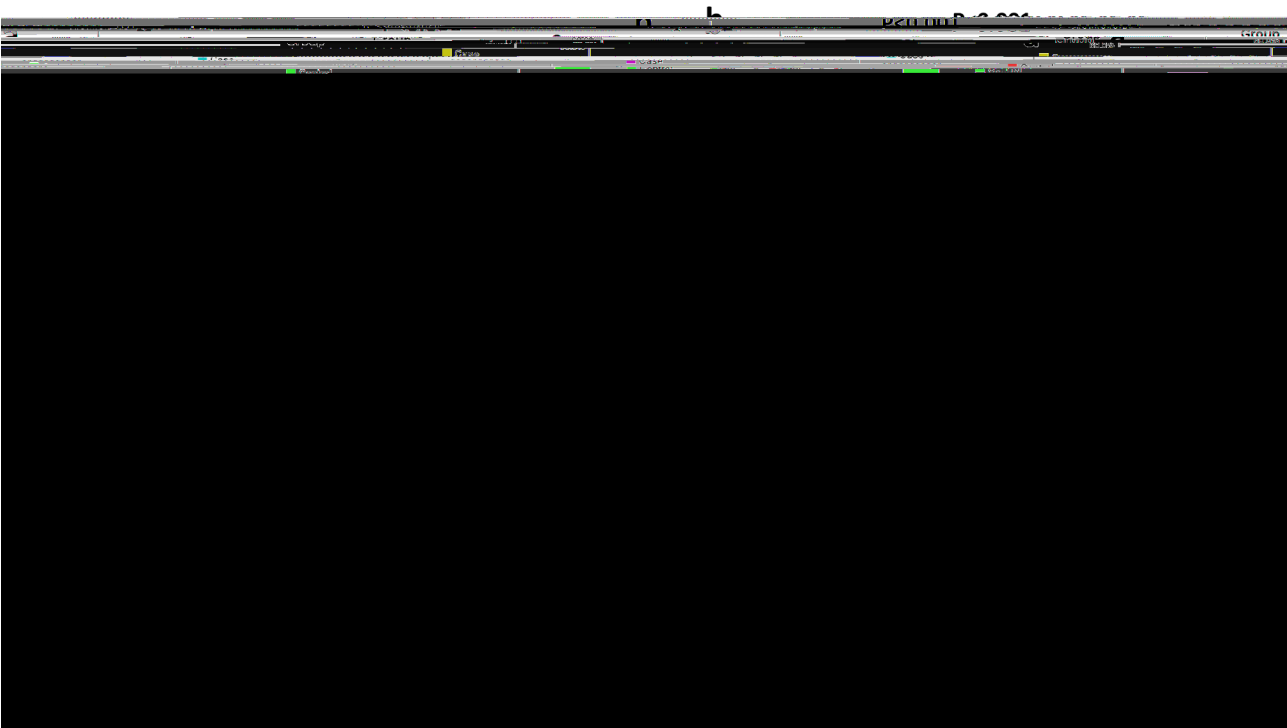


Fig. 1 Demographic and clinical characteristics of the participants between groups. (a) Gender, (b) Education, (c) Age, (d) Anthropometric measurements

Table 1 Comparison of energy-adjusted dietary intakes in Nordic diet adherence between groups

| Variable | Nordic diet adherence in case group (n= 120) | | | Nordic diet adherence in control group (n= 120) | | | P-val- ue # |
|--|--|--------------------------|-----------------------------|---|--------------------------|-----------------------------|----------------|
| | Low | Medium | High | Low | Medium | High | |
| †Energy and dietary macronutrient intake (g/day) | | | | | | | |
| Energy | 2973.18 ± 1097.11 | 2818.40 ± 1040.73 | 2569.72 ± 859.49 | 2061.59 ± 882.10 | 2245.28 ± 770.43 | 1716.94 ± 521.43* | 0.036 |
| Carbohydrate | 186.91 ± 113.94 | 232.79 ± 57.70 | 240.63 ± 79.81* | 255.85 ± 79.03 | 265.32 ± 76.24 | 256.30 ± 42.78 | 0.180 |
| Protein | 83.48 ± 32.74 | 72.86 ± 19.25 | 77.77 ± 20.87 | 75.47 ± 16.42 | 83.92 ± 15.45 | 80.51 ± 9.27* | 0.576 |
| Fat | 117.62 ± 47.40 | 107.84 ± 23.05 | 103.10 ± 30.72 | 97.03 ± 28.58 | 89.87 ± 28.79 | 94.61 ± 17.06 | 0.199 |
| †Components of Nordic (g/day) | | | | | | | |
| Whole grains | 52.86 (10.76-101.72) | 83.68 (27.01–167.50) | 97.22 (53.97-167.29)* | 105.48 (59.67-184.65) | 174.06 (60.86-330.13) | 142.71 (115.53-192.07) | 0.640 |
| Legumes | 7.8 (3.04–12.30) | 9.39 (2.89–22.29) | 14.17 (11.38–30.73)** | 9.55 (4.18–16.19) | 13.52 (6.96–20.51) | 19.33(13.13– 28.71)** | 0.419 |
| Fruits | 3294.32 ± 373.96 | 3550.99 ± 399.64 | 3661.58 ± 414.26** | 3348.42 ± 727.92 | 3370.99 ± 337.17 | 3427.69 ± 179.10** | 0.168 |
| cabbages and vegetables | 78.60 (42.79-145.21) | 117.13 (57.59-220.12) | 169.80 (108.90-236.76)** | 67.96 (42.93-101.28) | 102.13 (51.54-170.98) | 140.35 (117.34-181.73)** | 0.290 |
| Root vegetables | 25.27 (16.77–51.32) | 35.04 (18.36–47.38) | 46.33 (29.61–65.64) | 21.23 (12.16–30.18) | 23.34 (12.29–41.92) | 36.95 (27.86–54.84)** | 0.562 |
| Fish | 2.33 (0.28–5.44) | 5.34 (2.53–8.41) | 8.00 (4.83–10.20)** | 4.19 (2.28–6.28) | 5.97 (4.05–7.70) | 6.33 (2.51–8.05)** | 0.930 |

Obtained from Multivariate analysis of variance (MANOVA) test

Data presented as Median (IQR) or Mean ± SD

†The parameters are adjusted based on the energy intake

p* < 0.05 and *p* < 0.001 within classification of Nordic diet adherence

p-value for differences between case and control group

and control groups (*p* > 0.05). Nevertheless, there was a significant difference in educational level and height between the two groups (*p* < 0.05) (Fig. 1b).

Table 1. demonstrates the comparison of the mean energy, macronutrients, and components of the HNFI

score in classification of adherence ND between both groups. There was a significant difference in energy consumption between the case and control groups (*p* = 0.036). Regarding components of the HNFI score, there were significant differences between fruits,

legumes, cabbage and vegetables, fish intakes, and classification of HNFI score in both groups ($p < 0.05$). There was a significant difference in carbohydrate and whole grain intakes between classification of adherence HNFI score in case subjects ($p < 0.05$).

Heat map (Fig. 2) demonstrates that there was a significant opposite association between total anxiety, stress, and depression scores and the consumption of whole grains ($r = -0.35$; $P < 0.05$, $r = -0.36$; $P < 0.05$, $r = -0.33$; $P < 0.05$ respectively). Furthermore, there was a significant opposite relation between depression and fruit intake ($r = -0.29$; $P < 0.05$). A significant negative association was observed between insomnia and sleep quality and the consumption of root vegetables ($r = -0.26$; $P < 0.05$, $r = -0.28$; $P < 0.05$, respectively).

Multinomial logistic regression analyses were applied to evaluate the relationship between psychological function and the Nordic diet in crude and adjusted models. As observed in Table 2, the odds ratio was adjusted for gender, age, educational levels, and energy intake in the adjusted model. High adherence to the ND was significantly related to anxiety, stress, and depression in the adjusted model (OR=0.759, 95% CI 0.602–0.956, P-value=0.019; OR=0.719, 95% CI 0.563–0.918, p-value=0.008; OR=0.755, 95% CI 0.609–0.934, P-value=0.010, respectively) only in the case group.

Discussion

This case-control study evaluated the relationship between adherence to the ND and psychological role in 240 adults aged ≥ 30 years old who were healthy and recovered from COVID-19. In this study, we found that more adherence to ND was related to lower odds of anxiety, stress, and depression in recovered COVID-19

patients. Regarding components of the Nordic style, only in the case group, we found a significant opposite correlation between total anxiety, stress, and depression scores and the consumption of whole grains. Also, there was a significant opposite relation between depression and fruit consumption in this group.

The relationship between dietary patterns and psychological health has been considered an important issue [25]. Multiple studies recommended consuming food sources of vitamins and fibre during COVID-19, that are rich in the Nordic diet [26–28]. Choosing food like fruits, vegetables, and whole grains which are rich in fibre, antioxidant, and anti-inflammatory constituents might be important in COVID-19 [29]. Brown et al. found that a diet containing mostly whole grains, vegetables, and fruits with low amounts of foods with animal sources decreased the severity of COVID-19 [30]. Another study showed that increasing the intake of fruits, vegetables, and whole grains and decreasing the consumption of red meat, processed meat, sweets, refined cereals, fried food, and sugary drinks have antidepressant effects [31]. In line with our study, a randomized controlled trial performed in 2021 showed that a healthy Nordic diet improves depressive symptoms [13]. Also, a cross-sectional study with 181 subjects, aged between 18 and 25 years old, showed that adherence to a Nordic diet with a high intake of fruits and vegetables reduces stress and anxiety scores [11]. A plant-based diet rich in fibre, resistant starch, and carbohydrates appears to be advantageous because it fills the host's intestinal with beneficial microbes that have health benefits for COVID-19 patients [29]. Enhancing diet quality improved mood. Dietary patterns rich in omega-3 and fibre may be related to decreased symptoms of anxiety, stress, and depression [32].

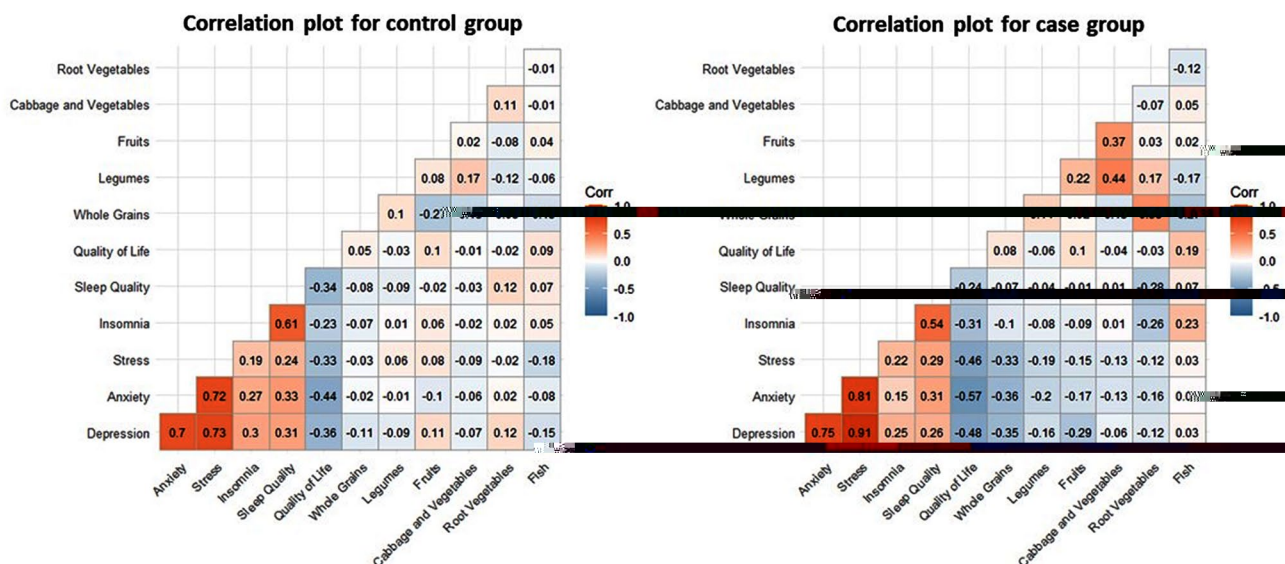


Fig. 2 Correlation between components of Nordic diet and psychological tests in case and control groups

Table 2 Multiple-adjusted odds ratio (OR) and 95% confidence intervals (CI) for OR between classification of adherence the Nordic diet

| | Nordic diet adherence in case group (n= 120) | | | Nordic diet adherence in control group (n= 120) | | |
|------------------------|--|---------------------|------------------------|---|---------------------|---------------------|
| | Low | Medium | High | Low | Medium | High |
| Anxiety | | | | | | |
| Crude | Ref. | 0.986 (0.862–1.128) | 0.839 (0.723–0.973) | Ref. | 0.988 (0.921–1.059) | 0.980 (0.916–1.050) |
| Adjusted model | Ref. | 0.997 (0.838–1.185) | 0.719 (0.563–0.918) * | Ref. | 1.002 (0.927–1.083) | 0.972 (0.898–1.053) |
| Stress | | | | | | |
| Crude | Ref. | 1.006 (0.902–1.123) | 0.849 (0.742–0.972) | Ref. | 0.984 (0.940–1.030) | 0.962 (0.919–1.007) |
| Adjusted model | Ref. | 1.000 (0.863–1.158) | 0.755 (0.609–0.934) ** | Ref. | 0.992 (0.941–1.045) | 0.950 (0.901–1.002) |
| Depression | | | | | | |
| Crude | Ref. | 0.994 (0.884–1.117) | 0.985 (0.734–0.994) | Ref. | 0.993 (0.943–1.047) | 0.044 (0.961–1.045) |
| Adjusted model | Ref. | 0.979 (0.841–1.139) | 0.759 (0.602–0.956) * | Ref. | 1.005 (0.950–1.063) | 0.982 (0.927–1.041) |
| Sleep Quality | | | | | | |
| Crude | Ref. | 1.063 (0.892–1.266) | 0.964 (0.815–1.139) | Ref. | 1.024 (0.949–1.105) | 1.017 (0.945–1.095) |
| Adjusted model | Ref. | 1.130 (0.850–1.501) | 0.869 (0.634–1.192) | Ref. | 1.045 (0.958–1.140) | 1.049 (0.965–1.139) |
| Insomnia | | | | | | |
| Crude | Ref. | 1.134 (1.005–1.279) | 1.064 (0.943–1.200) | Ref. | 0.956 (0.872–1.048) | 1.000 (0.918–1.090) |
| Adjusted model | Ref. | 1.109 (0.953–1.289) | 1.087 (0.915–1.291) | Ref. | 0.981 (0.885–1.087) | 1.076 (0.976–1.185) |
| Quality of Life | | | | | | |
| Crude | Ref. | 0.988 (0.956–1.021) | 1.029 (0.999–1.059) | Ref. | 1.015 (0.971–1.062) | 0.995 (0.954–1.038) |
| Adjusted model | Ref. | 0.969 (0.921–1.020) | 1.056 (1.008–1.106) | Ref. | 1.005 (0.955–1.057) | 0.990 (0.942–1.041) |

Obtained from multinomial logistic regression based on adherence the Nordic diet

Model 1: Adjusted for age, gender, education stage and energy intake

* $p < 0.05$

** $p < 0.01$

People suffer from mental problems after contracting COVID-19 due to the fear of losing people and social rejection. A dietary pattern rich in vegetables and fruits plays a role in improving mental distress [33]. In this study, we revealed that more adherence to ND was associated with less odds of anxiety, stress, and depression score through recovered COVID-19 patients. Our results were in line with the findings of prior studies [11, 13]. We concluded that depression scores were inversely associated with the consumption of fruit. Also, root vegetable consumption was correlated with insomnia and sleep quality among recovered COVID-19 patients. Root vegetable and Fruit intake improve life satisfaction and mental health. A meta-analysis consisting of 446,551 subjects, revealed that vegetable and fruit intake may play an essential function in reducing the depression risk [34]. Some studies estimated that the consumption of fruits can negatively affect mental health [35, 36]. Liu et al. in their meta-analysis indicated that fruit intake lowered depression and anxiety symptoms [37]. Various possible mechanisms could link fruit and vegetable intake with psychological symptoms. Oxidative stress has negative effects on mental health. A large number of antioxidants in vegetables and fruits, such as beta-carotene, folic acid, vitamin E, and vitamin C reduce the harmful oxidative stress effects on mental well-being and improve depression [38]. Fruits and vegetables are rich in different minerals and vitamins like folate. Folate and vitamin B12

deficiency increase the levels of homocysteine and the risk of depression [39]. Also, magnesium deficiency may increase in inflammatory factors like C-reactive protein which helps the development of depression [40].

A healthy diet and lifestyle could affect symptoms of mood disorder in recovered COVID-19 patients [5, 41]. Inflammation caused by COVID-19 can affect neurological mechanisms, so having a healthy diet should be prioritized to prevent long-term neurological symptoms from COVID-19 [11]. Therefore, consumption of fibre and whole grains is recommended [42]. Our results revealed a significant relationship between whole grains anxiety, stress, and depression which confirms previous studies [43–45]. A cohort study found that regular consumption of whole grains, fruits, and vegetables is inversely related to anxiety and depression risk in elderly persons [6]. Mohammadi et al. in their randomized clinical trial study recognized a positive association between stress and anxiety and whole grains [44]. A previous study revealed that a greater intake of non-refined grains concluded to decrease depression and anxiety severeness [45]. A dietary pattern identified by high whole grain consumption was significantly connected with decreased depression risk [46]. In contrast, high consumption of refined grains was related to more depression risk [47]. Nutritional factors also have a direct and potent effect on neurophysiology [48, 49]. Berk et al. recognized inflammation as a mediating pathway for

the development of depression [50]. Evidence suggests that frequent consumption of magnesium-rich foods may improve COVID-induced inflammation. A healthy diet provides sources of magnesium. For example, whole grains are identified as one of the best sources of food due to their magnesium content [51–53]. Also, a previous study revealed that a dietary pattern with higher intake of whole grains, fruits, and vegetables reduces inflammation by decreasing IL-6 and CRP in plasma [3]. Whole grains are a rich source of B vitamins like thiamine, nicotinic acid, pyridoxine, and pantothenic acid but they are not rich in folates unless fortified with folic acid. These vitamins can positively affect mental health [54]. For instance, folate and pyridoxine deficiency are effective in mental health due to their function in the synthesis of neurotransmitters for example serotonin, as well as their coenzyme role in one-carbon metabolism pathways [55].

Conclusion

Our study suggests that adherence to the ND may reduce anxiety, stress, and depression in patients recovered from COVID-19. A dietary pattern rich in fruit and whole grains might be beneficial in treating depressive symptoms in patients who have recovered from COVID-19. Additional large-scale longitudinal studies are essential to substantiate.

Tables.

Abbreviations

| | |
|----------|---|
| ND | Nordic diet |
| FFQ | food frequency questionnaire |
| DASS | Depression anxiety stress scales |
| PSQI | Pittsburgh Sleep Quality Index |
| ISI | Insomnia Severity Index |
| SF-36 | Short-Form Health Survey |
| COVID-19 | Coronavirus disease 2019 |
| SD | standard deviation |
| BMI | body mass index |
| HNFI | Healthy Nordic Food Index |
| IQR | interquartile range |
| MANOVA | Multivariate Analysis of Variance |
| SPSS | Statistical package for social sciences |

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Author contributions

MGH, and ZKH initially conceptualized and designed the study. MGH contributed to obtaining the initial funding. The manuscript was written by AA, ZKH, KMH, and MVF and was reviewed by all members. PSH, NT and RAD were responsible for the design optimization and statistical analysis. EH, ML, PAS, MKHB, MSHFM, and AGH contribute sampling. GF performed English editing. All authors read and approved the final manuscript.

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Data availability

The datasets collected and/or analyzed during the present study are not publicly accessible due to ethical concerns but the corresponding author may provide datasets upon request.

Declarations

Ethics approval and consent to participants

was obtained from the ethics committee of Mashhad University of Medical Sciences (code: IR.MUMS.REC.1399.237). Informed consent was obtained from all study participants. All methods were performed based on related guidelines and regulations or the Helsinki Declaration.

Consent for publication

Not applicable as no personal data was used in this article.

Competing interests

The authors declare no competing interests.

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