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ORIGINAL ARTICLE

Better muscle strength with healthy eating

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Abstract

Purpose Hand grip strength (HGS) can predict physical function in next year when it is positively associated with nutritional and health status. This study aimed to determine the relationship between the healthy eating index (HEI)-2015 and hand grip strength.

Methods This cross-sectional study was conducted on data from 4010 participants in the Ravansar non-communicable disease (RaNCD) cohort study. HGS was measured using a hand-held hydraulic hand grip dynamometer. HEI-2015 was calculated using data from the food frequency questionnaire.

Results The mean of total HEI-2015 score was significantly higher in participants with an optimal HGS than in participants with a weak HGS ($P=0.006$). Higher adherence to healthy eating was associated with optimal muscle strength (OR 1.26; CI 95% 1.02–1.62). This association was remained after being adjusted for potential confounders ($P=0.01$). Among the HEI-2015 components, we only found association between whole fruit, added sugar, and HGS ($P=0.01$, 0.019).

Conclusions Our findings indicated that adherence to HEI-2015 could promote muscle strength. Among the HEI-2015 components, higher intake of whole fruit and lower adherence to added sugar had significantly positive effects on HGS.

Level of evidence Level V, descriptive cross-sectional study.

Keywords Healthy eating index · Muscle strength · Non-communicable disease

Introduction

Hand grip strength (HGS) is defined as the total flexor muscles strength versus palmar muscles as well as extensor muscles, playing a secondary role in this contraction [1]. Evidence suggests that increased muscle strength is associated with improving health and reducing non-communicable diseases (NCDs) such as cardiovascular disease, diabetes, and overall mortality [2, 3]. In addition, poor muscle strength can increase the risk of fall, fractures, and disability in the years to come [4]. HGS is a simple, reliable, and noninvasive tool applied in many epidemiological studies to measure muscle strength [5, 6] and can predict overall muscle strength [1]. Inappropriate lifestyle such as sedentary behaviors and adherence to unhealthy dietary can accelerate the process of low muscle mass and strength [6, 7].

Healthy eating index (HEI) is developed to assess diet quality based on the Dietary Guidelines for Americans (DGA) that is updated every 5 years [8]. HEI-2015 emphasizes adequacy and moderation. Components of adequacy part include total fruits, whole fruits, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood

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and plant proteins, and fatty acids, and the other part emphasizes the limitation of the consumption of refined grains, sodium, added sugars, and saturated fats [9]. Adherence to a Mediterranean diet as a healthy diet can strengthen muscle strength [6, 10]. This dietary pattern is associated with high intake of whole grains, fruits, vegetables, nuts, legumes, olive oil, low-fat dairy, moderate consumption of poultry and fish, and low consumption of red meat, processed meat, and sweets [6]. Additionally, a Nordic diet with low intake of added sugar, dietary fat, and high fiber intake and sea foods has protective effects on muscle strength and mobility [4, 10]. To the best of our knowledge, there is no any study on HEI-2015 and muscle strength. Since recognition and screening of the muscle status and nutritional quality of the community are important to prevent NCDs, this study aimed to assess HEI-2015 and muscle strength in the Ravansar non-communicable diseases (RaNCDs) cohort study.

Methods

Study design and population

This cross-sectional study was conducted using the baseline data from the RaNCD cohort study. Since 2014, this study is the first Kurdish population-based study on 10,059 Kurdish participants aged 35–65 years living in Ravansar city, Kermanshah province, Western Iran. The RaNCD is one of 18 studies developed by the PERSIAN (Prospective Epidemiological Research Studies in Iran) mega-cohort study that was approved by the Ethics Committees in the Ministry of Health and Medical Education, the Digestive Diseases Research Institute, Tehran University of Medical Sciences, Iran. The protocol of the RaNCD cohort study was described in previous studies [11, 12]. The cohort study was given ethical approval by the Ethics Committee of Kermanshah University of Medical Sciences (ethics approval number: KUMS.REC.1394.318).

In the current study, we included the participants with an available dynamometry status at the baseline. Owing to loss of muscle mass in CVDs [13], cancer [14], and thyroid disorders [15, 16], we did not include participants with these disease as well as participants with pregnancy. Furthermore, the participants consuming energy intake less than 800 kcal/day and more than 4200 kcal/day were considered under and over energy intake reporter, respectively; therefore, they were not included in this study. Fourteen participants, who did not have complete information to calculate the HEI, were excluded from the study (Fig. 1).

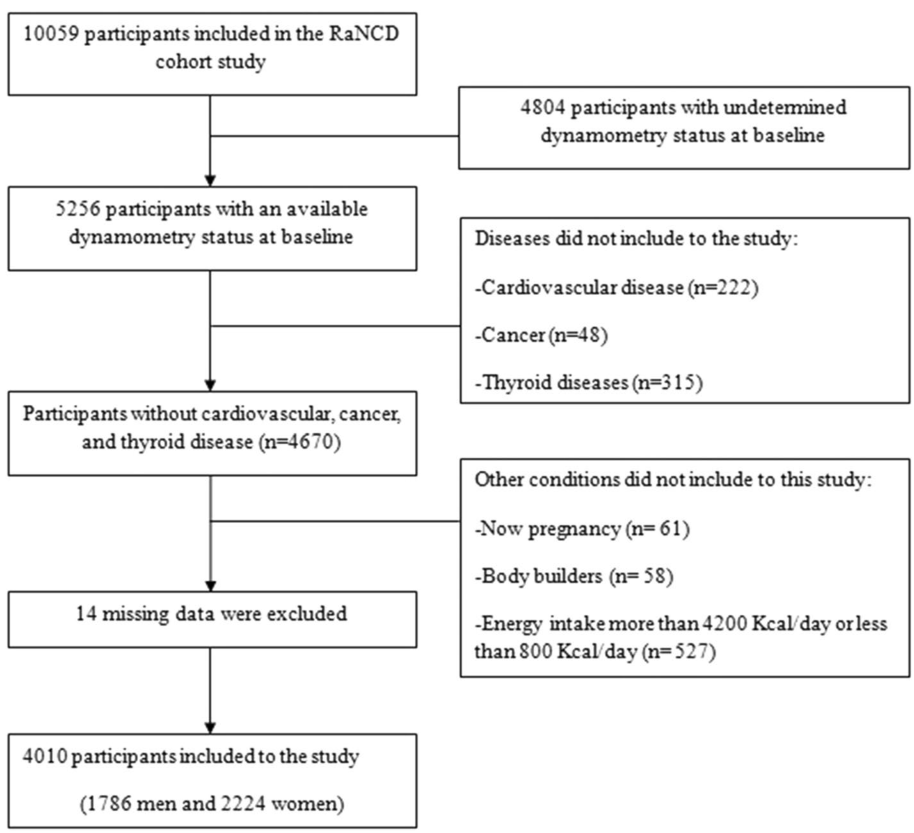

Fig. 1 Flowchart of the study

Data collection

We included the demographic data, anthropometric indices, nutritional assessments, and HGS measurement collected by well-trained interviewers in the study site in Ravansar.

Anthropometric indices

In the RaNCD cohort study, height was measured by the automatic stadiometer BSM 370 (Biospace Co., Seoul, Korea) in a standing position without shoes and with the precision of 0.1 cm. Weight was measured using the InBody 770 device (InBody Co, Seoul, Korea) with at least clothing and without shoes. Body mass index (BMI) was calculated by dividing the weight (kg) by the square of the height (meter).

Hand grip strength

HGS was determined using a hand-held hydraulic hand grip dynamometer (model SH5003; Saehan Corporation, Masan, Korea). Calibration of this dynamometer was carried out according to the manufacturers' manual. The measurement was taken with the dominant hand when the participant was sitting and the elbow was at 90º of flexion. The participant was asked to squeeze the handle with maximal effort for 10 s. The measurement was repeated after 30 s, and the latter was recorded as hand grip strength. Based on the guidelines of this device, we considered optimal and weak muscle strength for each age group and gender [17].

Dietary assessment and Healthy eating index 2015

A total of the 130-item food frequency questionnaire was completed to assess dietary intake in the previous year that consisted of ten parts as follows: bread and grains, beans, meat and its products, dairies, vegetables, fruits, oils, oilseeds and butter, added sugar, and spices. The validity and reliability of this questionnaire were assessed in previous studies [18]. We obtained the dietary information of this questionnaire and then calculated HEI-2015, based on the last revised HEI available in the Department of Agriculture, Center for Nutrition Policy and Promotion [19]. This index has two sections: adequacy and moderation. The adequacy was related to the adequate intake of total fruits, whole fruits, total vegetables, greens and beans, whole grains, dairies, total protein foods, seafood and plant proteins, and fatty acids. Moderation intake of refined grains, sodium, added sugars, and saturated fats was evaluated using this index (Table 1).

Statistical analysis

Statistical analyses were conducted using Stata, version 14 (Stata Corp, College Station, TX). All quantitative variables were presented as mean ± standard deviation. Qualitative variables were reported using frequency (%). Comparison of baseline characteristics was assessed according to the HEI-2015 quartiles using ANOVA and Chi-square tests. In addition, comparison of components of HEI-2015 between participants with weak and optimal muscle strength was made using the ANOVA test. Radar graphs were constructed using the Excel software (Microsoft Office 2010) to show difference in the obtained score of HEI-2015 components between participants with weak and optimal muscle strength. Binary logistic regression was used in crude and adjusted models. In adjusted Model 1, we controlled the variables of age, gender, smoking, and alcohol use. Furthermore, in adjusted Model 2, in addition to the variables of Model 1, we controlled the variables of physical activity and diabetes. First, the quartile of HEI-2015 was considered the reference category in all binary logistic regression analyses. P-values were considered significant at the level of < 0.05.

Results

In the current study, the mean of total HEI-2015 score was significantly higher in participants with an optimal HGS than in participants with a weak HGS ($P = 0.006$) (Table 1). In addition, the mean of HGS was significantly increased with the increase in the HEI-2015 score ($P < 0.001$). Table 2 presents the baseline characteristics according to HEI-2015 quintiles.

Our findings indicated that higher adherence to healthy eating was associated with optimal muscle strength (OR 1.26; CI 95% 1.02–1.62). This association was remained after being adjusted for potential confounders ($P = 0.01$) (Table 3).

Although totally all HEI-2015 components were higher than in participants with an optimal HGS than in participants with a weak HGS, this difference was only significant for whole fruit and added sugar components.

In this study, we found that higher intake of whole fruits was associated with an optimal HGS (OR 1.01; CI 95% 1.02–1.18). In addition, participants who consumed less added sugar had an optimal HGS (OR 1.06; CI 95% 1.01–1.12) (Table 4).

Discussion

This study highlights that higher adherence to healthy eating is associated with an optimal HGS. Epidemiological studies have indicated that proper nutrition can prevent the

Table 1 Healthy eating index—2015

Component	Standard for maximum score	Standard for minimum score of zero	Maximum points	Weak muscle strength	Optimum muscle strength	*P* value*
Adequacy						
Total fruits[a]	≥ 0.8 cup equivalent per 1000 kcal	No fruit	5	2.59 ± 1.25	2.69 ± 1.26	0.881
Whole fruits[b]	≥ 0.4 cup equivalent per 1000 kcal	No whole fruit	5	3.78 ± 1.3	3.93 ± 1.24	0.004
Total vegetables[c]	≥ 1.1 cup equivalent per 1000 kcal	No vegetables	5	3.43 ± 1.1	3.46 ± 1.1	0.837
Greens and beans[c]	≥ 0.2 cup equivalent per 1000 kcal	No dark green vegetables or legumes	5	3.19 ± 1.25	3.23 ± 1.27	0.432
Whole grains	≥ 1.5 cup equivalent per 1000 kcal	No whole grains	10	1.37 ± 0.97	1.35 ± 0.92	0.476
Dairy[d]	≥ 1.3 cup equivalent per 1000 kcal	No dairy	10	4.95 ± 2.81	4.99 ± 2.74	0.291
Total protein foods[c]	≥ 2.5 cup equivalent per 1000 kcal	No protein foods	5	3.02 ± 1.09	3.1 ± 1.08	0.736
Seafood and plant proteins[c,e]	≥ 0.8 cup equivalent per 1000 kcal	No seafood or plant Proteins	5	4.13 ± 0.67	4.17 ± 0.69	0.136
Fatty acids[f]	(PUFAs + MUFAs)/SFAs ≥ 2.5	(PUFAs + MUFAs)/SFAs ≤ 1.2	10	4.69 ± 3.04	4.85 ± 3	0.512
Moderation						
Refined grains	≤ 1.8 oz equivalent per 1000 kcal	≥ 4.3 oz equivalent per 1000 kcal	10	0.09 ± 0.6	0.07 ± 0.62	0.199
Sodium	≤ 1.1 grams per 1000 kcal	≥ 2.0 grams per 1000 kcal	10	2.11 ± 2.59	2.15 ± 2.62	0. 809
Added sugars	≤ 6.5% of energy	≥ 26% of energy	10	8.72 ± 1.97	8.92 ± 1.76	0.001
Saturated fats	≤ 8% of energy	≥ 16% of energy	10	7.47 ± 2.54	7.54 ± 2.54	0.784
Total score			100	49.54 ± 6.97	52.46 ± 6.89	0.006

Intakes between the minimum and maximum standards are scored proportionately

**P* value was obtained independent samples *T* test

[a]100% fruit juice

[b]All forms except juice

[c]Legumes (beans and peas)

[d]All milk products, such as fluid milk, yogurt, and cheese, and fortified soy beverages

[e]Seafood, nuts, seeds, soy products (other than beverages), and legumes (beans and peas)

[d]Ratio of poly- and monounsaturated fatty acids (PUFAs and MUFAs) to saturated fatty acids (SFAs)

progression of frailty during aging, which is characterized by a low HGS [6, 7]. Since low muscle strength is associated with decreased physical function [20], increased fractures [21], worsening cardiometabolic status [3], and all-cause mortality [22], identification of dietary components is an effective strategy to prevent low muscle strength. To the best of our knowledge, this study is the first study evaluating HEI-2015 and its components using HGS.

Stress oxidative and inflammation contribute to development of low muscle strength and its subsequence frailty [23, 24]. The HEI-2015 confirms an adequate intake of fruits, vegetables, whole grain, seafood, plant protein, dairy, and essential fatty acid. In addition, consumption of refined grain, added sugar, sodium, and saturated fatty acid should be moderate [8]. Fruits and vegetables are high in antioxidants and play a key role in systemic inflammation [25]. Furthermore, omega-3 fatty acid had beneficial effects on decreasing inflammation [26]. Dairy products, sea food, and plant protein spatially soy protein can promote muscle strength and muscle mass [27–29]. Moreover, dairy products are rich in high biological value protein and important minerals, including calcium and phosphorus [30]. In addition to high biological value protein, seafood can provide omega-3 fatty acid, contributing to reduction in inflammation [31, 32].

Among the HEI-2015 components, higher adherence to whole fruits intake was related to better muscle strength. In the components, all fruits were considered without fruits

Table 2 Demographic and baseline characteristics according to the healthy eating index-2015 quintiles

Determinants	Total ($n=4010$)	HEI quintiles				*P* value
		Q1 ($n=1121$)	Q2 ($n=903$)	Q3 ($n=1011$)	Q4 ($n=975$)	
Age (years), mean ± SD	47.77 ± 8.36	49.25 ± 8.38	48.33 ± 8.31	46.84 ± 8.25	46.55 ± 8.21	< 0.001
Weight (kg), mean ± SD	70.96 ± 13.6	67.96 ± 13.53	70.22 ± 13.13	72.35 ± 13.76	73.68 ± 13.25	< 0.001
BMI (kg/m^2), mean ± SD	27 ± 4.68	26.13 ± 4.77	26.71 ± 4.50	27.41 ± 4.75	27.89 ± 4.48	< 0.001
Muscle strength (kg), mean ± SD	31.47 ± 11.16	30.23 ± 10.81	30.96 ± 10.84	32.24 ± 10.99	32.59 ± 11.86	< 0.001
Physical activity (MET hour/ day), Mean ± SD	41.19 ± 7.47	42.32 ± 7.61	41.47 ± 7.29	40.68 ± 7.55	40.19 ± 7.25	< 0.001
Gender (%)						
Male	44.5	43.9	46	44.7	43.8	0.763
Education year (%)						
Illiterate	29.5	40.8	33.8	22.3	20.1	< 0.001
1–5 years	38.6	38.4	39.3	41.6	35.0	
6–12 years	26.8	19.6	24.3	30.8	33.3	
≥ 13 years	5.1	1.2	2.7	5.3	11.6	
Income status (%)						
Very poor	24.7	36.4	27	22	12.7	< 0.001
Poor	22.5	24.4	25.2	20.5	19.8	
Normal	20.9	22.1	20.8	22.3	18.9	
Rich	18.4	12.2	18.2	20.5	22.8	
Wealthy	13.5	5	8.8	14.9	25.7	
Smoking (%)						
No	80.2	73.8	78.2	83.3	86.4	< 0.001
Yes	19.8	26.2	21.8	16.7	13.6	
Alcohol consumption (%)						
No	94.2	94.5	94.4	94.3	93.7	0.904
Yes	5.8	5.5	5.6	5.7	6.3	
Diabetic (%)						
No	93.2	94.5	94.1	93	90.8	0.006
Yes	6.8	5.5	5.9	7	9.2	

BMI body mass index

P value was obtained ANOVA and Chi-square tests

Table 3 Relationship between HEI-2015 and muscle strength

Muscle strength	Quartiles of HEI—2015, OR (CI 95%)				*P*-trend
	Q1	Q2	Q3	Q4	
Crude	1	0.96 (0.73–1.26)	1.39 (1.09–1.78)	1.26 (1.02–1.62)	0.009
Model 1	1	0.95 (0.73–1.25)	1.38 (1.07–1.76)	1.24 (1.01–1.6)	0.015
Model 2	1	0.96 (0.73–1.26)	1.36 (1.09–1.79)	1.26 (1.02–1.64)	0.01

Model 1 adjusted with age, gender, smoking, and use alcohol

Model 2 adjusted with variable in Model 1, physical activity, and diabetes

juice. In one study by Barrea et al. [6], fruits consumption more than three times per day in women was associated with a better HGS. The higher intake of fruits as a component of the Mediterranean diet had positive effects on muscle strength and fat-free mass [33–35]. Lima Ribeiro et al. [36] indicated that intake of the fruits juice worsened muscle strength. Fruits are rich in vitamins having anti-oxidative and anti-inflammatory effects. They can also prevent muscle atrophy owing to the effect of fruits on the gut microbiota in animal models [33, 37].

In this study, the other component contributing to calculation of HEI-2015 was added sugar in which its lower

Table 4 Relationship between the HEI-2015 component and muscle strength

Components of HEI	OR (CI 95%)[a]	*P* value
Total fruits	1.06 (0.99–1.43)	0.086
Whole fruits	1.01 (1.02–1.18)	0.01
Total vegetables	1.03 (0.95–1.11)	0.46
Greens and beans	1.02 (0.95–1.1)	0.521
Whole grains	0.98 (0.89–1.08)	0.724
Dairy	1 (0.97–1.03)	0.72
Total protein foods	1.07 (0.98–1.16)	0.1
Seafood and plant proteins	1.09 (0.95–1.25)	0.208
Fatty acids	1.01 (0.98–1.05)	0.246
Refined grains	0.94 (0.8–1.11)	0.506
Sodium	1 (0.97–1.03)	0.832
Added sugars	1.06 (1.01–1.12)	0.019
Saturated fats	1.01 (0.97–1.04)	0.57

[a]Adjusted for all variables in Table 3

intake was associated with optimal muscle strength. In animal models, no change in strength was shown after drinking sugar-sweetened beverages [38]. Cameron et al. [39] did not observe any association between dietary carbohydrates and fat-free mass; however, high protein intake can predict high fat-free mass. Additionally, Hashemi et al. did not find any association between adherence Western diet and sarcopenia; in this case, Western diet was introduced by high sugar, fat, desserts, and fast food [40]. Since reduction in simple carbohydrates intake is accompanied by an increase in the intake of complex carbohydrates and proteins to provide energy, it seems that this relationship was owing to an increase in intake of complex carbohydrates, not necessarily a decrease in added sugar intake.

This study had several limitations; HEI-2015 was calculated based on FFQ. Although it is considered an appropriate nutritional assessment tool in large epidemiological studies, it can be affected by the recall bias. Furthermore, this study design was cross sectional in which a causal relationship maybe is inferred.

In conclusion, our findings indicated that adherence to HEI-2015 could enhance muscle strength. Although the score of all HEI-2015 components was higher in participants with an optimal HGS than in participants with a weak HGS, these associations were significant only between two HEI-2015 components (including whole fruits and added sugar) and HGS. Therefore, these results reflect that higher adherence to HEI-2015, especially adequate intake of whole fruits and moderation intake of added sugar, is an appropriate strategy to improve muscle strength.

What is already known on this subject?

Over 80% of the study participants had poor muscle strength. Previous studies have shown that weak muscle strength is associated with decreased mobility, increased fractures, and increased risk of cardiometabolic diseases. Identification and screening of nutritional factors affecting muscle strength can play a crucial role in muscle strength improvement.

What does this study add?

The study findings indicated that adherence to the HEI-2015 guidelines enhanced HGS, especially an adequate intake of whole fruits and a moderation intake of added sugar.

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Availability of data and materials Data will be available upon request from the corresponding author.

Compliance with ethical standards

Conflict of interest The authors have no conflict of interest to disclose.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This study was approved by the Ethics Committee of Kermanshah University of Medical Sciences (ethics approval number: KUMS.REC.1394.318).

Informed consent Written informed consent was obtained from each studied subject after explaining the purpose of the study. The right of subjects to withdraw from the study at any time and subjects information is reserved and will not be published.

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