Review Article

The Relationship between Healthy Eating Index and Lipid Profile in Healthy Individuals: A Systematic Review

Abstract

Background: The Healthy Eating Index (HEI) and Alternate Healthy Eating Index (AHEI) are instruments developed by competing American research teams, aiming to assess the level of adherence to a dietary pattern, claimed to prevent chronic illness conditions such as dyslipidemia. This systematic review evaluated cross-sectional studies examining the association between HEI/AHEI score and the lipid profile in healthy participants. **Methods:** The systematic review was Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) compliant, and a search process was conducted through Scopus, Web of Knowledge, Google Scholar, Cochrane, PubMed, and ScienceDirect up to November 2022. Studies assessing the relationship between HEI/AHEI and lipid profile (low-density lipoprotein cholesterol (LDL-C), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), and triglyceride (TG)) were eligible for inclusion. The statistical differences in outcomes, anthropometric indices, and demographic data were extracted from the selected studies. Also, the quality assessment of studies was performed using the Newcastle–Ottawa scale. **Results:** The systematic search presented 17 cross-sectional studies. Most of the studies revealed a significant correlation between HEI score and lipid profile (LDL-C, HDL-C, TG, and TC) ($P < 0.05$), while a few of them indicated a significant relationship between AHEI score and these factors. Overall, the elevation of HEI/AHEI score was associated with the improvement in lipid profile ($P < 0.05$), though this association was more obvious for HEI compared with AHEI. **Conclusions:** Overall, the results of the study indicated that an improved lipid profile in healthy individuals is associated with a higher score in either HEI or AHEI. Further research in the future is required to confirm the claim.

Keywords: *Dyslipidemia, food quality, healthy eating index, lipid profile, systematic review*

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Introduction

Dyslipidemia is considered a modifiable risk factor for cardiovascular diseases. The control of this risk factor leads to reduced mortality caused by cardiovascular diseases.[1] Cardiovascular diseases remain the cause of 80% of deaths in developing countries.[2] The prevalence of dyslipidemia and thus cardiovascular diseases significantly changes with improvements in the economic status of societies and lifestyle modifications.[3] Although the prevalence of cardiovascular diseases has decreased over the past two decades in developed countries, recent findings suggest that 37% of Americans have a low high-density lipoprotein (HDL) cholesterol level, while this number in some Eastern countries such as Iran is 69%.[4,5] The results of a study in China indicated that the prevalence of dyslipidemia among women in 2012 was 34%.[3] Generally, the prevalence of dyslipidemia and cardiovascular diseases is higher among Eastern societies compared with their Western counterparts.[2,6]

The etiology of dyslipidemia and cardiovascular diseases indicates that lifestyle factors such as diet can play an important role in preventing these disorders.[7] A reduction in the consumption of saturated fatty acids, salt, and cholesterol can be a useful strategy in preventing dyslipidemia and cardiovascular disorders.[8] Most previous studies have dealt with examining individual food items. Nevertheless, assessing the quality of diet and its general components, because of the complexity of dietary patterns in different societies, can offer a better perspective for preventing dyslipidemia and cardiovascular diseases.[9] The American Healthy Eating Index (HEI) was designed to measure the general quality of an individual's

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diet by assessing adherence to the Dietary Guidelines for Americans (DGA) and MyPyramid recommendations.[10] The HEI score is calculated by summing up the scores gained from assessing dietary diversity and the amount of sodium, cholesterol, saturated fatty acids, and total lipid consumed.[9] Obesity and lipid profile levels have an inverse relationship with HEI scores.[11] The Alternate Healthy Eating Index (AHEI) is a competing tool that assesses similar dietary parameters, while also taking the quality and source of nutrients consumed into account.[12] The AHEI is claimed to outperform HEI in predicting the risk of chronic disease.[13]

Adherence to special dietary patterns in different societies has increased considerably. For both HEI and AHEI, a high-scoring diet is claimed to help prevent chronic illness conditions, but previous studies have contradictory findings. Accordingly, this study aimed to systematically review cross-sectional studies conducted on evaluating the relationship between HEI/AHEI and lipid profile levels in healthy individuals.

Methods

Protocol

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Strategy was applied[14] with the registered code CRD42021287098. According to the research protocol and the local legislation, ethical approval was not needed.

Inclusion and exclusion criteria

Papers were included in this study according to the following inclusion criteria: i) studies that were issued as an original paper with full-text availability; ii) recruiting healthy individuals aged 18 years or older as study participants; iii) applying Food Frequency Questionnaire and 24-h recall as the dietary intake assessment tools; iv) those analyzing the association between HEI and AHEI with appropriate results; v) papers assessing at least one outcome from one of the following lipid profiles: total cholesterol (TC), TG, low-density lipoprotein cholesterol (LDL-C), or HDL-C; and vi) cross-sectional design. The exclusion criteria were as follows: i) studies documenting specific nutrients or other dietary patterns other than HEI and AHEI; ii) research conducted on nonhuman participants; iii) papers with unclear explained information about the research topic, study design, the data analysis method, and participants' characteristics; and v) studies conducted on infants, children, adolescents, or pregnant or lactating women.

Data sources and search strategy

An online search was conducted for papers evaluating the relationship between HEI/AHEI score and lipid profiles (TG, LDL-C, HDL-C, and TC) using Scopus, Google Scholar, PubMed, Science Direct, Web of Knowledge, and Cochrane databases. Also, publisher databases including Springer Link, Wiley Online, and Elsevier were used up to the end of November 2022. No language limitations were considered in the literature search process, and supplementary data were gathered using reference lists of relevant publications. The keywords for searching in the PubMed database were the following: "Diet," "Healthy," "Food Quality," "Diet Therapy," "lipids," "Lipid Metabolism," "Triglycerides," "High-Density Lipoproteins," "Cholesterol, LDL," "Cholesterol, HDL." The keywords were searched as Medical Subject Headings (MeSH) terms and abstracts of documents. EndNote software (version 20, X9) was used to manage search results.

Study selection

Initially, the publications extracted from the aforementioned databases were categorized based on the title and abstract, and duplicate papers were eliminated. Then, the authors separately evaluated the list of the specified references, and the remaining studies, which did not meet the inclusion criteria, were omitted. Next, study selection was done by assessing full texts based on the eligibility criteria from the remaining studies. The authors finally checked the reference lists of qualitative synthesis publications to discover other related studies. Discrepancies were resolved through consensus.

Data extraction and analysis

The data extraction process was performed using Microsoft Excel software. For data extraction in selected papers, the purpose and design of the studies were applied, along with study participants and sample size, research topic and location, measurement tools, the demographic information of individuals including age, body mass index (BMI), and gender, inclusion and exclusion criteria, time of the study, outcome data, result of analysis, food record template (e.g., 24-h recall or Food Frequency Questionnaire (FFQ)), and type of diet quality index. In addition, effect size correlation was extracted and calculated using the formula ($r_{Yl} = d / \sqrt{(d2 + 4)}$ for each outcome. The authors solved any disagreement via consensus.

Method for quality assessment

The Newcastle–Ottawa scale was used to evaluate the quality of cross-sectional studies in systematic review research. This instrument uses a "star" system for quality assessment of non-randomized studies in three units: ascertainment of outcomes (maximum three stars), comparability of research groups (maximum two stars), and participant selection (maximum five stars).[15] Since the maximum score on the scale was 10, we considered studies with scores of 6 or higher to enter the qualitative synthesis phase.[16] The details of quality assessment via the Newcastle-Ottawa scale are presented in Table 1.

Table 1: Quality assessment of studies based on the Newcastle–Ottawa Scale*

Studies	Selection				Comparability	Outcome		Total
	Representative samples	Justice of sample size	Satisfactory response rate	Validated tool for exposure measurement	Controlling for confounding factors	Outcome assessment	Appropriate statistical test	
Kant *et al*. (2005)[17]	☆	☆	☆	☆	☆☆	☆☆	☆	9
Drewnowski *et al*. (2009)[18]	☆	☆	-	☆	☆☆	☆	☆	7
Shah *et al*. (2010)[10]	-	☆	☆	☆	☆	☆☆	☆	7
Tardivo *et al*. (2010)[19]	-	☆	☆	☆	-	☆☆	☆	6
Belin *et al*. (2011)[20]	☆	☆	☆	☆	-	☆	☆	7
Nicklas *et al*. (2012)[21]	☆	☆	-	☆	☆☆	☆☆	☆	8
Asghari *et al*. (2013)[22]	-	☆	-	☆	☆☆	☆☆	☆	7
Haghighatdoost *et al*. (2013)[9]	☆	☆	☆	☆☆	☆	☆☆	☆	9
De Almeida Ventura *et al*. (2014)[23]	-	☆	☆	☆	-	☆☆	☆	6
Saraf-Bank *et al*. (2017)[11]	☆	☆	-	☆☆	☆☆	☆	☆	8
Rashidipour-Fard *et al*. (2017)[24]	-	☆	-	☆☆	☆	☆☆	☆	7
AlEssa *et al*. (2017)[25]	☆	☆	-	☆☆	☆☆	☆	☆	8
Lavigne-Robichaud *et al*. (2018)[26]	☆	☆	☆	☆	☆	☆	☆	7
Fallaize *et al*. (2018)[27]	☆	☆	-	☆☆	☆	☆	☆	7
Whitton *et al*. (2018)[28]	☆	☆	☆	☆☆	☆☆	☆☆	☆	10
Khakpouri *et al*. (2019)[29]	☆	☆	☆	☆☆	-	☆☆	☆	8
Landry *et al*. (2019)[30]	-	☆	-	☆	☆	☆☆	☆	6

*The Newcastle–Ottawa Scale included three sections: selection (representative samples: 0–1 star, justice of sample size: 0–1 star, satisfactory response rate: 0–1 star, validated tool for exposure measurement: 0–2 stars); comparability (controlling for confounding factors: 0–2 stars); outcome (appropriate statistical test: 0–1 star, outcome assessment: 0–2 star)

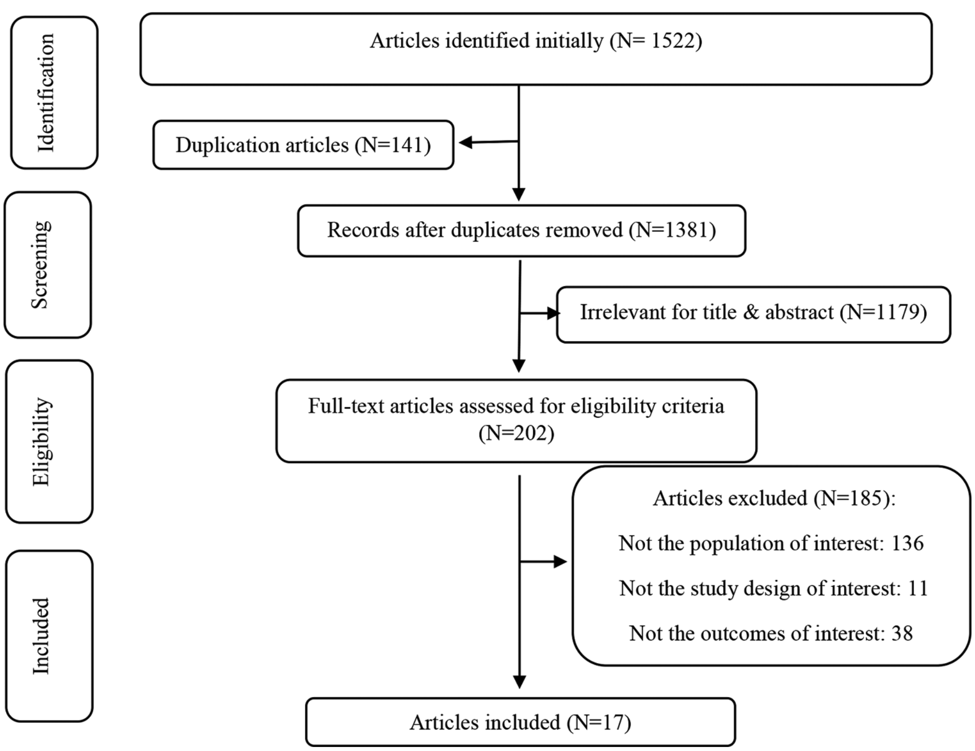

Figure 1: Flow chart of study selection

Table 2: Characteristics of the included studies investigating the association between diet quality score and lipid profile

Author/year	Location	Sample size	Age range and BMI	Quality Index	Outcome	Food measurement tool	Adjustment	Effect size (*r*)*	Findings
Kant *et al*. (2005),[17]	USA	8719 adults	<50 y: 67% ≥50 y: 33% BMI <25 kg/m²: 45% BMI ≥25 kg/m²: 55%	HEI	TC HDL-C LDL-C TG	24-h recall	Age, race/ethnicity, education, smoking, alcohol use, BMI, recreational physical activity, hours of fasting, supplement use in the past 24 hours, supplement use in the past month	-0.57 -0.89 -0.73 0.70	NS (*P*: 0.2) S (*P*: 0.02) S (*P*: 0.05) NS (*P*: 0.1)
Drewnowski *et al*. (2009),[18]	France	5081 adults	35–61 years	HEI	TC TG	24-h recall	Age, energy intake, tobacco use, and alcohol consumption	NR NR	NS (*P*>0.05) NS (*P*>0.05)
Shah *et al*. (2010),[10]	USA	125 Women	18–40 years; BMI >25 kg/m²	HEI	TC HDL-C LDL-C TG	24-hour recall	Energy intake and BMI	-0.75 0.78 -0.82 -0.22	S (*P*: 0.04) S (*P*: 0.03) S (*P*: 0.033) NS (*P*: 0.333)
Tardivo *et al*. (2010),[19]	Brazil	173 women	45–75 years; BMI: 19.1–42.3 kg/m²	HEI	TC HDL-C LDL-C TG	24-h recall	NR	NR NR NR NR	NS (*P*>0.05) NS (*P*>0.05) NS (*P*>0.05) NS (*P*>0.05)
Belin *et al*. (2011),[20]	USA	1014 adults	50–79 years; BMI: 24.6–27.8 kg/m²	AHEI	HDL-C LDL-C TG	FFQ	-	0.39 -0.12 -0.15	S (*P*<0.001) NS (*P*: 0.279) S (*P*: 0.004)
Nicklas *et al*. (2012),[21]	USA	18989 adults	≥19 years; BMI: 27.4–29 kg/m²	HEI	TC HDL-C LDL-C TG	24-h recall	Ethnicity, gender, age, estimated energy ratio poverty–income ratio, BMI, physical activity, smoking, and alcohol	-0.92 0.86 -0.91 0.02	S (*P*: 0.001) S (*P*: 0.005) S (*P*: 0.004) NS (*P*: 0.70)
Asghari *et al*. (2013),[22]	Iran	469 adults (Male: 33%) (Female: 67%)	38.7±12.3 years; BMI <25: 43.03% BMI ≥25: 56.97%	HEI	TC HDL-C LDL-C TG	24-h recall	Age, smoking status, waist circumference, body mass index, physical activity, and energy intake	NR NR NR NR	NS (*P*>0.05) NS (*P*>0.05) NS (*P*>0.05) S (*P*: 0.038); just for male
Haghighatdoost *et al*. (2013),[9]	Iran	9568 adults	33–44 years; BMI: 25.6 kg/m²	HEI	TC HDL-C LDL-C TG	FFQ	Age, smoking status, and BMI	0.00 0.00 0.01 0.00	NS (*P*: 0.4) NS (*P*: 0.4) NS (*P*: 0.05) NS (*P*: 0.3)
De Almeida Ventura *et al*. (2014),[23]	Brazil	215 postmenopausal women	44.5–90.1 years; BMI: 18.1–42.5 kg/m²	HEI	TC HDL-C LDL-C TG	24-hour recall	-	NR NR NR NR	NS (*P*: 0.27) NS (*P*: 0.37) NS (*P*: 0.75) NS (*P*: 0.58)
Saraf-Bank *et al*. (2017),[11]	Iran	1036 Iranian women	>30 years; BMI: 21.7–25.7 kg/m²	HEI	HDL-C TG	FFQ	Age, BMI, cigarette smoking, physical activity, socioeconomic status, current estrogen use, menopausal status, and family history of diabetes and stroke	NR NR	S (*P*: 0.01) S (*P*: 0.001)

Contd...

Table 2: Contd...

Author/year	Location	Sample size	Age range and BMI	Quality Index	Outcome	Food measurement tool	Adjustment	Effect size (*r*)*	Findings
Rashidipour-Fard *et al*. (2017),[24]	Iran	107 elderly	60–65 years BMI: 25.9 kg/m^2	HEI	TC	FFQ	Age, sex, energy intake, BMI	0.01	NS (*P*: 0.985)
					HDL-C			-0.02	NS (*P*: 0.975)
					LDL-C			-0.16	NS (*P*: 0.816)
					TG			0.47	NS (*P*: 0.452)
AlEssa *et al*. (2017),[25]	USA	775 healthy women	51–75 years; BMI: 26.7 kg/m^2	AHEI	TC	FFQ	Age, BMI, Caucasian race, postmenopausal status and postmenopausal hormone use, parity, and age at first birth, family history of myocardial infarction, family history of diabetes, diabetes, diabetes medication use, statin use, smoking status, moderate-to-vigorous physical activity, multivitamin use	0.50	NS (*P*: 0.15)
					HDL-C			0.18	NS (*P*: 0.40)
					TG			0.00	NS (*P*: 0.94)
Lavigne-Robichaud *et al*. (2018),[26]	Canada	811 adults	35–37 years BMI: 33.1 kg/m^2	AHEI	HDL-C	24-h recall	Age, sex, area of residence, total daily dietary energy intake, smoking status	NR	NS (*P*: 0.88)
					TG			NR	NS (*P*: 0.37)
Fallaize *et al*. (2018),[27]	Seven European Union (EU) countries	1480 adults (Male: 41.6%) (Female: 58.4%)	18–75 years; BMI: 25.4 kg/m^2	HEI	TC	FFQ	Sex, age, country, energy intake (kcal), objective PAL	0.00	NS (*P*: 0.20)
				AHEI				0.04	NS (*P*: 0.39)
Whitton *et al*. (2018),[28]	Singapore	2108 Singapore residents	27–53 years BMI: NR	AHEI	TC	FFQ	BMI, age, sex, ethnic group, daily energy intake, physical activity, cigarette smoking, working status, and housing type	NR	S (*P*<0.05)
					HDL-C			NR	S (*P*<0.05)
					LDL-C			NR	S (*P*<0.05)
					TG			NR	NS (*P*>0.05)
Khakpouri *et al*. (2019),[29]	Iran	748 men	43.50±8.88 years BMI: 27.16±3.76 kg/m^2	HEI	TC	FFQ	-	0.07	NS (*P*: 0.1)
					HDL-C			- 0.03	NS (*P*: 0.6)
					LDL-C			0.09	NS (*P*: 0.08)
					TG			- 0.03	NS (*P*: 0.5)
				AHEI	TC			0.01	NS (*P*: 0.7)
					HDL-C			- 0.03	NS (*P*: 0.5)
					LDL-C			0.00	NS (*P*: 0.9)
					TG			0.00	NS (*P*: 0.9)
Landry *et al*. (2019),[30]	USA	92 Hispanic college freshmen	18–19 years BMI: NR	HEI	TC	24-h recall	Sex, BMI percentile, total moderate-to-vigorous physical activity	NR	NS (*P*: 0.653)
					HDL-C			NR	NS (*P*: 0.244)
					LDL-C			NR	NS (*P*: 0.898)
					TG			NR	S (*P*: 0.037)

AHEI=Alternative Healthy Eating Index, HEI=Healthy Eating Index, FFQ=Food Frequency Questionnaire, BMI=body mass index, LDL-C=low-density lipoprotein cholesterol, HDL-C=high-density lipoprotein cholesterol, TG=total cholesterol, TG=triglycerides, PAL=physical activity level, NR=not reported, S=significant, NS=not significant, NR=no reported suitable data. * Calculate the effect size correlation, *r*Yl, using the means and standard deviations of two quartiles (the first quartile and the last quartile); effect size correlation: r_{Yl}=d/ √(d2+4)

Results

Search results

A primary database search resulted in the collection of 1522 articles, of which 141 articles were removed from the study due to duplication. Then, titles and abstracts were assessed and irrelevant studies were removed. Furthermore, 185 articles were removed from the study due to the following reasons: a) examining unrelated outcome variables, b) improper study design, and c) irrelevant target population. In the final step, 17 articles were included in the present systematic review. Figure 1 presents the search process.

Quality assessment

The results of the quality assessment of studies using the Newcastle-Ottawa scale indicated that the studies by Tardivo *et al.* and Landry *et al.* had the lowest score (six stars), while the study by Whitton *et al.* obtained the highest score (ten stars) [Table 1]. Overall, the mean score on the scale was 7.47/10.

Study characteristics

The total number of participants in the 17 studies was 51510, with the age ranging from 18 to 90 years. The gender distribution was as follows: 17% male and 83% female. Also, the reported BMI values were within 18–43 kg/m^2. Regarding the assessment of diet quality, four studies evaluated HEI, 11 studies assessed AHEI, and two studies examined HEI and AHEI simultaneously.[27,29] The average score of HEI and AHEI in the studies was within the range of 50 to 55. Assessment of the food intake of individuals was performed using FFQ (in eight studies) and 24-h recall (in nine studies) questionnaires [Table 1]. Studies had been carried out in the United States (n = 6), Brazil (n = 2), Iran (n = 5), France (n = 1), Canada (n = 1), and Singapore (n = 1). In addition, one study was conducted in seven countries of the European Union (EU).[27] Although the search strategy in this study included papers published by 2021, the publication date of studies was between 2005 and 2019 [Table 2].

Outcomes

Considering the lipid profile components in this study, one of the included studies assessed the relationship between cholesterol and HEI and AHEI. However, two studies evaluated only two components of lipid factors including TG/TC and TG/HDL-C [Table 2]. Also, two studies examined the association between the three components of the lipid profile (TG, TC, and HDL-C) and AHEI. Likewise, other studies have evaluated the association between each of the four components of the lipid profile and dietary quality indices, including HEI and AHEI [Table 2].

Regarding the relationship between lipid profile and HEI and AHEI, two studies showed that a reduction in TC is associated with an increase in HEI score (P = 0.001 and P < 0.001).[10,21] In addition, the results of Whitton *et al.* indicated an inverse association between AHEI score and TC (β (95% CI): - 0.05 (- 0.07, - 0.03), P < 0.05).[28] However, other studies did not show a significant relationship between TC and dietary quality score (P > 0.05).

The results of four studies revealed that a significant increase in HDL-C occurs following an increase in HEI score (P = 0.03, P = 0.01, P = 0.02, P = 0.005).[10,11,17,21] Also, the findings of Whitton *et al.* and Belin *et al.* indicated a direct association between AHEI and HDL-C in a significant manner (β (95% CI) = 0.02 (0.01, 0.02), P < 0.05), β (95% CI) = 57.0 (48.0, 71.0) (quintile 1) vs 66.0 (56.0, 77.0) (quintile 5), P < 0.001)[20,28] [Table 2].

The statistical results of four studies showed that an increase in the score of HEI led to a significant decline in LDL-C (P = 0.033, P = 0.006, P = 0.02, P = 0.004).[9,10,17,21] A study by Whitton *et al.* reported that the AHEI score also has a significant inverse relationship with LDL-C (β (95% CI) = - 0.04 (- 0.06, - 0.02), P < 0.05).[28] The results of three studies indicated that elevation of HEI score led to a significant reduction in blood TG (P = 0.001, P = 0.005, and P = 0.037).[9,11,30] Also, the study of Asghari *et al.* revealed an opposite association between TG status and HEI score in men only (TG changes = - 8.8 vs 2.9; P = 0.038).[22] Furthermore, the results of Belin *et al.'s* study showed a significant reduction in blood TG following an increase in the AHEI score (β (95% CI) = 132.0 (95.0, 187.5) (quintile 1) vs 120.0 (94.0, 150.0) (quintile 5), P = 0.004).[20] Overall, the effect size of each of the outcomes was also extracted from papers included in the final phase, as shown in Table 2.

Discussion

The current systematic review evaluated 17 cross-sectional studies exploring the link between HEI/AHEI and lipid profile. Based on the studies reviewed here, four papers reported a negative significant association between HEI and TC, four between HEI and LDL-C, and four between HEI and TG, respectively, while two papers indicated a positive correlation between HEI and HDL-C. However, only one study revealed a negative relationship between AHEI and TC, one between AHEI and LDL-C, and one between AHEI and TG, respectively. In addition, two articles showed a positive association between AHEI and HDL-C.

Since diet and dietary patterns have a direct, pivotal effect on maintaining health, dietary quality indicators should be investigated thoroughly. To track dietary quality, HEI was created to improve health behaviors and prevent chronic complications, which is revised every 5 years.[31,32] The HEI scores up to 100 points to measure adherence to the US Dietary Guidelines, consumption of the five food groups, dietary variety, plus intakes of fat, cholesterol, and sodium.[19] Also, the most recent update of the HEI added an emphasis on healthy choices within groups, including whole grains, plant proteins, seafood, and an appropriate ratio of unsaturated to saturated fatty acids.[33] The AHEI was developed by making adjustments to the original HEI, with more focus on food sources and quality, with the particular target of mortality prediction.[12,34] Higher AHEI scores have been strongly related to a lower risk of chronic diseases such as heart failure and cardiovascular disease, diabetes, breast and colorectal cancer, and total mortality.[29] The key differences between AHEI and the original HEI include attention to cereal fiber, moderate alcohol intake, the red-to-white meat ratio, fat quality, and duration of multivitamin consumption.[35] However, overall both HEI and AHEI have been linked to significant risk reductions for all-cause mortality.[36,37]

The current study found that the studies by Saraf-Bank, Belin, Haghighatdoost, Kant, Whitton, and Nicklas *et al.* were powerful and well-designed with large sample sizes, which found an association between HEI/AHEI and different components of lipid profile improvements. In line with these findings, an updated meta-analysis indicated that diets with high scores of HEI and AHEI were associated with a remarkable decrease in the risk of neurodegenerative diseases, cardiovascular diseases (CVDs), type 2 diabetes, cancer, and all-cause mortality.[38] Also, in a cohort study with 12,413 participants, those in the highest quintile of HEI-2015, compared with those in the lowest quintile, had 16, 32, and 18% lower risk of CVD incident, CVD mortality, and all-cause mortality, respectively.[32] Nevertheless, the participants included in the study by Saraf-Bank *et al.*[11] were female nurses, which would make the results less generalizable to other women and men due to different socio-demographic situations, educational level, occupation, and income.

As Asghari *et al.*[22] revealed, HEI conformity has been linked to a lower level of TG, particularly in men. Also, Yu *et al.* demonstrated that a higher HEI score is associated with a lower mortality rate in men.[39] These results might be attributed to a higher intake of favorable dietary factors such as vegetables and fruits.[40] Although Fallaize *et al.*[27] did not find a significant link between either HEI or AHEI and TC, higher HEI/AHEI was associated with more advanced age, total carotenoids, and omega-3 index, as well as lower BMI, waist circumference (WC), and waist-to-height ratio (WHtR). The lack of significant results for TC could be due to the uncommon approach used, called dried blood spot (DBS), to assess cholesterol level, which differs from previous studies.[41,42]

However, there is a lack of information about other aspects of lipid profile including TG, LDL-C, and HDL-C. Another study by Drewnowski *et al.*[18] showed that HEI was a poor predictor of lipid indices. However, this result might reflect the fact that plasma TG and TC were normal in the participants. In this regard, Huffman *et al.* revealed that there was no association between HEI score and congenital heart defect (CHD) risk among Cuban American individuals. However, AHEI was a predictor of 10-year CHD risk in diabetic patients.[43] In addition, another cross-sectional study indicated no possible relationship between HEI and overweight/obesity in adolescents.[44] Note that HEI/AHEI does not involve functional foods and phytochemicals as a component, which is an important limitation of both indices.[9]

Shah *et al.*[10] reported that HEI scores were linked to improved TC, LDL-C, and HDL-C, but since the 24-hour recall was used to collect dietary information, measurement error related to within-person variability is possible. Furthermore, insignificant improvements in lipid indices in Ventura[23] and Landry *et al.*[30] studies might result from small sample sizes and one-day 24-hour recall to gather dietary information. Since dietary guideline recommendations are intended to be fulfilled over time,[12] a single day's intake is inadequately representative of dietary pattern and seasonal variations.

In a study by AlEssa *et al.*, almost all participants were nurses and they were healthy with normal lipid profiles, which makes the results of the study debatable.[25] Also, Lavigne-Robichaud *et al.*[45] revealed that the use of 24-hour recall would increase the risk of omitting or forgetting some foods. Although Khakpouri *et al.*[29] was a well-designed study, it was conducted only on Iranian male employees with normal health status, which made the result less representative of the entire population of Iran. Note that the sample sizes of Rashidipour[24] and Tardivo[19] studies were small, due to the nature of cross-sectional studies. Also, in Tardivo and colleagues' research, all individuals came from low socioeconomic groups and the results may not reflect the general population. Some evidence indicated that consumption of whole grains, fish, lean meats, low-fat dairy, vegetables, and fruits is more likely in higher socioeconomic groups. In contrast, due to the association between food costs and food selection, people with a low-level income have weakened health, nutritional status, and diet quality.[46,47] Of note, due to different cultures, dietary behaviors, and habits, HEI and AHEI may not be valid in all populations.[48] Since the etiology of obesity and its related complications is multifactorial and lifestyle parameters such as socioeconomic status play an important role in its development, it may explain the different findings in the included studies, which had been conducted in developed and developing countries.[49] Developing countries experience several challenges related to corruption and political instability, while in developed countries various forms of food insecurity and urban poverty can occur such as establishment of more fast-food restaurants and few grocery stores.[50]

Our study had certain limitations based on the studies included in the review. First, FFQ was employed as a dietary assessment tool in some studies, while some others employed 24-h recall questionnaire. FFQ shows the dietary intake of participants in the long term, while 24-h recall reveals the dietary intake of individuals in the short term. This can make bias and affect our conclusion to some extent. Furthermore, according to the search strategy and published articles, the main limitation has been the exclusive inclusion of cross-sectional studies. In these studies, no causal associations can be established and individuals with higher serum lipids may have altered their nutrition because of their lipid profile. Moreover, studies have large variations in the determination of HEI, AHEI, blood parameters, and dietary evaluation. Also, considering the reported results of included studies and heterogeneity assessment, it was not possible to conduct a meta-analysis. Finally, although biological age is a pronounced risk factor for dyslipidemia, the eligible studies in our systematic review had been conducted on different group ages.

Conclusions

In conclusion, HEI/AHEI might have a positive correlation with lipid profile improvement, and healthcare professionals should be aware of the potential use of these indices for characterizing the diet-related risk of chronic disease conditions. Further studies are required to confirm this conclusion.

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Conflict of Interest

The authors declare no conflict of interest.

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Ethical Consideration

Not applicable.

Code of Ethics

Not applicable; Prisma Code: CRD42021287098.

Authors' Contributions

1) H.Faraji and S.Ferrie: Paper searching, study designing, writing the manuscript, and final checking 2) S.Jamshidi and P.S.Azar: Manuscript editing, writing the manuscript, paper reading and outcomes assessing.

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