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The relationship between the intake of fruits, vegetables, and dairy products and dyslipidemia in STEPs study

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Abstract

Objective Due to the contradictory findings and the lack of a comprehensive study investigating the relationship between fruits, vegetables, and dairy intake with lipid profiles in Iran, the present study was conducted to further assess the potential role of fruits, vegetables, and dairy intake in influencing blood lipid levels.

Results The mean age and body mass index (BMI) of the participants were 46.67 ± 15.48 years and 26.89 ± 5.09 kg/m^2, respectively. Regarding lipid profiles, the mean levels of triglycerides, total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C) were 127.36 ± 81.13, 163.61 ± 36.52, 96.95 ± 31.24, and 41.23 ± 11.32, respectively. In the adjusted model, the odds of abnormal triglyceride levels decreased with the consumption of one serving (odds ratio (OR) = 0.90; 95% confidence interval (CI): 0.83–0.98) and two servings of dairy products (OR = 0.87; 95% CI 0.78–0.97). No significant association was observed for the other variables.

Keywords Fruit, Vegetables, Dairy products, STEPs, Lipid profile, Triglyceride, Total cholesterol, High-density lipoprotein

Introduction

Dyslipidemia refers to abnormal blood lipid and lipoprotein levels, characterized by one or a combination of elevated low-density lipoprotein cholesterol (LDL-C), increased total cholesterol (TC) [1], elevated triglycerides [2], and reduced high-density lipoprotein cholesterol (HDL-C) [3]. In recent decades, dyslipidemia has been on the increase [4]. It is a major risk factor for cardiovascular diseases (CVDs), which are the leading cause of death worldwide, with dyslipidemia being a significant contributor [5]. The prevalence of dyslipidemia in some populations has been reported as 59.74% [6]. In Iran, studies have reported the prevalence of hypercholesterolemia, hypertriglyceridemia, elevated LDL-C, and low HDL-C levels to range from 14% to 61%, 14% to 40.6%, 13.4% to 45.5%, and 5.73%, respectively [7–10].

Among various dietary factors, fruits and vegetables (FV) are essential components of a healthy diet [3]. FV are highly nutritious, providing abundant dietary fiber, vitamins, minerals, antioxidants, and other bioactive compounds [11]. These compounds influence lipid profiles through various mechanisms. For instance, the cholesterol-lowering effect of dietary fibers may result from increased viscosity, which binds cholesterol and bile acids

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and inhibits their absorption [12, 13]. Therefore, FV consumption may effectively reduce the risk of blood lipid disorders and diseases such as diabetes, CVDs, and certain cancers [14]. Several studies have reported a positive relationship between FV intake and blood lipid control [15–17]. However, other studies have found no association between FV consumption and lipid profiles [18, 19].

Recent scientific interest and debate have focused on the potential relationship between dairy intake and lipid profiles, but the findings are conflicting [20–22]. The study by Derakhshandeh-Rishehri et al. [22] showed no significant association between dairy product consumption and triglyceride, TC, LDL-C, or HDL-C levels. In contrast, the study by Park et al. [20] revealed a significant association between dairy intake and lower risk of hypertriglyceridemia. Dairy products may reduce the risk of dyslipidemia due to their bioactive compounds, including linoleic acid, protein, medium-chain fatty acids, vitamin D, and calcium [23].

Given the increasing prevalence of dyslipidemia and its related diseases, the beneficial effects of consuming FV and dairy products in preventing and controlling these disorders, and the lack of comprehensive studies investigating this relationship in Iran, along with contradictory results, the present study was conducted to further assess the potential role of FV and dairy intake on blood lipid levels.

Methods

Study design and participants

A World Health Organization (WHO)-based STEPwise approach to surveillance (STEPs) questionnaire

Table 1 Socio-demographic characteristics of the study population based on fruit category

Variables	Fruit intake				
	< 1 serving (n = 8409)	1 serving (n = 7911)	2 servings (n = 2626)	˃ 2 servings (n = 899)	P-value*
Gender, female, %[a]	55.6	54.8	51.0	48.1	**< 0.001**
Area, rural, %[a]	41.7	31.1	29.2	28.5	**< 0.001**
Medication, no, %[a]	71.3	71.4	72.0	74.5	0.217
Marital status, single, %[a]	9.6	8.7	8.8	9.8	0.195
Occupation, %[a]					
Employee	4.7	8.4	10.6	12.1	**< 0.001**
Worker	6.0	5.2	6.0	5.5	
Self-paid	24.2	24.4	25.0	29.8	
Housekeeper	48.8	46.6	41.9	38.4	
Other	16.3	15.4	16.5	14.2	
Smoking, no, %[a]	77.2	81.6	80.1	78.1	**< 0.001**
Age, year[b]	48.04 ± 16.22	46.11 ± 15.03	45.26 ± 14.47	43.15 ± 13.76	**< 0.001**
BMI (kg/m^2)[b]	26.40 ± 5.23	27.15 ± 4.91	27.44 ± 5.07	27.60 ± 4.72	**< 0.001**
Physical activity, MET, min per week[c]	300.0 (0.0–1800.0)	480.0 (0.0–2009.0)	560.0 (0.0–2280.0)	600.0 (0.0–2520.0)	**< 0.001**
Education, year[b]	6.31 ± 5.23	8.11 ± 5.28	8.72 ± 5.26	9.68 ± 5.09	**< 0.001**
Triglyceride (mg/dL)[b]	122.19 ± 75.88	130.56 ± 86.59	132.14 ± 80.07	131.70 ± 77.46	**< 0.001**
TC (mg/dL)[b]	163.12 ± 36.48	164.03 ± 36.87	163.81 ± 35.82	162.72 ± 35.87	0.375
LDL-C (mg/dL)[b]	97.11 ± 31.24	96.89 ± 31.49	96.54 ± 30.60	95.75 ± 30.52	0.582
HDL-C (mg/dL)[b]	41.60 ± 11.47	41.07 ± 11.26	40.89 ± 11.12	40.70 ± 11.07	**0.002**
Triglyceride abnormality, %[a]	24.5	28.0	28.4	29.5	**< 0.001**
TC abnormality, %[a]	14.4	15.6	15.5	14.5	0.202
LDL-C abnormality, %[a]	43.1	42.7	42.4	41.4	0.723
HDL-C abnormality, %[a]	68.1	70.2	68.1	69.9	**0.024**

BMI body mass index, *MET* metabolic equivalent, *TC* Total cholesterol, *LDL-C* low-density lipoprotein cholesterol, *HDL-C* high-density lipoprotein cholesterol

Values are presented as mean ± standard deviation for parametric variables and median (25th-75th CI) for non-parametric continuous variables. For categorical variables, values are presented as percentages

[a] Obtained from chi-square test for categorical variables

[b] Obtained from independent-samples T-test for parametric continuous variables

[c] Obtained from Mann–Whitney for non-parametric continuous variables

Bold values represent the significant values was used to collect data, and its validity and reliability have already been evaluated [24]. Of the 31,050 participants selected, 30,541 qualified participants completed the questionnaire in the first phase. This phase assessed socio-demographic characteristics, medical risk factors, non-communicable diseases (NCDs), and lifestyle information (e.g., physical activity, nutrition, etc.). A consent form was also completed and signed during this phase. In the second phase (physical measurements), 30,042 participants were selected. The third phase (biochemical evaluations) was conducted only for participants aged 25 and older. Among the 30,541 participants, 27,738 aged 25 years and older were eligible and invited for biochemical assessments. Finally, 19,868 of the eligible participants underwent blood lipid measurements and were included in this study. A detailed description of the study design is provided in the study protocol [24].

In this cross-sectional study, we used the NCDs Research Center database of Tehran University of Medical Sciences. Participants were selected through systematic cluster random sampling from both rural and urban areas across 30 provinces of Iran, excluding Qom province (April to November 2016). This study was approved by the Medical Research and Ethics Committee of Shiraz University of Medical Sciences (IR.SUMS.SCHEANUT.REC.1400.035), and informed consent was obtained from all participants. Further details of the study have been published elsewhere [25, 26].

Anthropometric measures and biochemical assessment

Weight was measured with minimal clothing and without shoes (accuracy: 100 g). Standing height was measured without shoes, with flat feet against the wall, and the participant looking straight ahead, using a stadiometer (accuracy: 0.5 cm). Body mass index (BMI) was calculated

Table 2 Socio-demographic characteristics of the study population based on vegetable category

Variables	Vegetable intake				
	< 2 servings (n = 11,319)	**2 servings (n = 6835)**	**3 servings (n = 1349)**	**˃ 3 servings (n = 365)**	**P-value***
Gender, female, %[a]	53.7	54.8	56.5	56.7	0.137
Area, rural, %[a]	37.9	31.6	31.7	32.9	**< 0.001**
Medication, no, %[a]	71.4	71.8	72.7	69.2	0.550
Marital status, single, %[a]	9.4	8.8	8.8	7.4	0.417
Occupation, %[a]					
Employee	5.9	8.9	9.4	11.2	**< 0.001**
Worker	6.1	5.2	4.5	3.9	
Self-paid	24.9	24.7	23.0	22.9	
Housekeeper	47.0	45.8	47.2	48.2	
Other	16.1	15.4	15.9	13.8	
Smoking, no, %[a]	77.9	81.3	81.2	82.4	**< 0.001**
Age, year[b]	47.22 ± 16.16	46.15 ± 14.63	45.22 ± 13.83	45.73 ± 14.45	**< 0.001**
BMI (kg/m^2)[b]	26.52 ± 5.14	27.28 ± 4.96	27.79 ± 5.01	27.79 ± 5.01	**< 0.001**
Physical activity, MET, min per week[c]	320.0 (0.0–1800.0)	480.0 (0.0–2160.0)	720.0 (0.0–2552.0)	560.0 (0.0–2400.0)	**0.001**
Education, year[b]	6.95 ± 5.34	8.17 ± 5.29	8.48 ± 5.33	8.36 ± 5.17	**< 0.001**
Triglyceride (mg/dL)b[2]	125.62 ± 80.19	128.70 ± 79.31	132.75 ± 96.57	134.11 ± 78.17	**0.001**
TC (mg/dL)[b]	163.41 ± 36.68	163.97 ± 36.39	162.06 ± 35.98	165.66 ± 35.20	0.212
LDL-C (mg/dL)[b]	97.13 ± 31.20	96.92 ± 31.43	94.45 ± 30.35	97.63 ± 30.49	**0.028**
HDL-C (mg/dL)[b]	42.21 ± 11.35	41.33 ± 11.30	41.12 ± 11.40	41.14 ± 11.19	0.879
Triglyceride abnormality, %[a]	25.9	27.6	27.6	30.7	**0.024**
TC abnormality, %[a]	14.9	15.3	13.9	16.2	0.480
LDL-C abnormality, %[a]	43.0	42.8	40.4	44.8	0.262
HDL-C abnormality, %[a]	69.1	68.7	69.3	71.4	0.703

BMI body mass index, *MET* metabolic equivalent, *TC* Total cholesterol, *LDL-C* low-density lipoprotein cholesterol, *HDL-C* high-density lipoprotein cholesterol

Values are presented as mean ± standard deviation for parametric variables and median (25th-75th CI) for non-parametric continuous variables. For categorical variables, values are presented as percentages

[a] Obtained from chi-square test for categorical variables

[b] Obtained from independent-samples T-test for parametric continuous variables

[c] Obtained from Mann–Whitney for non-parametric continuous variables

Bold values represent the significant values

Table 3 Socio-demographic characteristics of the study population based on dairy product category

Variables	Dairy product intake				
	< 1 serving (n = 6301)	1 serving (n = 9432)	2 servings (n = 3213)	> 2 servings (n = 859)	P-value*
Gender, female, %[a]	57.9	54.3	50.1	44.8	**< 0.001**
Area, rural, %[a]	35.1	33.3	38.6	44.6	**< 0.001**
Medication, no, %[a]	71.8	70.7	74.1	71.9	0.003
Marital status, single, %[a]	9.2	9.3	8.4	9.3	0.495
Occupation, %[a]					
Employee	6.0	7.6	8.5	8.9	**< 0.001**
Worker	5.9	5.5	6.2	4.7	
Self-paid	23.0	24.3	27.0	32.5	
Housekeeper	50.0	46.4	42.4	37.5	
Other	15.1	16.2	15.9	16.4	
Smoking, no, %[a]	78.4	80.4	79.5	75.4	**< 0.001**
Age, year[b]	47.27 ± 15.99	46.53 ± 15.28	46.32 ± 15.20	45.37 ± 14.75	**< 0.001**
BMI (kg/m^2)[b]	26.62 ± 5.20	27.01 ± 5.03	26.99 ± 4.99	27.15 ± 4.97	**< 0.001**
Physical activity, MET, min per week[c]	240.0 (0.0–1600.0)	420.0 (0.0–1960.0)	800.0 (0.0–2956.0)	840.0 (0.0–3360.0)	**< 0.001**
Education, year[b]	6.84 ± 5.26	7.75 ± 5.32	7.84 ± 5.45	8.39 ± 5.62	**< 0.001**
Triglyceride (mg/dL)[b]	126.71 ± 81.27	127.97 ± 83.09	126.65 ± 75.28	127.40 ± 79.34	0.755
TC (mg/dL)[b]	163.00 ± 36.37	163.92 ± 36.76	163.84 ± 36.54	162.65 ± 34.68	0.370
LDL-C (mg/dL)[b]	96.46 ± 30.95	97.08 ± 31.64	97.27 ± 30.99	96.46 ± 29.38	0.530
HDL-C (mg/dL)[b]	41.27 ± 11.38	41.26 ± 11.33	41.28 ± 11.32	40.70 ± 10.89	0.559
Triglyceride abnormality, %[a]	26.8	26.6	26.7	26.3	0.987
TC abnormality, %[a]	14.8	15.1	15.8	14.1	0.501
LDL-C abnormality, %[a]	42.1	43.1	43.4	42.6	0.571
HDL-C abnormality, %[a]	69.8	69.3	66.9	68.2	**0.029**

BMI body mass index, *MET* metabolic equivalent, *TC* Total cholesterol, *LDL-C* low-density lipoprotein cholesterol, *HDL-C* high-density lipoprotein cholesterol

Values are presented as mean ± standard deviation for parametric variables and median (25th-75th CI) for non-parametric continuous variables. For categorical variables, values are presented as percentages

[a] Obtained from chi-square test for categorical variables

[b] Obtained from independent-samples T-test for parametric continuous variables

[c] Obtained from Mann–Whitney for non-parametric continuous variables

Bold values represent the significant values

as weight (kg) /height (m^2) [27]. Venous blood samples were collected from eligible individuals after a 12-h fast. Serum lipids (TC, HDL-C, and triglycerides) were measured using an auto-analyzer (Cobas C311 Hitachi, Tokyo, Japan). To minimize inter-laboratory comparison bias, samples were transported to the laboratory for evaluation with the same auto-analyzer. LDL-C was calculated using the Friedewald formula: LDL-C = TC−[HDL-C + triglyceride/5] [28].

Assessment of other variables

In the current study, the Global Physical Activity Questionnaire (GPAQ) was used to assess participants' physical activity [29]. This questionnaire consists of 16 questions evaluating frequency, duration, and intensity. The results from the GPAQ were then expressed as metabolic equivalents (METs)-min per week [24].

Dietary intake assessment

FV and dairy intake were assessed by asking participants, "How many servings of FV or dairy do you usually eat daily?". A serving was defined as one cup of diced or medium-sized fruit, one cup of raw or half a cup of cooked vegetables, and one cup of dairy. Fruit, vegetable, and dairy consumption were then categorized as follows: fruits—less than 1, 1, 2, and more than 2 servings per day (with one serving equivalent to about 150 g or 1 cup); vegetables—less than 3, 3, and more than 3 servings per day (with one serving equivalent to about 75 g or 1 cup); and dairy—less than 1, 1, 2, and more than 2 servings per day (with one serving equivalent to 1 cup).

Statistical analysis

An independent samples T-test and Mann–Whitney U test were used to examine differences in continuous

Table 4 Association between intake of fruits, vegetables, and dairy products with lipid profiles in the crude and adjusted models

Fruit Intake				
Variables	**< 1 serving**	**1 serving**	**2 servings**	**> 2 servings**
Triglyceride				
Crude	Ref	**1.20 (1.11–1.28)**	**1.22 (1.10–1.34)**	**1.28 (1.10–1.49)**
Adjusted	Ref	1.00 (0.84–1.19)	1.07 (0.90–1.27)	0.97 (0.80–1.17)
TC				
Crude	Ref	**1.09 (1.00–1.18)**	1.08 (0.96–1.22)	1.00 (0.82–1.21)
Adjusted	Ref	0.94 (0.76–1.17)	1.01 (0.82–1.26)	0.99 (0.78–1.25)
LDL-C				
Crude	Ref	0.98 (0.92–1.04)	0.97 (0.88–1.06)	0.93 (0.80–1.07)
Adjusted	Ref	0.95 (0.89–1.02)	0.94 (0.85–1.05	1.01 (0.87–1.18)
HDL-C				
Crude	Ref	**1.10 (1.03–1.17)**	1.00 (0.91–1.10)	1.08 (0.93–1.26)
Adjusted	Ref	0.98 (0.83–1.17)	1.03 (0.87–1.23)	0.92 (0.77–1.11)
Vegetable intake				
Variables	**< 2 servings**	**2 servings**	**3 servings**	**> 3 servings**
Triglyceride				
Crude	Ref	**1.08 (1.01–1.16)**	1.08 (0.95–1.23)	**1.26 (1.00–1.58)**
Adjusted	Ref	0.98 (0.90–1.05)	0.89 (0.77–1.04)	1.15 (0.88–1.50)
TC				
Crude	Ref	1.03 (0.95–1.12)	0.91 (0.78–1.08)	1.10 (0.83–1.46)
Adjusted	Ref	1.02 (0.93–1.12)	0.93 (0.77–1.11)	0.99 (0.71–1.38)
LDL-C				
Crude	Ref	0.99 (0.93–1.05)	0.89 (0.80–1.01)	1.07 (0.87–1.32)
Adjusted	Ref	0.96 (0.90–1.03)	0.89 (0.78–1.02)	1.09 (0.86–1.38)
HDL-C				
Crude	Ref	0.98 (0.91–1.04)	1.00 (0.89–1.13)	1.11 (0.88–1.40)
Adjusted	Ref	0.93 (0.87–1.01)	0.94 (0.82–1.09)	1.00 (0.76–1.31)
Dairy product intake				
Variables	**< 1 serving**	**1 serving**	**2 servings**	**> 2 servings**
Triglyceride				
Crude	Ref	0.99 (0.92–1.06)	0.99 (0.90–1.09)	0.97 (0.82–1.14)
Adjusted	Ref	**0.90 (0.83–0.98)**	**0.87 (0.78–0.97)**	0.88 (0.73–1.07)
TC				
Crude	Ref	1.02 (0.93–1.12)	1.08 (0.96–1.21)	0.94 (0.77–1.16)
Adjusted	Ref	1.00 (0.90–1.10)	1.01 (0.89–1.16)	0.96 (0.76–1.22)
LDL-C				
Crude	Ref	1.04 (0.97–1.11)	1.05 (0.96–1.14)	1.02 (0.88–1.18)
Adjusted	Ref	1.03 (0.96–1.11)	0.99 (0.90–1.09)	1.07 (0.90–1.27)
HDL-C				
Crude	Ref	0.97 (0.91–1.04)	**0.87 (0.80–0.95)**	0.92 (0.79–1.08)
Adjusted	Ref	1.01 (0.94–1.10)	0.93 (0.84–1.04)	0.99 (0.83–1.20)

TC Total cholesterol, *LDL-C* low-density lipoprotein cholesterol, *HDL-C* high-density lipoprotein cholesterol

These values are odds ratios (95% CIs)

Abnormality: Triglyceride > 150 mg/dL, TC > 200 mg/dL, LDL-C > 100 mg/dL, and low HDL-C (< 40 mg/dL in males and < 50 mg/dL in females)

Obtained from logistic regression by enter method

Bold values represent the significant values

Adjusted model: for age, gender, BMI, physical activity, education, marital status, medication, area of residency, smoking history, and occupation

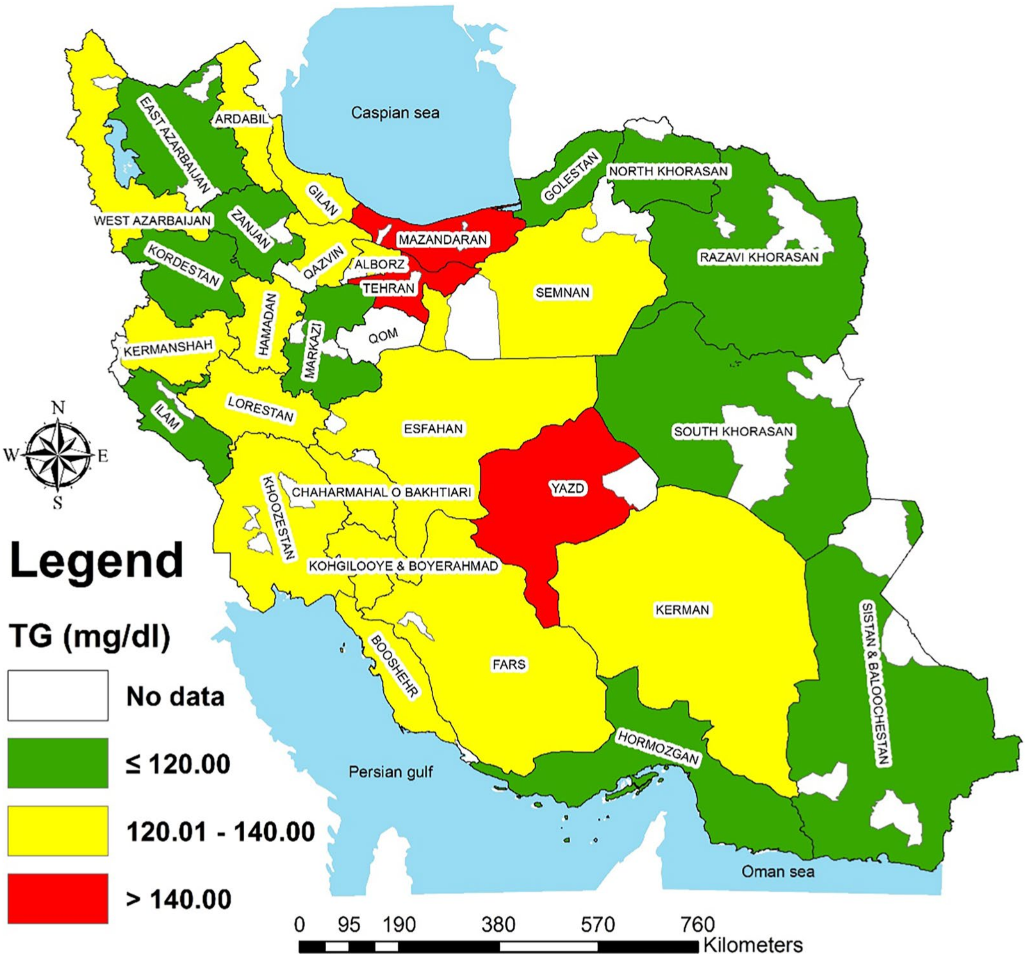

Fig. 1 The distribution of triglyceride at the provincial level

variables with parametric and non-parametric distributions across categories of fruit, vegetable, and dairy product intake. The distribution of participants regarding categorical variables across lipid profile levels was assessed using the chi-square test. Binary logistic regression was applied to obtain odds ratios (ORs) and 95% confidence intervals (CIs) for the associations between higher fruit, vegetable, and dairy intake and binary outcome variables (triglycerides > 150 mg/dL, TC > 200 mg/dL, LDL-C > 100 mg/dL, and low HDL-C (< 40 mg/dL in males and < 50 mg/dL in females)). In all analyses, individuals with normal levels were considered the reference group. In the adjusted model, we adjusted for age, gender, BMI, physical activity, education, marital status, medication, area of residency, smoking history, and occupation. All analyses were performed using IBM SPSS Statistics version 26. $P < 0.05$ were considered statistically significant.

Results

According to the sample size of the present study, the mean age and BMI were 46.67 ± 15.48 years and 26.89 ± 5.09, respectively. Additionally, the mean levels of triglyceride, TC, LDL-C, and HDL-C were 127.36 ± 81.13, 163.61 ± 36.52, 96.95 ± 31.24, and 41.23 ± 11.32, respectively. The prevalence of abnormalities in triglyceride, TC, LDL-C, and HDL-C in the total population was 26.7%, 15.1%, 42.8%, and 69.0%, respectively.

Socio-demographic characteristics of the study population based on fruit intake are shown in Table 1. Significant differences were observed across fruit intake categories for gender, area of residence, occupation, smoking, age, BMI, physical activity, education, triglycerides, HDL-C, and triglyceride abnormality (p-value < 0.001 for all, except HDL-C ($p = 0.002$) and HDL-C abnormality ($p = 0.024$)).

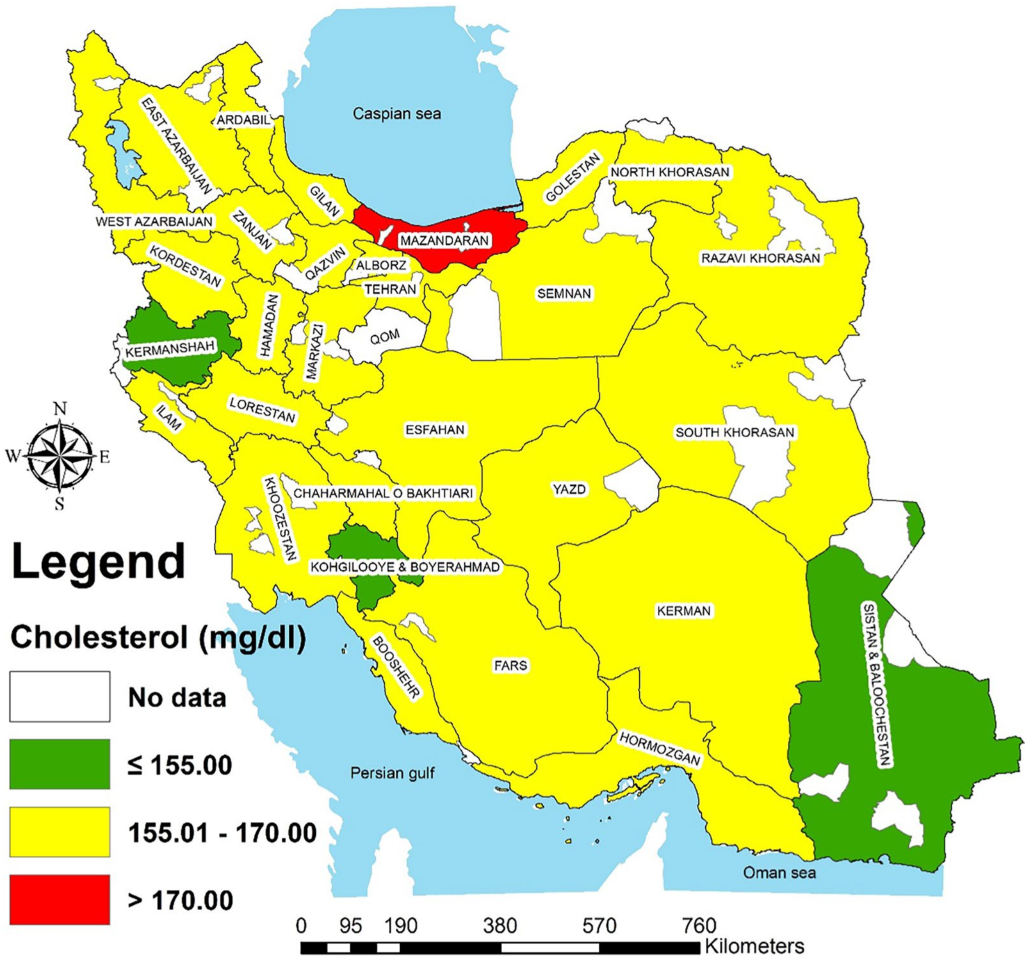

Fig. 2 The distribution of total cholesterol at the provincial level

Socio-demographic characteristics of the study population based on vegetable intake are presented in Table 2. Significant differences were observed across vegetable intake categories for area of residence, occupation, smoking, age, BMI, physical activity, education, triglycerides, LDL-C, and triglyceride abnormality ($p < 0.001$ for all, except physical activity ($p = 0.001$), triglyceride ($p = 0.001$), LDL-C ($p = 0.028$) and triglyceride abnormality ($p = 0.024$)).

Socio-demographic characteristics of the study population based on dairy intake are shown in Table 3. Significant differences were observed across dairy intake categories for gender, area of residence, occupation, smoking, age, BMI, physical activity, education, and HDL-C abnormality ($p < 0.001$ for all, except HDL-C abnormality ($p = 0.029$)).

Table 4 presents fruit, vegetable, and dairy intakes by triglyceride, TC, LDL-C, and HDL-C levels in both crude and adjusted models. Consuming one serving of fruit was significantly associated with increased levels of triglyceride (odds ratio (OR) = 1.20; 95% confidence interval (CI): 1.11–1.28), TC (OR = 1.09; 95% CI: 1.00–1.18), and HDL-C (OR = 1.10; 95% CI: 1.03–1.17) in the crude model. Also, the consumption of two servings (OR = 1.22; 95% CI: 1.10–1.34) and more than two servings (OR = 1.28; 95% CI 1.10–1.49) of fruits, as well as more than three servings (OR = 1.26; 95% CI 1.00–1.58) of vegetables, were significantly associated with increased triglyceride levels. A significant association was also found between the intake of more than two dairy servings and the level of HDL-C (OR = 0.87; 95% CI: 0.80–0.95). In the adjusted model, the odds of abnormal triglyceride levels decreased with the consumption of one serving (OR = 0.90; 95% CI: 0.83–0.98) and two servings of dairy products (OR = 0.87; 95% CI: 0.78–0.97). No significant associations were observed for the other variables.

The average levels of triglycerides, TC, LDL-C, and HDL-C at the provincial levels are shown in Figs. 1, 2, 3, and 4. The prevalence of triglycerides, TC, and HDL-C

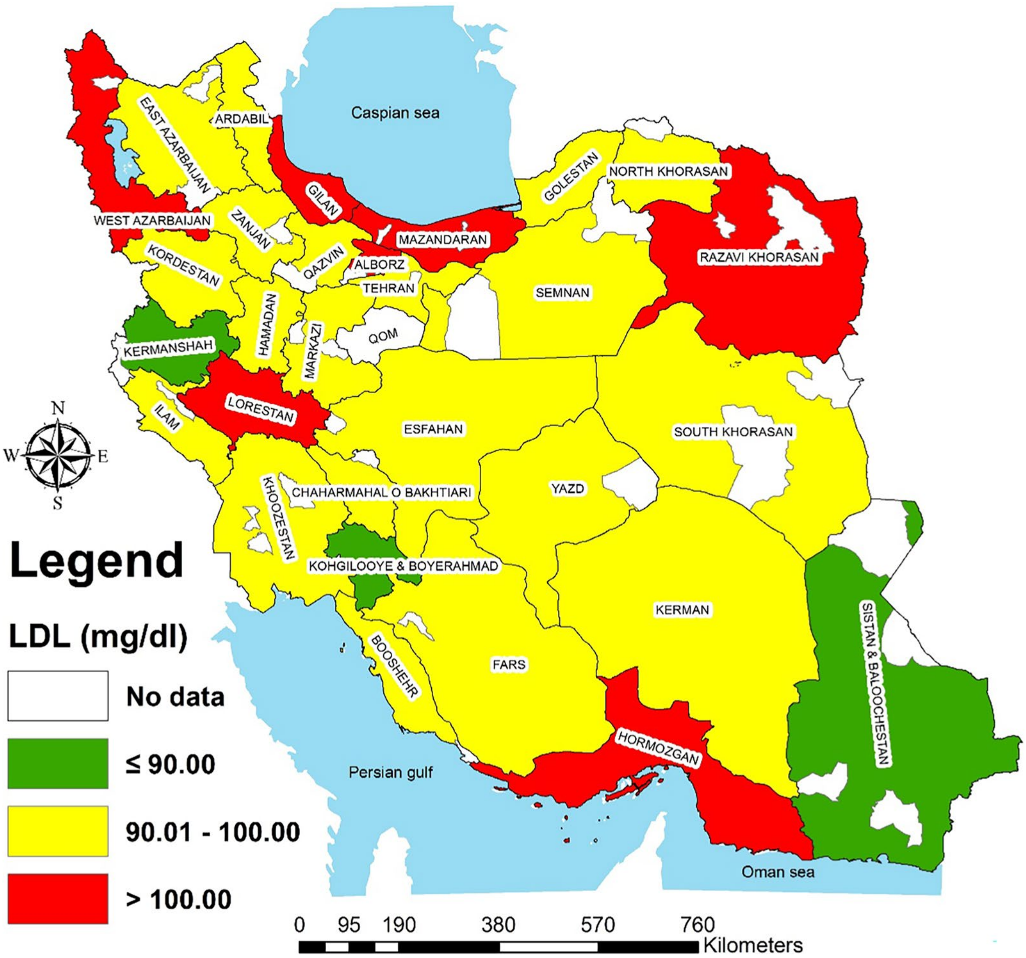

Fig. 3 The distribution of LDL-C at the provincial level

at the national and subnational levels is presented in Supplementary Figures.

Discussion

The present study showed that the consumption of one and two servings of dairy products was associated with a 10% and 13% reduction in serum triglycerides, respectively. However, no significant association was observed between dairy product intake and the other lipid variables. Also, the findings revealed no significant association between FV consumption and lipid profiles.

As noted, our study found no association between FV consumption and lipid profiles. In line with our findings, a cross-sectional study in individuals with type 2 diabetes also showed no significant association between increased FV intake and certain lipid profile levels [18]. Similarly, a randomized controlled trial found that FV consumption had no significant effect on serum lipids [19]. In contrast, a cross-sectional study revealed that students with lower fruit intake had higher rates of low HDL-C and high triglyceride levels [15]. A study conducted on Korean women indicated an inverse relationship between FV intake and high triglyceride and low HDL-C levels [16]. Besides, a parallel trial demonstrated that consuming 5 and 8 servings/day of FV significantly reduces LDL-C concentrations [17]. Findings from another cross-sectional study showed that increasing vegetable intake was inversely related to LDL-C and TC, whereas fruit intake had no such association [30]. Comparing these studies, we conclude that differences in target groups and evaluation criteria for FV consumption likely account for the varying results.

The findings of this study revealed that most participants consume less than one serving of fruit (150 g) and fewer than two servings of vegetables (75 g per serving). In a study conducted on 4,487 participants in the United Kingdom, the average consumption of FVs, as estimated through a food frequency questionnaire, was 241.8 g and

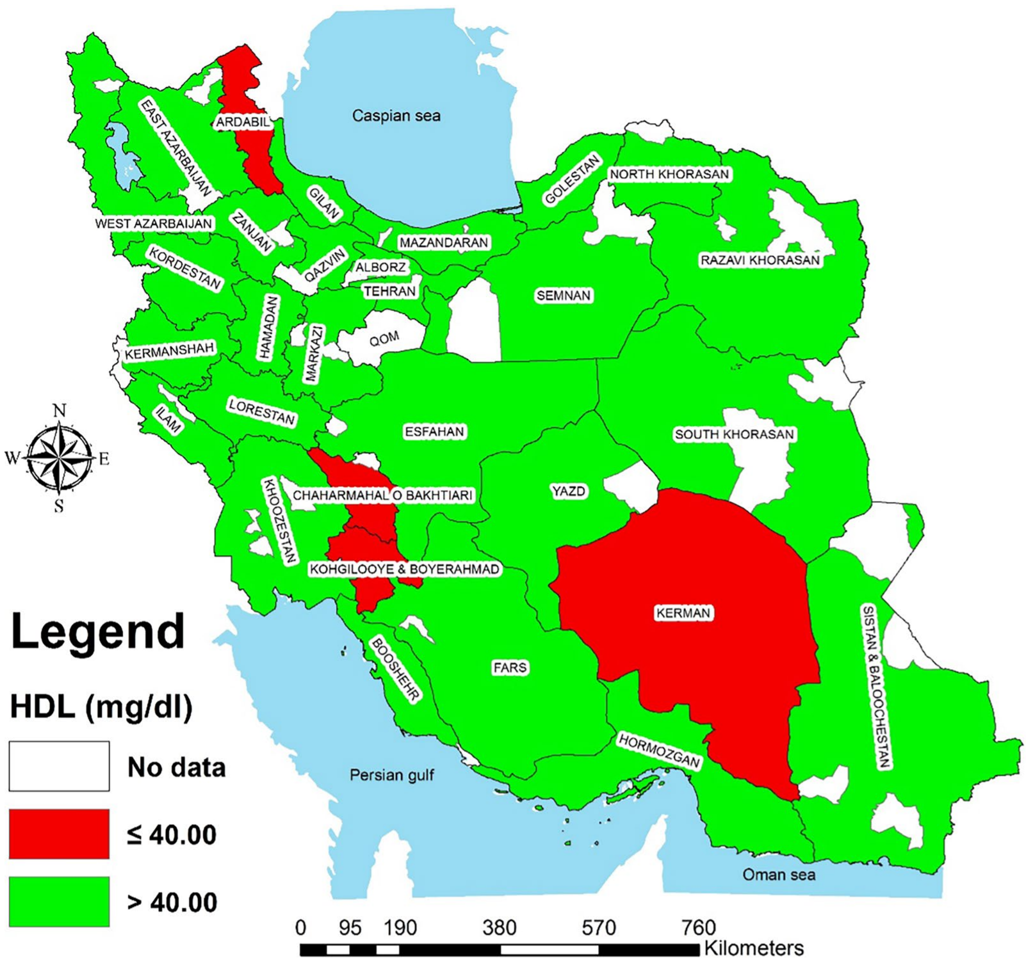

Fig. 4 The distribution of HDL-C at the provincial level

207.5 g, respectively [31]. Similarly, a study of 2,397 Australian adults found that the mean daily consumption of FVs was 128 g and 205 g, respectively [32]. These results suggest that the daily consumption of FVs among Iranians is comparatively lower than that in other populations.

Although no association was observed between FV consumption and lipid profiles in the present study, FV can affect lipid profiles through various mechanisms. For example, the cholesterol-lowering effect of dietary fibers may be due to their ability to increase viscosity, which slows the diffusion of nutrients, binds cholesterol and bile acids, and inhibits their absorption [12]. Also, the fermentative properties of fibers initiate another mechanism where they help reduce LDL-C levels by promoting the production of short-chain fatty acids by colonic bacteria and inhibiting cholesterol synthesis in the liver through the suppression of 3-hydroxy-3-methylglutaryl (HMG)-Co_A reductase [12]. Plant sterols, which are structurally similar to cholesterol, reduce serum cholesterol concentrations by inhibiting the absorption of dietary and biliary cholesterol in the small intestine [33]. Furthermore, FV consumption is effective in controlling weight and, subsequently, lipid profiles due to their low-fat content, reduced eating rate, and low energy density [11, 30, 34]. Also, antioxidants in the blood and organs are often reduced in chronic conditions like hyperlipidemia. In such cases, antioxidant intake can effectively normalize both lipid profiles and blood antioxidant levels [13].

Conflicting findings have been published regarding the effects of dairy products on chronic diseases such as diabetes, CVDs, and metabolic syndrome. These differences are attributed to factors such as race, dietary pattern [21, 35–37], the amount of dairy consumed [38–40], sex, and obesity [41–43]. In the present study, we observed a reduction in triglycerides associated with dairy product consumption. Consistent with our findings, Park et al. reported that participants with the highest dairy consumption (≥ 1 serving/day) had a lower risk of hypertriglyceridemia compared to those with the lowest intake of dairy products [20]. Similarly, Machlik et al. found an inverse relationship between the consumption of fermented dairy products and serum triglyceride levels [44]. Several mechanisms may explain the effect of dairy consumption on triglyceride reduction. One such mechanism involves the presence of calcium in dairy products. Increased dietary calcium intake can reduce the activity of 1,25-dihydroxyvitamin D. Higher calcium concentrations within cells promote lipolysis and inhibit fatty acid synthesis, potentially reducing triglyceride reserves [45]. Additionally, calcium increases the excretion of fat in feces, possibly by forming calcium-insoluble fatty acid soaps or by binding bile acids, which disrupts micelle formation [46].

In our study, dairy consumption had no significant effect on TC and HDL-C. Consistent with our findings, Machlik et al. also found no relationship between the consumption of fermented dairy products and HDL-C and TC levels [44]. Moreover, a meta-analysis of randomized clinical trials indicated that dairy consumption had no significant effect on HDL-C in healthy adults [47]. A randomized clinical trial also showed that dairy product intake did not affect HDL-C levels [48]. However, some studies have highlighted the beneficial effects of dairy consumption on reducing TC and increasing HDL-C levels [49–52]. Despite the high saturated fat content in dairy products, they are rich in minerals (such as calcium), vitamins, linoleic acid, and whey protein, all of which have positive effects on health [37, 52, 53]. For instance, calcium has been shown to dose-dependently reduce the postprandial lipid response [54].

Strengths and limitations

Our study has several strengths. It is the first comprehensive study with a large sample size to explore the association between FV and dairy products intake and lipid profiles in Iran, encompassing individuals from diverse ethnic backgrounds in both urban and rural areas. In addition, we accounted for a wide range of potential confounders. However, there are limitations to consider. Due to the cross-sectional design, we cannot infer a causal relationship between FV and dairy products intake and lipid profiles, as exposure and outcome may have been reversed. Moreover, due to the unavailability of data, we were unable to compare the effects of high-fat versus low-fat dairy products on lipid profiles. Another limitation is the lack of data on energy intake, which may have influenced the results. In addition, a more detailed and comprehensive questionnaire would be beneficial for a more accurate assessment in future studies.

Conclusions

Based on our findings, we observed an inverse association between dairy consumption and serum triglyceride levels. However, no association was found between FV consumption or dairy intake and lipid profiles such as TC and HDL-C. Further studies are needed to confirm these findings. Also, longitudinal and intervention studies are required to better understand the mechanisms through which different FV and dairy products affect lipid profiles.

Supplementary Information

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Supplementary material 1.

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Author contributions
M.N, Z.E, and Z.S; Contributed to writing the first draft. M.N; Contributed to all data, statistical analysis, and interpretation of data. S.F.; Contributed to the research concept, supervised the work, and revised the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
Data are available through a reasonable request from the corresponding author.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the ethical standards of the Declaration of Helsinki and approved by the medical research and ethics committee of Shiraz University of Medical Sciences (IR.SUMS.SCHEANUT.REC.1400.035) and informed consents were completed by all participants.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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