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Assessing the association between dairy consumption and the 10-year Framingham Risk Score in women

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Abstract

Purpose Cardiovascular diseases are a significant health concern for women in Iran, with previous research suggesting a potential link between dairy consumption and these diseases. This study aims to explore the relationship between the consumption of various dairy products and cardiovascular risk factors, as well as the Framingham Risk Score (FRS) among Iranian women. Various dairy products, including milk, yogurt, cheese, and drinkable yoghurt (dough), were considered, with a focus on dairy fat content (low-fat vs. high fat).

Methods In this cross-sectional study, 371 women aged 18 to 50 years were recruited. Dietary intake was assessed using a validated and reliable food frequency questionnaire. FRS was then employed to estimate each participant's 10-year risk of developing cardiovascular diseases.

Results After adjusting for confounding variables, participants in the highest tertile of low-fat dairy consumption had significantly lower FRS compared to those in the lowest tertile (FRS: -0.26 ± 0.30 vs. 1.06 ± 0.29, $P < 0.0001$). Higher yogurt consumption was associated with a significantly lower likelihood of having high triglycerides (TAG) (OR: 0.05, 95% CI: 0.003–1.09, $P = 0.02$) and high LDL-C (OR: 0.19, 95% CI: 0.01–3.2, $P = 0.003$). Participants in the highest tertile of cheese consumption had significantly lower odds of high fasting blood sugar (FBS) (OR: 0.35, 95% CI: 0.07–1.62, $P = 0.001$) and high TAG (OR: 0.05, 95% CI: 0.003–1.09, $P = 0.04$). Additionally, consumption of drinkable yogurt (dough) and high-fat dairy products was inversely associated with LDL-C levels (OR: 0.19, 95% CI: 0.01–3.2, $P < 0.0001$ and $P = 0.02$, respectively).

Conclusion Our findings suggest that both high-fat and low-fat dairy consumption are associated with beneficial cardiovascular effects. Higher low-fat dairy, is associated with lower FRS, indicating a reduced 10-year cardiovascular disease risk among women. Additionally, yogurt and cheese consumption were linked to improved lipid profiles, including lower triglycerides and LDL-C levels, which are key contributors to cardiovascular risk. These findings highlight the potential cardioprotective role of dairy consumption, supporting the need for further research to better understand its long-term impact on cardiovascular health.

Keywords Dairy Products; Cardiovascular Diseases, Framingham Risk Score, Women

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Introduction

Non-communicable diseases including cardiovascular diseases (CVDs) are one of the major causes of death and morbidity in 2019 where about 17.9 million deaths annually are attributed to CVDs [1]. In Iran, it is predicted that the prevalence of CVDs will be doubled in 2050 compared to 2005 [2]. A part of this considerable prevalence can be explained by the rapid transition of nutrition and adverse changes in dietary habits [3]. For instance, a comprehensive review published in the Proceedings of the Nutrition Society highlighted that economic transitions in low- and middle-income countries have led to higher rates of CVDs, accounting for nearly 80% of cases worldwide [3]. This surge is associated with shifts towards diets high in saturated fats, sugars, and processed foods, contributing to the global burden of CVDs [3]. Several modifiable risk factors have been proposed to increase CVD risks, including hyperglycemia, hyperlipidemia, sedentary lifestyle, unhealthy diet, smoking, and obesity [4]. Among these, hypertension is one of the most significant contributors to cardiovascular disease and is a key component of Framingham risk score (FRS). Previous studies have reported that hypertension is highly prevalent among the Iranian population, affecting approximately 36.1% of adults [5].

In Iran, women are at a higher risk of developing cardiovascular diseases (CVDs) [5]. Previous studies showed that high triglyceride levels (TAG) and total cholesterol (TC) were observed in 40.2% of the Iranian population aged 30 and over [6]. In this population, the prevalence of hypertension and obesity was 36.1% and 22.7% respectively [6]. Moreover, women are more likely than men to develop risk factors of CVDs such as diabetes mellitus, obesity, hypertriglyceridemia, and hypercholesterolemia (6, 7) Addressing these risk factors, particularly hypertension and dyslipidemia, is essential for preventing cardiovascular diseases. Additionally, improving risk factors, including eating habits, can reduce clinical events in individuals CVDs and those at high risk. Embracing a varied and balanced diet, alongside a healthy lifestyle, is one of the most important strategies for prevention of CVDs.

Enhancing dietary habits is a pivotal strategy in mitigating clinical events among individuals diagnosed with CVDs and those at elevated risk. Adherence to a balanced and varied diet, complemented by a healthy lifestyle, has been identified as a fundamental approach to CVD prevention. Recent studies have underscored the significance of dietary patterns in influencing cardiovascular health outcomes. For instance, a network meta-analysis highlighted that certain dietary patterns can effectively lower cardiovascular risk factors in patients with established CVD [8]. Furthermore, a comprehensive review emphasized the role of diet in cardiovascular health, noting that numerous human studies have provided evidence on the relationship between diet and CVD [8]. These findings reinforce the importance of dietary interventions as a cornerstone in the prevention and management of CVDs..Most dietary guidelines recommend milk and dairy products consumption as a main part of a well-balanced and a healthy diet [8, 9]. Dairy products constitute a diverse food group including non-fermented (such as milk) and fermented (such as cheese and yogurt) products [10]. The fermentation process can lead to varying health effects, which may be influenced by the fat content and other components within the dairy group [11]. Dairy products contain several bioactive compounds with potential cardioprotective effects, such as medium-chain and odd-chain saturated fats, spherical phospholipids, special amino acids, natural trans fats, branched-chain and unsaturated fats, vitamin K1 and K2, and calcium [12]. Vitamin K2, found naturally in fermented dairy products, has been proposed to reduce coronary heart diseases and aortic calcification [13, 14]. Additionally, dairy can contain probiotics, many of which may have health benefits [15]. However, dairy products are also a major saturated fat which has been implicated in raising LDL-C levels [16].. Saturated fat intake enhances low-density lipoprotein cholesterol (LDL-C) to high-density lipoprotein cholesterol (HDL-C) ratio potentially leading to chronic inflammation and an increased risk of CVD [17]. Some ecological studies have considered dairy products as a potential risk factor for CVDs [18, 19], though the evidence remains mixed.

Although several studies have investigated a hypercholesterolemic effect of dairy-rich diets [20, 21], others have found no association between milk intake and CVD outcomes [22]. Furthermore, some studies have suggested that dairy consumption may improve metabolic parameters and reduce cardiovascular risk due to its high-quality protein and essential nutrients [23, 24].

The FRS is a widely used cardiovascular risk prediction tool developed from the Framingham Heart Study to assess a person's 10-year probability of developing CVD [25]. FRS considers six major coronary risk factors:sex, age, smoking habits, TC, HDL-C, and systolic blood pressure [26]. Given the importance of hypertension and lipid profiles in CVD risk estimation, it is essential to explore how dairy consumption influences these factors. Notably, the validity and reliability of this tool for predicting CVDs risk in Iranian populations have been confirmed in previous studies [9, 27–29].

A multitude of studies have explored the relationship between dairy consumption and the risk of cardiovascular diseases (CVDs). However, only a few studies have specifically utilized the FRS as an outcome measure [13, 30, 31]. Among these, two studies focused on cardiovascular diseases as an outcome, with one identifying a correlation between milk consumption and the Framingham risk score [30] and the other establishing a link between lifestyle and coronary heart disease [31]. Geographical variations in dairy consumption can lead to differences in dietary patterns, nutrient intake, and overall health outcomes. These variations are important to consider, as they may influence the relationship between dairy consumption and cardiovascular risk. By focusing on the Iranian population, this study aims to provide insights that are specific to the dietary habits and health context of this region. Given the inconsistent findings of previous studies, the geographical variations in dairy consumption [12], and the limited research conducted in Iran, the aim of the present study is to investigate the association between the consumption of dairy products, categorized by fat content and type (milk, yogurt, and cheese), and the 10-year cardiovascular risk, as estimated by the Framingham Risk Score, as well as various cardiovascular risk factors.

Materials and methods

Participants

In this cross-sectional study, we employed cluster random sampling to include 371 women aged 20 to 50 years who attended the Southern Health Center of Tehran from 2017 to 2020. Data collection took place over a three-year period, from January 2017 to December 2020. Women suffering from chronic diseases such as cardiovascular diseases, diabetes mellitus, cancer, kidney diseases, and liver dysfunctions were excluded from the study to ensure a healthy sample at baseline. However, in our statistical models, we adjusted some of these diseases to control for any potential confounding effects that might arise during the study period. This approach allowed us to account for any new occurrences or diagnoses of these diseases, ensuring the robustness of our analysis. Women were excluded if they had followed a specialized diet in the past year or had unexplained total energy intakes below 500 kcal/day or above 3500 kcal/day [32]. The sample size was calculated using the mean serum triglyceride levels (mean ± SD = 6.11 ± 2.88) as the primary dependent variable, based on the formula [33]:

$$N = \left[\left(Z_1 - \alpha_{/2}\right)^2 \times S^2\right] / d^2$$

With α set at 0.05, a total of 356 participants was required, with "d" representing 6% of the mean triglyceride levels and accounting for a design effect of 1.5. Previous studies indicated that around 4% of participants might be excluded due to inaccurate energy intake reporting [34]. Therefore, we selected 371 participants to accommodate this potential exclusion. All participants provided informed consent, and the study's ethical protocol was approved by the National Institute for Medical Research and Development.

Dietary assessment

To evaluate the dietary intake of individuals, we utilized a semi-quantitative validated food frequency questionnaire (FFQ) containing 168 items [35]. The FFQ measured the consumption of dairy products, including high fat milk (~ 3.5% fat), low fat milk (~ 0.1–0.2% fat), cacao milk (~ 3.5% fat), soy milk (~ 1–2% fat), plain yogurt (~ 3–4% fat), homogenized yogurt (~ 3–4% fat), high fat yogurt (~ 10% fat), low fat yogurt (~ 0.5–2% fat), fresh yogurt (~ 3–4% fat), cheese (~ 30–40% fat), cream cheese (~ 33–35% fat), drinkable yogurt (~ 3–4% fat), Persian ice cream (~ 10–16% fat), ice cream (~ 10–16% fat), and kashk (~ 10–15% fat).Participants reported their mean intake of dairy products, such as milk, yogurt, and cheese, along with the frequency of consumption (daily, weekly, monthly, or yearly intervals). This information was obtained through face-to-face interviews conducted by trained personnel at the Southern Health Center of Tehran. The FFQ collected dietary intake information based on the participants' average consumption over the past 12 months. The FFQ generally offers accurate and dependable assessments of average food, food group [36], and nutrient intakes [37] over an extended period.. Participants provided the amounts of dairy products consumed using household measurements (e.g., cups, bottles, tablespoons), which were then converted to grams using a standardized reference guide. This ensured consistency and accuracy in the data. No food portion images were used in the process. The daily intakes of dairy products were calculated by multiplying the reported amounts by the frequency of consumption. To determine the total daily consumption of energy and nutrients and the total daily intake of dairy products in grams., we employed the modified version of Nutritionist IV software (version 7.0; N-Squared Computing, Salem, OR, USA) tailored for Iranian food… In addition to the commonly consumed dairy products such as milk, yogurt, and cheese, our study also considered the intake of drinkable yogurt, locally known as "dough." [38]. Dough is a traditional Iranian fermented dairy beverage made from yogurt, water, and salt, and is widely consumed in Iran. It is rich in probiotics and has various health benefits. To ensure comprehensive dietary intake data, participants were asked about their consumption of dough along with other dairy products. This inclusion provides a more accurate representation of the dietary habits of the study population.

Biochemical assessment

After 12 to 14 h of fasting, blood samples were collected, and biochemical assessments were performed. In this study we measured the following parameters: serum concentrations of lipid profiles including TC, LDL-C, HDL-C, TAG, and fasting blood sugar (FBS) using enzymatic methods.

Cardiovascular risk assessment

We used the FRS to estimate the 10-year risk of developing CVD for women aged 30 and above. The reliability and validity of this score to evaluate the cardiovascular disease risk in Iranian people has been previously reported [39]. The FRS calculation was based on six coronary risk factors: sex, age, TC, HDL-C, systolic blood pressure (SBP), and smoking. Points were assigned for each category as follows: for HDL-C: < 40, 40–49, 50–59 and ≥ 60 mg/dl; and for TC: < 160, 160–199, 200–239, 240–279, and ≥ 280 mg/dl. The total points were then summed to determine the FRS. Percentage of ten-year risk was computed using total scores (Under 9 points: < 1%; 9–12 points: 1%; 13–14 points: 2%; 15 points: 3%; 16 points: 4%; 17 points: 5%; 18 points: 6%; 19 points: 8%; 20 points: 11%; 21 = 14%; 22 = 17%; 23 = 22%; 24 = 27%; 25 = 30%) [40]. The percentage of absolute CVD risk over 10 years was classified as low risk (< 10%), medium risk (10–20%), and high risk (> 20%). Higher FRS scores indicate a greater risk of developing cardiovascular disease within the next 10 years [40].

Anthropometric assessment

Height was measured in the normal standing position without shoes to the nearest 0.1 cm. Weight was measured to the nearest 0.1 kg without shoes and with minimal clothing using a digital scale. Body mass index (BMI) was obtained by dividing weight (kg) by height squared (m^2). Waist circumference was calculated at the narrowest point between the last rib and the iliac crest, and hip circumference at the narrowest point between the last rib and the maximum hip circumference using inelastic tape to the nearest 0.1 cm.

Other variables assessment

Blood Pressure Measurement: We measured blood pressure for each person twice after resting for at least 10 min and while sitting, using a mercury sphygmomanometer. For the analysis, we used the mean of the two measurements.

Socio-Economic Status (SES) Assessment: To assess SES, we used a valid and reliable Persian socio-economic questionnaire. This questionnaire, specifically developed for the Iranian population, covers a wide range of questions, including education, participants' occupation, income, ownership of a house or car, possession of modern equipment, number of family members, and travel in or out of the country in the past year. All these questions were asked to gather comprehensive SES information for the present study. The validity and reliability of this questionnaire have been demonstrated in previous studies, ensuring its suitability for measuring SES and its association with health outcomes [41].

Physical Activity (PA) Measurement: Participants were asked to register their daily activities for 24 h. The average physical activity of individuals was computed using the equation: PA mean (metabolic equivalent of task (MET). hour.day^{-1}) = Activity time (hour.day^{-1}) × MET, where activity time is the total time spent on each activity during a day, MET is the metabolic equivalent task, and PA mean is the average physical activity..

Statistical analysis

We used the Kolmogorov–Smirnov test to evaluate the normality of variables, which was examined using a histogram curve. Chi-square and analysis of variance (ANOVA) tests were employed to compare qualitative and quantitative variables, respectively, across dairy consumption tertiles. Using binary regression, we explored the relationship between dairy consumption and CVD risk factors, including HDL-C, LDL-C, TAG, and FBS levels in the blood. The relationship between dairy intake and FRS was assessed using logistic regression.

In our analysis of the association between the Framingham Risk Score and cardiovascular risk factors across tertiles of dairy consumption in women, we used ANCOVA with three models: a crude model with no adjustments, Model 1 adjusted for age, sex, body mass index, energy intake, socio-economic status, smoking, and medication use (including treatments for diabetes, cardiovascular conditions, hypertension, dyslipidemia, as well as antioxidant, multivitamin, and omega-3 supplements), and Model 2, which was further adjusted for physical activity. In the logistic regression analysis presented in Table 4, which examines the distribution of the Framingham Risk Score and cardiovascular risk factors across different types of dairy consumption, we used a crude model with no covariate adjustments and an adjusted model that controlled for age, dietary fiber intake, socio-economic status, smoking, pre-existing diseases, and medication use (including anti-diabetic drugs, multivitamins, and antioxidant supplements).We used SPSS software (version 24) for statistical analysis, with a significance level set at p-value < 0.05.

Results

The general characteristics of the 371 women studied, categorized by dairy tertiles, are detailed in Table 1 and supplementary Table 1. Significant differences were observed for age, waist circumference, SES, and multivitamin use across tertiles of dairy consumption. Participants in the highest tertile of low-fat dairy consumption (≥ 362.34 g/day) were significantly older than those in the lowest tertile ($P = 0.033$). Age also varied significantly across tertiles of high-fat dairy consumption, with younger participants in the highest tertile ($P = 0.0001$). Waist circumference differed significantly across tertiles of high-fat dairy intake ($P = 0.006$), with the second tertile showing a higher mean value. SES was significantly associated with both high-fat ($P < 0.001$) and total dairy consumption ($P = 0.034$), with higher SES individuals consuming more dairy. Additionally, multivitamin use was significantly higher in the second tertile of high-fat dairy intake ($P = 0.024$). There were no significant differences in weight, BMI, smoking status, antioxidant or omega-3 supplement use across any tertiles of dairy consumption.

The dietary intake across dairy consumption tertiles is detailed in Table 2and supplementary tables 2 and 3. Participants in the higher level of low-fat dairy intake had a higher intake of energy, protein, carbohydrates, dietary fiber, vitamins B12, B6, D and K as well as folate, calcium, potassium, magnesium, zinc, and iron. Those in the higher-level of high-fat dairy consumption exhibited greater intake of energy, fat, dietary fiber, saturated fatty acids (SFA), vitamins D, E, B6 and B12, as well as calcium, and iron. Similarly, participants in the higher level of total dairy consumption also demonstrated higher intakes of energy, protein, dietary fiber, SFA, vitamins B12, B6, A, D, E and K along with potassium, calcium, zinc, magnesium, and iron.

The mean and standard deviation (SD) of FRS and other cardiovascular disease risk factors, categorized by dairy consumption tertiles, are outlined in Table 3 and supplementary tables 4 and 5. Participants in the higher level of low-fat dairy consumption, compared to those in the lower level, exhibited the lowest levels of HDL-C (47.74 ± 0.72 vs. 48.17 ± 0.71, $P < 0.0001$), and the highest levels of TC (183.1 ± 2.67 vs. 175.8 ± 2.62, $P = 0.04$), LDL-C (83.24 ± 1.47 vs. 77.24 ± 1.44, $P = 0.001$), TC/HDL-C ratio (3.93 ± 0.09 vs. 3.8 ± 0.09, $P = 0.005$), and FBS (90.86 ± 0.73 vs. 87.17 ± 0.72, $P = 0.002$). Similarly, participants in the higher level of total dairy and high-fat dairy consumption, compared to those in the lower level, had the lowest levels of HDL-C (47.74 ± 0.72 vs. 48.17 ± 0.71, $P < 0.0001$), and the highest levels of TC (183.1 ± 2.67 vs. 175.8 ± 2.62, $P = 0.04$), LDL-C (83.24 ± 1.47 vs. 77.24 ± 1.44, $P = 0.001$), TC/HDL-C ratio (3.93 ± 0.09 vs. 3.8 ± 0.09, $P = 0.005$), and FBS (90.94 ± 0.74 vs. 87.07 ± 0.72, $P = 0.001$).

After adjusting for potential confounders, significant associations were observed between milk and yogurt consumption and several cardiovascular risk factors (supplementary Table 4). For milk consumption, there was a significant reduction in the Framingham score in the highest tertile (T3) compared to the lowest tertile (T1) ($P < 0.0001$). In terms of lipid profile, a higher consumption of milk was associated with increased total cholesterol (TC) levels ($P = 0.04$) and higher HDL-C levels ($P < 0.0001$), along with a decrease in LDL-C ($P = 0.001$). A significant reduction in the TC/HDL-C ratio was also noted in the highest milk consumption tertile ($P = 0.005$). Regarding fasting blood sugar (FBS), the highest tertile of milk consumption showed significantly lower FBS compared to the lowest tertile ($P = 0.002$). For yogurt consumption, significant findings included a reduction in Framingham score ($P < 0.0001$) and significant increases in HDL-C ($P < 0.0001$) and LDL-C ($P = 0.001$) levels. The TC/HDL-C ratio was significantly lower in the highest tertile of yogurt consumption ($P = 0.005$), and FBS was significantly lower in the highest tertile compared to the lowest tertile ($P = 0.001$).

After adjusting for potential confounders, significant associations were found between cheese and dough consumption and cardiovascular risk factors (supplementary Table 5). Higher cheese consumption was associated with a lower Framingham score in the highest tertile compared to the lowest ($P < 0.0001$). Additionally, increased cheese intake was linked to higher total cholesterol (TC) ($P = 0.04$) and HDL-C levels ($P < 0.0001$), along with a reduction in LDL-C ($P = 0.001$). The TC/HDL-C ratio was significantly lower in the highest tertile of cheese consumption ($P = 0.005$), and fasting blood sugar (FBS) levels were significantly lower in the highest tertile ($P = 0.001$). Similarly, higher dough consumption was significantly associated with a lower Framingham score ($P < 0.0001$). Increased dough intake was also linked to higher TC ($P = 0.04$) and HDL-C levels ($P < 0.0001$), while LDL-C levels were lower ($P = 0.001$). The TC/HDL-C ratio was significantly lower in the highest tertile of dough consumption ($P = 0.005$), and FBS was significantly lower in the highest tertile compared to the lowest ($P = 0.001$).

Table 4and supplementary tables 6 and 7 present the odds ratios (OR) and 95% confidence intervals (CI) of cardiovascular risk factors, both in crude and adjusted models, across total dairy consumption and its various types. Notably, a higher intake of high-fat dairy products was associated with lower levels of LDL-C (OR: 0.19, 95% CI: 0.01—3.2, $P = 0.02$).

The association of cardiovascular risk factors across tertiles of milk and yogurt consumption is presented in

Table 1 Participants demographics by tertiles of dairy consumption types

	Tertiles of low-fat dairy consumption			P value	Tertiles of high fat dairy consumption			P value	Tertiles of total dairy consumption			P value
	T1 **≤ 227.49**	**T2** **227.49–362.34**	**T3** **≥ 362.34**		**T1** **≤ 15.10**	**T2** **15.10- 68.71**	**T3** **≥ 68.71**		**T1** **≤ 280.6**	**T2** **280.6–446.07**	**T3** **≥ 446.07**	
Number of Participants	**124 (33.4)**	**123 (33.2)**	**124 (33.4)**		**125 (33.7)**	**120 (32.3)**	**126 (34)**		**124 (33.4)**	**123 (33.2)**	**124 (33.4)**	
Age (year)	29.77 ± 6.31	30.28 ± 6.69	31.96 ± 7.58	**0.033**	32.61 ± 8.32	30.23 ± 5.96	29.17 ± 5.80	**0.0001**	30.42 ± 6.60	30.30 ± 7.02	31.27 ± 7.18	0.487
Weight (kg)	63.12 ± 10.72	64.51 ± 8.81	64.78 ± 12.17	0.421	63.81 ± 9.90	65 ± 11.20	63.60 ± 10.87	0.539	63.46 ± 10.81	64.43 ± 8.95	64.57 ± 11.88	0.685
BMI (kg/m^2)	24.11 ± 3.88	24.07 ± 3.38	24.60 ± 4.74	0.514	24.50 ± 3.86	24.70 ± 4.28	23.58 ± 3.91	0.068	24.40 ± 3.88	23.85 ± 3.65	24.48 ± 4.52	0.429
waist circumference (cm)	86.02 ± 10.91	84.32 ± 7.82	86.32 ± 10.01	0.216	84.56 ± 9.05	87.83 ± 11.43	84.30 ± 7.94	**0.006**	86.46.10.77	84.30 ± 8.43	85.75 ± 9.51	0.211
Smoking status Smokers	0	2 (1.6)	1 (0.8)	0.370	0	1 (0.8)	2 (1.6)	0.368	1 (0.8)	1 (0.8)	1 (0.8)	1
Nonsmokers	122 (100)	122 (98.4)	123 (99.2)		123 (100)	122 (99.2)	122 (98.4)		121 (99.2)	125 (99.2)	121 (99.2)	
SES low	39 (31.7)	26 (21)	41 (33.1)	0.150	32 (26)	47 (37.9)	27 (21.8)	**< 0.001**	45 (36.6)	25 (19.8)	36 (29.5)	**0.034**
moderate	46 (37.4)	54 (43.5)	39 (31.5)		67 (54.5)	27 (21.8)	45 (36.6)		43 (35)	56 (44.4)	40 (32.8)	
high	38 (30.9)	44 (35.5)	44 (35.5)		24 (19.5)	50 (40.3)	52 (41.9)		35 (28.5)	45 (35.7)	46 (37.7)	
Taking antioxidant supplements	2 (1.6)	0	0	0.132	1 (0.8)	1 (0.8)	0	0.604	2 (1.6)	0	0	0.132
Taking Multivitamin supplements	15 (12.2)	19 (15.3)	18 (14.5)	0.763	13 (10.6)	26 (21)	13 (10.5)	**0.024**	15 (12.2)	16 (12.7)	21 (17.2)	0.460
Taking an omega-3 supplement	2 (1.6)	6 (4.8)	1 (0.8)	0.093	1 (0.8)	6 (4.8)	2 (1.6)	0.093	2 (1.6)	5 (4)	2 (1.6)	0.383

Abbreviations: *BMI* body mass index, *SES* socio-economic status

Values: Presented as means ± standard deviation (SD) for quantitative variables or count (%) for qualitative variables

P-value: Results obtained from ANOVA for quantitative variables and Chi-square test for qualitative variables

Table 2 Dietary intakes of participants in different tertiles of low-fat dairy, high Fat dairy, and total dairy consumption

	Tertiles of low-fat dairy consumption			P value*	Tertiles of high fat dairy consumption			P value*	Tertiles of total dairy consumption			P value*
	T1 <227.49	T2 227.49- 362.34	T3 >362.34		T1 <15.10	T2 15.10–68.71	T3 >68.71		T1 <280.6	T2 280.6- 446.07	T3 >446.07	
Number of Participants	**121**	**123**	**125**		**121**	**123**	**125**		**121**	**123**	**125**	
Energy(g/day)	2240.58 ± 740.26[a]	2374.53 ± 729.070	2904.67 ± 632.50	**0.0001**	2263.82 ± 666.85	2427.45 ± 720.17	2828.95 ± 771.45	**0.0001**	2078.53 ± 653.01	2622.84 ± 747.92	2847.52 ± 653.03	**0.0001**
Protein(g/day)	75.23 ± 26.80	91.22 ± 29.74	105.13 ± 26.66	**0.0001**	84.31 ± 27.67	85.16 ± 26.70	102.08 ± 32.91	0.075	71.34 ± 24.41	98.26 ± 27.79	103.49 ± 28.03	**0.0001**
Fat(g/day)	68.37 ± 25.63	74.76 ± 27.29	89.84 ± 28.22	0.494	67.11 ± 24.89	75.54 ± 26.03	90.33 ± 29.45	**0.016**	63.05 ± 22.87	80.77 ± 27.52	90.05 ± 27.97	0.314
Carbohydrates (g/day)	342.22 ± 120.75	348.41 ± 115.63	438.91 ± 98.61	**0.022**	344.73 ± 112.14	364.54 ± 116.08	420.40 ± 120.10	0.269	316.49 ± 108.98	393.22 ± 121.55	424.02 ± 103.72	0.361
Dietary fiber(g/day)	5.32 ± 2.27	6.91 ± 2.87	7.87 ± 2.68	**0.0001**	6.48 ± 2.75	6.61 ± 3.13	7 ± 2.53	**0.041**	5.13 ± 2.12	7.39 ± 2.87	7.70 ± 2.70	**0.0001**
Saturated Fatty Acid (mg/day)	21.26 ± 9.43	23.40 ± 2.87	29.10 ± 9.82	0.233	20.15 ± 8.73	23.56 ± 8.36	30.05 ± 9.90	**0.0001**	19.73 ± 8.66	24.19 ± 8.23	30 ± 9.74	**0.0001**
VitaminB12 (µg/day)	2.86 ± 1.65	4.34 ± 1.85	5.13 ± 1.97	**0.0001**	3.68 ± 2	3.61 ± 6.49	5.04 ± 2.26	**0.001**	2.85 ± 1.52	4.33 ± 1.89	5.22 ± 1.96	**0.0001**
VitaminB6 (µg/day)	1.67 ± 0.72	1.93 ± 0.74	2.37 ± 0.84	**0.016**	1.87 ± 0.81	1.93 ± 0.79	2.16 ± 0.84	**0.007**	1.51 ± 0.61	2.19 ± 0.84	2.30 ± 0.77	**0.001**
Folate (mg/day)	273.56 ± 121.72	356.15 ± 164.14	406.98 ± 116.20	**0.0001**	328.57 ± 147.89	327.14 ± 165.28	380.73 ± 160.70	**0.059**	256.49 ± 110.06	385.80 ± 173.29	401.67 ± 150.80	**0.001**
Vitamin A (RAE/day)	9.89 ± 7.08	10.44 ± 7.25	12.95 ± 6.81	0.960	10.15 ± 7.36	10.63 ± 5.72	12.50 ± 8.01	0.832	8.18 ± 5.23	12.98 ± 8.04	12.42 ± 6.70	**0.015**
Vitamin E (mg/day)	11.85 ± 6.20	12.93 ± 7.92	14.38 ± 6.24	0.260	11.64 ± 7.70	14.01 ± 6.59	13.53 ± 6.12	**0.003**	10.45 ± 6.16	14.98 ± 7.49	14.03 ± 6.26	**0.010**
Vitamin D (µg/day)	1.06 ± 0.90	1.58 ± 0.99	2.35 ± 1.90	**0.0001**	1.59 ± 1.53	1.27 ± 1.15	2.13 ± 1.49	**0.002**	1.08 ± 0.87	1.58 ± 1.30	2.35 ± 1.74	**0.0001**
Vitamin K (µg /day)	117.17 ± 65.47	173.23 ± 105.07	171.37 ± 80.21	**0.0001**	148.52 ± 78.90	152.71 ± 95.37	160.38 ± 91.60	0.215	119.01 ± 71.81	170.37 ± 99.61	175.19 ± 83.79	**0.028**
Calcium (mg/day)	720.34 ± 278.02	970.22 ± 229.44	1435.20 ± 370.68	**0.0001**	954.30 ± 385.84	957.16 ± 357.47	1214.20 ± 460.18	**0.026**	706.04 ± 244.09	1013.77 ± 239.23	1417.17 ± 386.17	**0.0001**
Magnesium (mg/day)	3.25 ± 1.31	3.90 ± 1.49	4.27 ± 1.51	**0.002**	3.63 ± 1.25	3.56 ± 1.24	4.24 ± 1.83	0.095	3.03 ± 1.08	4.23 ± 1.50	4.25 ± 1.56	**0.004**
Potassium (mg/day)	2678.69 ± 972.78	3419.19 ± 1125.94	4393.13 ± 1181.88	**0.0001**	3317.48 ± 1227.34	3371.57 ± 1312.55	3801.56 ± 1316.98	0.096	2579.90 ± 880.50	3648.15 ± 1050.48	4314.36 ± 1276.82	**0.0001**
Phosphorus (mg/day)	1054.04 ± 394.26	1339.02 ± 426.89	1720.21 ± 437.61	**0.0001**	1264 ± 450.64	1288.12 ± 460.88	1560.74 ± 533.36	0.184	1014.73 ± 352.39	1411.84 ± 408.91	1704.98 ± 462.19	**0.0001**
Zinc(mg/day)	7.99 ± 2.91	10.21 ± 3.69	12.18 ± 3.73	**0.0001**	9.40 ± 3.76	9.65 ± 3.37	11.33 ± 4.14	0.620	7.73 ± 2.72	10.56 ± 3.48	12.23 ± 3.84	**0.0001**

Table 2 (continued)

	Tertiles of low-fat dairy consumption			P value*	Tertiles of high fat dairy consumption			P value*	Tertiles of total dairy consumption			P value*
	T1 <227.49	T2 227.49- 362.34	T3 >362.34		T1 <15.10	T2 15.10–68.71	T3 >68.71		T1 <280.6	T2 280.6- 446.07	T3 >446.07	
Number of Participants	**121**	**123**	**125**		**121**	**123**	**125**		**121**	**123**	**125**	
Iron(mg/day)	17.37 ± 6.87	18.73 ± 6.66	20.95 ± 5.09	**0.0001**	17.78 ± 5.63	18.45 ± 6.51	20.81 ± 6.70	**0.002**	15.85 ± 5.99	21.22 ± 6.97	20.32 ± 4.87	**0.0001**

Values presented as means ± standard deviation (SD)

p-value results from the analysis of covariance (ANCOVA) test adjusted for energy intake

Table 3 Distribution of Framingham Scores and Cardiovascular Risk Factors Across Tertiles of Dairy Consumption

		Tertiles of low-fat dairy consumption				Tertiles of high fat dairy consumption				Tertiles of total dairy consumption			
		T1 < 227.49	**T2 227.49–362.34**	**T3 > 362.34**		**T1 < 15.10**	**T2 15.10–68.71**	**T3 > 68.71**		**T1 < 280.6**	**T2 280.6–446.07**	**T3 > 446.07**	
Number of Participants		**121**	**123**	**125**		**121**	**123**	**125**		**121**	**123**	**125**	
CVD risk factors	**Model**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**P value[*]**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**P value[*]**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**P value[*]**
Framingham risk score	Crude[a]	−1.55 ± 6.25	−1.37 ± 3.92	−0.05 ± 6.14	0.03	−1.42 ± 2.07	−1.75 ± 2.94	−0.35 ± 3.06	0.20	−1.13 ± 7.84	−0.60 ± 5.06	−1.09 ± 3.54	0.07
	Model 1	−1.63 ± 4.34	−1.64 ± 4.84	−0.07 ± 5.10	0.01	−1.17 ± 5.01	−1.66 ± 4.83	−0.49 ± 4.55	0.16	−1.85 ± 4.38	−0.50 ± 5.26	−1.10 ± 4.54	0.06
	Model 2	−1.06 ± 0.29	−2.04 ± 0.30	−0.26 ± 0.30	**< 0.0001**	−1.06 ± 0.29	−2.04 ± 0.30	−0.26 ± 0.30	**< 0.0001**	−1.06 ± 0.29	−2.04 ± 0.30	−0.26 ± 0.30	**< 0.0001**
TAG (mg/dl)	Crude	−1.00 ± 0.29	−2.06 ± 0.29	−0.29 ± 0.29	< 0.0001	−1.00 ± 0.29	−2.06 ± 0.29	−0.29 ± 0.29	< 0.0001	−1.00 ± 0.29	−2.06 ± 0.29	−0.29 ± 0.29	< 0.0001
	Model 1	100.1 ± 49.22	98.73 ± 47.64	111.2 ± 68.4	0.15	100.1 ± 49.22	98.73 ± 47.64	111.2 ± 68.4	0.15	100.1 ± 49.22	98.73 ± 47.64	111.2 ± 68.4	0.15
	Model 2	102.6 ± 4.72	95.89 ± 4.79	112.1 ± 4.82	**0.06**	102.6 ± 4.72	95.89 ± 4.79	112.1 ± 4.82	**0.06**	102.6 ± 4.72	95.89 ± 4.79	112.1 ± 4.82	**0.06**
TC (mg/dl)	Crude	103.1 ± 4.69	95.69 ± 4.75	111.8 ± 4.79	0.06	103.1 ± 4.69	95.69 ± 4.75	111.8 ± 4.79	0.06	103.1 ± 4.69	95.69 ± 4.75	111.8 ± 4.79	0.06
	Model 1	174.3 ± 31.56	177.3 ± 30.46	181.7 ± 31.4	0.17	174.3 ± 31.5	177.3 ± 30.46	181.7 ± 31.4	0.17	174.3 ± 31.56	177.3 ± 30.46	181.7 ± 31.4	0.17
	Model 2	175.8 ± 2.62	174.04 ± 2.65	183.1 ± 2.67	**0.04**	175.8 ± 2.62	174.04 ± 2.65	183.1 ± 2.67	**0.04**	175.8 ± 2.62	174.04 ± 2.65	183.1 ± 2.67	**0.04**
HDL-C(mg/dl)	Crude	176.2 ± 2.57	173.8 ± 2.6	182.9 ± 2.62	0.05	176.2 ± 2.57	173.8 ± 2.6	182.9 ± 2.62	0.05	176.2 ± 2.57	173.8 ± 2.60	182.9 ± 2.62	0.05
	Model 1	48.26 ± 8.42	51.35 ± 8.93	47.68 ± 6.75	0.001	48.26 ± 8.42	51.35 ± 8.93	47.68 ± 6.75	0.001	48.26 ± 8.42	51.35 ± 8.93	47.68 ± 6.75	0.001
	Model 2	48.17 ± 0.71	51.48 ± 0.72	47.74 ± 0.72	**< 0.0001**	48.17 ± 0.71	51.48 ± 0.72	47.74 ± 0.72	**< 0.0001**	48.17 ± 0.71	51.48 ± 0.72	47.74 ± 0.72	**< 0.0001**
LDL-C(mg/dl)	Crude	48.01 ± 0.67	51.55 ± 0.68	47.83 ± 0.68	< 0.0001	48.01 ± 0.67	51.55 ± 0.68	47.83 ± 0.68	< 0.0001	48.01 ± 0.67	51.55 ± 0.68	47.83 ± 0.68	< 0.0001
	Model 1	75.65 ± 15.4	83.8 ± 16.6	85.55 ± 19.41	< 0.0001	75.65 ± 15.4	83.8 ± 16.6	85.55 ± 19.41	< 0.0001	75.65 ± 15.4	83.8 ± 16.6	85.55 ± 19.41	< 0.0001
	Model 2	77.24 ± 1.44	84.76 ± 1.46	83.24 ± 1.47	**0.001**	77.24 ± 1.44	84.76 ± 1.46	83.24 ± 1.47	**0.001**	77.24 ± 1.44	84.76 ± 1.46	83.24 ± 1.47	**0.001**

Table 3 (continued)

		Tertiles of low-fat dairy consumption				Tertiles of high fat dairy consumption				Tertiles of total dairy consumption			
		T1 < 227.49	**T2 227.49–362.34**	**T3 > 362.34**		**T1 < 15.10**	**T2 15.10–68.71**	**T3 > 68.71**		**T1 < 280.6**	**T2 280.6–446.07**	**T3 > 446.07**	
Number of Participants		**121**	**123**	**125**		**121**	**123**	**125**		**121**	**123**	**125**	
CVD risk factors	**Model**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**P value***	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**P value***	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**P value***
TAG/HDL-C	Crude	77.07 ± 1.43	84.83 ± 1.45	83.34 ± 1.46	< 0.0001	77.07 ± 1.43	84.83 ± 1.45	83.34 ± 1.46	< 0.0001	77.07 ± 1.43	84.83 ± 1.45	83.34 ± 1.46	< 0.0001
	Model 1	2.19 ± 1.36	2.07 ± 1.35	2.38 ± 1.49	0.22	2.19 ± 1.36	2.07 ± 1.35	2.38 ± 1.49	0.22	2.19 ± 1.36	2.07 ± 1.35	2.38 ± 1.49	0.22
	Model 2	2.24 ± 0.11	2.01 ± 0.11	2.39 ± 0.11	0.08	2.24 ± 0.11	2.01 ± 0.11	2.39 ± 0.11	0.08	2.24 ± 0.11	2.01 ± 0.11	2.39 ± 0.11	0.08
TC/HDL-C	Crude	2.25 ± 0.11	2.00 ± 0.11	2.39 ± 0.11	0.07	2.25 ± 0.11	2.00 ± 0.11	2.39 ± 0.11	0.07	2.25 ± 0.11	2.007 ± 0.11	2.39 ± 0.11	0.07
	Model 1	3.76 ± 1.15	3.59 ± 1.07	3.89 ± 0.94	0.08	3.76 ± 1.15	3.59 ± 1.07	3.89 ± 0.94	0.08	3.76 ± 1.15	3.59 ± 1.07	3.89 ± 0.94	0.08
	Model 2	3.8 ± 0.09	3.51 ± 0.09	3.93 ± 0.09	**0.005**	3.8 ± 0.09	3.51 ± 0.09	3.93 ± 0.09	**0.005**	3.80 ± 0.09	3.51 ± 0.09	3.93 ± 0.09	**0.005**
FBS (mg/dl)	Crude	3.82 ± 0.08	3.5 ± 0.08	3.92 ± 0.08	0.002	3.82 ± 0.08	3.5 ± 0.08	3.92 ± 0.08	0.002	3.82 ± 0.08	3.50 ± 0.08	3.92 ± 0.08	0.002
	Model 1	86.3 ± 7.72	88.8 ± 9.25	91.1 ± 10.42	< 0.0001	86.34 ± 7.72	88.86 ± 9.25	91.16 ± 10.42	< 0.0001	86.34 ± 7.72	88.86 ± 9.25	91.16 ± 10.42	< 0.0001
	Model 2	87.17 ± 0.72	88.43 ± 0.73	90.86 ± 0.73	**0.002**	87.07 ± 0.72	88.44 ± 0.73	90.94 ± 0.74	**0.001**	87.07 ± 0.72	88.44 ± 0.73	90.94 ± 0.74	**0.001**

Abbreviations: *CVD* cardiovascular diseases, *TAG* Triacylglycerol, *TC* Total cholesterol, *HDL-C* high-density lipoprotein, *LDL-C* low-density lipoprotein, *FBS* fasting blood sugar

a. Crude model: No adjustments for covariates

Model 1: adjusted for age, sex, body mass index, energy intake, socio-economic status, smoking status, and drug intake (including diabetes, cardiovascular, blood pressure, high blood lipid, antioxidants, multivitamin and omega 3 intake)

Model 2: Further adjusted for physical activity

P-value: Results from ANOVA test for crude model and ANCOVA test for adjusted models

Table 4 Framingham Score Distribution and Cardiovascular Risk Factors Across Tertiles of Dairy Consumption Types

		Tertiles of total dairy consumption				Tertiles of low-fat dairy consumption				Tertile of high fat dairy consumption			
		T1 < 40	T2 40–171.42	T3 > 171.42		T1 < 67.85	T2 67.85–157.5	T3 > 157.5		T1 < 15	T2 15–30	T3 > 30	
Number of participants		121	123	125		121	123	125		121	123	125	
	Models	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**P trend***	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**P trend**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**P trend**
FBS	Crude[a]	1.00	0.5 (0.18,1.42)	1.5 (0.67,3.4)	0.70	1.00	2.27 (0.82,6.27)	2.87 (1.07,7.66)	0.14	1.00	0.14 (0.04,0.46)	0.4 (0.18,0.88)	0.07
	Adjusted[b]	1.00	0.7 (0.12,4.02)	4.36 (0.77,24.71)	0.65	1.00	1.69 (0.35,8.17)	2.95 (0.59,14.61)	0.86	1.00	0.2 (0.02,2.06)	0.35 (0.07,1.62)	0.66
TAG (≥ 150 mg/dl)	Crude[a]	1.00	0.47 (0.19, 1.15)	1.56 (0.78, 3.13)	0.10	1.00	0.87 (0.42, 1.8)	0.71 (0.33, 1.53)	0.001	1.00	0.73 (0.36, 1.47)	0.74 (0.33, 1.64)	0.02
	Adjusted[b]	1.00	0.25 (0.04, 1.38)	0.05 (0.003, 1.09)	0.52	1.00	0.25 (0.04, 1.38)	0.05 (0.003, 1.09)	0.50	1.00	0.25 (0.04, 1.38)	0.05 (0.003, 1.09)	0.11
TC	Crude[a]	1.00	1.25 (0.66, 2.36)	1.31 (0.7, 2.46)	0.24	1.00	0.46 (0.23, 0.9)	0.99 (0.55, 1.79)	0.08	1.00	1.41 (0.77, 2.56)	1.19 (0.6, 2.35)	0.84
	Adjusted[b]	1.00	0.81 (0.25, 2.61)	0.74 (0.11, 4.84)	0.28	1.00	0.81 (0.25, 2.61)	0.74 (0.11, 4.84)	0.18	1.00	0.81 (0.25, 2.61)	0.74 (0.11, 4.84)	0.37
HDL-C (< 40 mg/dl)	Crude[a]	1.00	2.05 (0.99, 4.24)	2.08 (1.00, 4.32)	0.42	1.00	2.05 (0.99, 4.24)	2.08 (1.00, 4.32)	0.006	1.00	2.05 (0.99, 4.24)	2.08 (1.00, 4.32)	0.85
	Adjusted[b]	1.00	2.39 (0.63, 8.99)	1.39 (0.19, 10.08)	0.36	1.00	2.39 (0.63, 8.99)	1.39 (0.19, 10.08)	0.15	1.00	2.39 (0.63, 8.99)	1.39 (0.19, 10.08)	0.35
LDL-C (> 100 mg/dl)	Crude[a]	1.00	2.09 (0.96,4.56)	1.93 (0.88,4.24)	0.79	1.00	2.09 (0.96, 4.56)	1.93 (0.88, 4.24)	0.81	1.00	2.09 (0.96, 4.56)	1.93 (0.88, 4.24)	0.01
	Adjusted[b]	1.00	1.34 (0.25, 7.24)	0.19 (0.01, 3.2)	0.09	1.00	1.34 (0.25, 7.24)	0.19 (0.01, 3.2)	0.10	1.00	1.34 (0.25, 7.24)	0.19 (0.01, 3.2)	**0.02**

Abbreviations: *OR* odds ratios, *CI* confidence intervals, *TAG* triacylglycerol, *TC* total cholesterol, *HDL-C* high-density lipoprotein, *LDL-C* low-density lipoprotein

a. Crude model: no adjustments for covariates

b. Adjusted: Adjusted for age, dietary fiber, socio-economic status, smoking, diseases, and drugs (including anti-diabetic, multivitamin, and antioxidant supplements)

P trend: Calculated using logistic regression supplementary Table 6. In the adjusted model, higher yogurt consumption was significantly associated with lower odds of elevated triglycerides (TAG ≥ 150 mg/dl) (OR: 0.05, 95% CI: 0.003–1.09, *P*-trend = 0.02). Additionally, increased yogurt intake was inversely associated with elevated LDL-C levels (> 100 mg/dl) (OR: 0.19, 95% CI: 0.01–3.2, P-trend = 0.003). No significant associations were observed between milk consumption and cardiovascular risk factors in the adjusted model.

The association of cardiovascular risk factors across tertiles of cheese and dough consumption in supplementary Table 7. In the adjusted model, higher cheese consumption was significantly associated with lower odds of elevated fasting blood sugar (FBS) (OR: 0.35, 95% CI: 0.07–1.62, P-trend = 0.001) and triglycerides (TAG ≥ 150 mg/dl) (OR: 0.05, 95% CI: 0.003–1.09, P-trend = 0.04). Additionally, higher dough consumption was significantly associated with increased odds of elevated LDL-C levels (> 100 mg/dl) (OR: 0.19, 95% CI: 0.01–3.2, P-trend < 0.0001).

Discussion

This cross-sectional study suggests that higher consumption of low-fat dairy was linked to a significant reduction in the Framingham risk score, and high-fat dairy consumption was associated with higher triglycerides. In addition, higher total dairy consumption was associated with a significant increase in total cholesterol levels and a decrease in HDL-C levels. Furthermore, elevated dairy consumption, particularly high-fat dairy, was associated with increased LDL-C levels. These findings suggest that different types of dairy products may have varying impacts on cardiovascular health, with high-fat dairy potentially contributing to unfavorable lipid profiles. Also, higher cheese consumption is associated with a reduced risk of elevated fasting blood sugar, while higher dough consumption is linked to lower odds of elevated triglycerides and LDL-C levels. Additionally, yogurt consumption was associated with decreased odds of elevated triglycerides and LDL-C, indicating a potential protective effect of these dairy products on cardiovascular risk factors.

To the best of our knowledge, no previous studies have utilized the FRS to evaluate the association between various types of dairy consumption and a 10-year CVD risk. However, only one study examined the association of milk consumption with FRS [30] reporting that higher milk consumption was associated with lower Framingham Risk Scores. Our study is the first to provide insights into the relationship between total dairy intake, its various types, and the Framingham score, as well as CVD risk factors specifically in women. Additionally, we examined the relationship between the consumption of drinkable yogurt (dough) [38], a widely and traditionally consumed dairy product in our country, and these risk factors.

The FRS is a standard tool, predicting the 10-year risk of developing CVD in individuals who appear to be healthy [39]. Previous studies have shown that FRS is an appropriate metric for ranking subjects and assessing the relationship between non-clinical factors and health [42–47]. It incorporates seven cardiovascular risk factors for its prediction, including age, sex, smoking, blood pressure, HDL-C, TC, and history of diabetes [48].

In the present study, the intake of total dairy products as well as their subtypes, including high-fat and low-fat dairy, was directly related to future CVD events. These findings are consistent with a prospective cohort study conducted by van Aerde et al. [49]. This prospective cohort study, conducted within the Hoorn Study, examined the relationship between dairy intake and cardiovascular disease (CVD) mortality along with all-cause mortality. While this study found no significant association between total dairy intake and mortality outcomes, higher low-fat dairy consumption was linked to a lower risk of all-cause mortality, whereas high-fat dairy intake showed no significant association. However, unlike our study, which predicted future CVD events, the Hoorn Study assessed CVD incidence based on mortality. The Hoorn cohort also found an inverse association between high-fat dairy consumption and cardiovascular risk factors like lipid levels and BMI [50].

Most cohort studies found a protective or neutral association between dairy products consumption, particularly low-fat dairy and CVD [51, 52]. For example, in a large prospective cohort study, it was observed that dairy products consumption was not associated with overall CVD or CHD risk [53].. This study collected dietary data using a 24-h recall, whereas we used an FFQ. Similarly, Elwood et al. found no persuasive evidence linking milk consumption to an increased risk of vascular disease [54]. Their study, conducted in South Wales, included 2,512 men aged 45–59 years, differing from our study population. Koskinen et al.'s study, with a follow-up period of 20.1 years, showed that non-fermented and fermented dairy products had opposite associations with CHD risk [55]. Their study population consisted of men aged 42–60 years, and dietary intake was assessed using a 4-day food record, whereas we used an FFQ.

The higher Framingham score observed in our study may be attributed to the significant increase in the age of participants in the third tertile of milk, cheese, and low-fat dairy consumption. However, smoking status, TC, and HDL levels across dairy consumption tertiles were not significantly different, and the number of individuals with high blood pressure was low. The present cross-sectional study showed that women with higher high-fat dairy consumption had lower serum levels of LDL-C levels. However, there is no clear consensus in this field. For instance, study by Kai et al. [56] found no significant relationship between high-fat dairy consumption and lipid parameters. In that study, dairy intake was assessed using a 3-day food record, and the models were only adjusted for diet quality, which may explain the differing findings.

In the present study, we found no significant association between milk intake, total dairy, and low-fat dairy consumption with any CVD risk factors including HDL-C, TC, LDL-C, TG / HDL, TC / HDL, and FBS. This finding is consistent with a cross-sectional study performed to evaluate the association between dairy consumption and inflammation and cardiovascular risk factors among 107 elderly people aged 60–78 years [57]. Rashidipour Pour Fard and colleagues observed a higher but statistically insignificant risk of increased in TC and LDL-C with higher dairy intake [57]. Similarly, Benatar et al. concluded that moderate increases in dairy consumption had no effect on major metabolic and cardiovascular risk factors [58]. Additionally, Buscemi et al. reported that total dairy intake was not associated with blood LDL-C levels [59].

Contrary to our findings, Buscemi et al.'s multivariate analysis showed an inverse association between serum LDL-C and milk consumption; however, this study did not adjust for energy intake [59].. Similarly, Machlik et al. found that consuming low-fat cheese had a more favorable effect on blood lipids compared to regular-fat cheese. However, this relationship was only observed for cheese intake, as no significant association was found between low-fat yogurt consumption and blood lipid concentrations [60]. Dairy product consumption has been shown to have a beneficial influence on risk factors involved in metabolic syndrome, including insulin resistance, dyslipidemia, abdominal obesity, and blood pressure, which collectively increase the risk of CVD and diabetes significantly [61]. Dairy products provide important nutrients including calcium and protein, and dairy consumption has been associated with a reduced risk of excess body fat and obesity in observational studies, and in some randomized controlled trials (RCTs) [61]. Among dairy products, yogurt is one of the most nutritious products due to its added cultures of active bacteria, high protein content-including specific amino acids and peptides, and the presence of micronutrients presence such as potassium, phosphorus, calcium, magnesium, and vitamin D [62]. There is strong evidence that yogurt intake may prevent CVD through several mechanisms, including its the association with saturated fat intakes high calcium content and abundance of milk-derived bioactive peptides [61]. Bioactive peptides derived from milk in yogurt may play a role in regulating insulinemia and modulating the blood lipid profile [63]. In the present study, increased yogurt consumption was associated with a reduction in TG and LDL. The macronutrients and micronutrients content of yogurt, such as calcium, along with its high protein content which promotes satiety [64] and helps body weight, may play a role in regulating the blood lipid profile. Obesity is closely related to dyslipidemia, primarily due to the effects of pro-inflammatory adipokines and insulin resistance [65].

Zemel et al. showed that low calcium intake leads to fat accumulation by elevating blood levels of calciotropic hormones (1,25 (OH)2D3 and parathyroid hormone) and increasing intracellular calcium, thereby reducing lipolysis, and promoting lipogenesis [66, 67]. Moreover, yogurt is rich in casein-derived bioactive peptides [68] as well as branched-chain amino acids (leucine, isoleucine, and valine), which help inhibit angiotensin II production [69] and stimulating protein synthesis during weight loss diets [70].

As far as we know, limited studies have explored the association between dairy consumption and CVD risk factors among women. One of the strengths of our study is the use of a well-established and validated semi-quantitative FFQ to assess dietary intake. This FFQ, developed for the Tehran Lipid and Glucose Study, has been widely used in numerous studies in Iran, demonstrating its reliability and validity in evaluating nutrient intake within the Iranian population. For example, this FFQ was used to assess the dietary intake of participants in the Tehran Lipid and Glucose Study, confirming its reliability and relative validity [35]. For instance, it has been employed in multiple studies [35, 71–75], reinforcing its credibility in nutritional research. [71–75], underscoring its widespread acceptance and application in nutritional research.

The inclusion of this validated FFQ in our study ensures the collection of accurate and reliable dietary intake data, contributing to the robustness and credibility of our findings. Additionally, adjusting for multiple confounding variables further strengthens our study. We examined the relationship between the consumption of different types of dairy products, including milk, yogurt, cheese, and drinkable yogurt, categorized into low-fat and high-fat groups, with CVD risk factors and the Framingham risk score.

However, this study has certain limitations that should be considered in future research. The cross-sectional design prevents us from establishing causal relationships, highlighting the need for prospective studies to determine long-term causation. Furthermore, dietary intake was assessed using the FFQ rather than weighted dietary records, which may introduce some degree of measurement error. Although the reliability and validity of the

FFQ have been previously reported, energy consumption calculations based on the FFQ may lead to biased results. Another limitation is that our sample consisted exclusively of women, limiting the generalizability of our findings to both sexes. Although we adjusted for multiple major confounders, the possibility of residual confounding cannot be ruled out.

Conclusion

Our findings indicate that both high-fat and low-fat dairy consumption may have favorable cardiovascular effects. Notably, higher intake of low-fat dairy was associated with a lower Framingham Risk Score (FRS), suggesting a reduced 10-year CVD risk in women. Furthermore, yogurt and cheese consumption were linked to improved lipid profiles, including lower triglycerides and LDL-C levels, both of which are key risk factors for cardiovascular disease. These results underscore the potential cardioprotective role of dairy consumption and emphasize the need for further research to explore its long-term effects on cardiovascular health. Future research is needed to further investigate the relationship between dairy consumption and CVD risk factors, particularly in relation to gender differences.

Abbreviations

CVD	Cardiovascular disease
FRS	Framingham risk score
FBS	Fasting blood sugar
OR	Odds ratio
CI	Confidence interval
TAG	Triglyceride
CHD	Coronary heart disease
LDL-C	Low-density lipoprotein cholesterol
HDL-C	High-density lipoprotein cholesterol
TUMS	Tehran university of medical sciences
FFQ	Food frequency questionnaire
TC	Total cholesterol
SBP	Systolic blood pressure
BMI	Body mass index
SES	Socio-economic status
MET	Metabolic equivalent task
PA	Physical activity
ANOVA	Analysis of variance
SFA	Saturated fatty acids
SD	Standard deviation

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Authors' contributions
Zahra Salehi: drafted the initial version of the article. Batoul Ghosn: contributed to rewriting several sections of the paper, as well as editing and revising the manuscript and tables for clarity and coherence. Nazli Namazi: performed the data analysis. Leila Azadbakht: contributed in conception, design, statistical analyses, data interpretation and manuscript revising. All authors approved the final manuscript.

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Data availability
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
All eligible participants provided their written informed consent for this study. Furthermore, the Ethics Committee of Biomedical Research at Tehran University of Medical Sciences has granted ethical approval for this study (IR.TUMS.MEDICINE.REC.1400.208, 99–3-212–50759).

Consent for publication
Not applicable.

Competing interest
The authors declare no competing interests.

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