# Dairy consumption, cardiovascular risk factors and inflammation in elderly subjects

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**Original Article**

## Abstract

**BACKGROUND:** Previous epidemiological studies of dairy product consumption and health outcomes have reported mixed findings. Despite increasing in life expectancy, scarce data are available in this field in elderly individuals. We tested the hypothesis that greater dairy intake is associated with lower high sensitive C-reactive protein (hs-CRP) level and better lipid profile and glycemic control.

**METHODS:** This cross-sectional study was undertaken on 107 elderly individuals who aged 60-78 years. Usual dietary intakes were assessed by means of a validated food frequency questionnaire (FFQ). Anthropometric measures and biochemical markers were determined using standard protocols.

**RESULTS:** The reported mean ± standard deviation (SD) of daily intake of dairy products and age were 588.02 ± 418.88 g/d and 63.22 ± 6.92 years, respectively. After control for demographic characteristics and dietary intakes, dairy consumption was not significantly related to the increased risk of insulin resistance [Odds ratio (OR): 2.19, 95% confidence interval (CI): 0.54, 8.86; P = 0.520] and elevated hs-CRP (OR: 1.54, 95% CI: 0.37, 6.35; P = 0.550). Participants in the top tertile of dairy had greater, but statistically not a significant risk of elevated triglyceride (TG), total cholesterol and low-density lipoprotein cholesterol (LDL-C). No significant relations were seen for hs-CRP, insulin resistance and lipid profile across tertiles of dairy products.

**CONCLUSION:** In this elderly population, total dairy consumption was not associated with inflammatory biomarkers levels and other cardiometabolic risk factors.

**Keywords:** Dairy Products, Elderly, Cardiovascular, Inflammation, Insulin Resistance

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## Introduction

Aging is accompanied by the chronic inflammatory state which increases the risk of insulin resistance, metabolic syndrome and cardiovascular diseases (CVDs).[1] Sarcopenia is a common phenomenon by aging. In addition, older people are at risk for obesity. Both of these physiological states are associated with greater adipose tissue that is known as the main source of inflammatory markers and induces higher insulin resistance. Therefore, elevated inflammatory markers and insulin levels by aging and consequently chronic diseases and metabolic syndrome are expected.[1] It seems that lifestyle factors such as dietary intakes and physical activity could modulate inflammation state and insulin resistance by affecting fat mass.

Higher diet quality is associated with lower levels of inflammatory markers,[2,3] fat mass and body mass index (BMI).[4,5] A healthy diet (e.g., dash diet) is considered as a diet rich in vegetable, fruit, whole grains and low-fat dairy products which have a protective role against CVDs.[6] Although the relations between individual food groups and chronic diseases have been investigated in several researches,[7,8] there is

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still debate regarding the effects of dairy products.[9-18] While some clinical trials and epidemiological studies have reported beneficial effects for dairies,[10,14] others failed to find significant associations,[9,15,16,18] and even some dietary guidelines recommend restriction of dairy intake.[19]

One explanation for this inconsistency is related to the different components of dairy products. Dairy is a complex food, and it is difficult to define its metabolic outcomes based on its individual components. Indeed, due to the high content of saturated fatty acids (SFA) in dairy products, lower consumption of dairy products has frequently been suggested.[12] On the other side, dairies are the important source of calcium that induces anti-inflammatory effects, enhances insulin sensitivity, lowers weight gain and consequently reduces cardiovascular risks.[14]

Although dairy consumption is important in all age groups, due to differences in body composition and metabolic profiles, elderly might be more or even differently affected by dairy products. In addition, due to lactase deficiency, elderly individuals are more likely to reduce dairy intake which causes calcium insufficiency. To the best of our knowledge, there is no report regarding dairy consumption among Iranian elderly subjects. Furthermore, there is little evidence to make a clear conclusion about health outcomes of dairy consumption, especially in elderly. Therefore, in the present study, we evaluated the associations of dairy consumption with dyslipidemia, insulin resistance, and inflammation in the elderly population.

## Materials and Methods

This cross-sectional study was conducted in 2013 among a sample of Isfahan, Iran, elderly subjects. Participants were recruited from retired employee of Isfahan Steel Company, who aged > 60 years.[20] In total, 120 elderly subjects were selected using simple random sampling method. Subjects were enrolled into the study if they aged 60-85 years and they had no inflammatory diseases that would affect serum inflammatory cytokines levels. We excluded participants if they were on a specific diet, or suffered from inflammatory diseases. We also excluded individuals who were receiving lowering blood sugar or lipid profile agents. Enough sample size was determined based on C-reactive protein (CRP) as the main dependent variables.[21] The protocol of the study was approved by Regional Bioethics Committee of Isfahan University of Medical Sciences. All participants expressed their willingness to participate in the current study by written informed consent.

Dietary intake was assessed using a 168-item semiquantitative validated food frequency questionnaire (FFQ).[11] Each food item was along with usual portion size. All FFQs were obtained through face-to-face interviews by a trained nutritionist. Household measures were used to convert the portion sizes of consumed foods to grams. Dairy products included all types of milk, yogurt, doogh (a traditional drink made of yogurt), cheese, and ice cream. Mean of energy and nutrient intakes from the FFQs were computed by an adopted version of NUTRITIONIST IV software for Iranian foods (version 7.0; N-Squared Computing, Salem, OR, USA).

### *Biochemical assessment*

All biochemical tests were done on 12-hour overnight fast venous blood samples. Fasting blood sugar (FBS) was measured on the day of blood sampling. Serum concentrations of FBS, total cholesterol, low-density lipoprotein cholesterol (LDL-C) and triglyceride (TG) were quantified using commercially available enzymatic reagents (Pars Azmoon, Tehran, Iran) adapted to an auto-analyzer system (Selectra E, Vitalab, Holliston, the Netherlands). Serum insulin levels were measured by enzyme-linked immunosorbent assay (ELISA) method (ELISA; Diagnostic Biochem Canada, Inc., Montreal, Canada). Insulin resistance was assessed by both homeostasis model assessment-insulin resistance (HOMA-IR)[22] and quantitative insulin sensitivity check index (QUICKI).[23] methods using fasting insulin and glucose levels. High sensitive CRP (High sensitive CRP) was measured in serum by using an ultrasensitive latex-enhanced immunoturbidimetric assay (Randox Laboratory Ltd., Belfast, UK). To determine the plasma concentration of fibrinogen, we used Clauss method which records the rate of fibrinogen conversion to fibrin by adding thrombin.

### *Anthropometric assessment*

A trained dietitian measured body weight, waist circumference, and height. Body weight was estimated using calibrated digital scales while participants were minimally clothed and recorded to the nearest 100 g. Height was measured while shoulders were in normal position using an upstretched tape measure and registered to the nearest 0.5 cm. Waist circumference was measured at the narrowest level between the lowest rib and iliac crest over light clothing to the nearest 0.5 cm. BMI was calculated as body weight in kg divided by height in $m^2$.

### *Assessment of other variables*

To measure blood pressure, participants were asked to rest for 10 minutes. Blood pressure was measured two times with at least a 30 seconds interval using a standard mercury sphygmomanometer. Final blood pressure was considered as the average of two measurements. Socio-economic status was evaluated using a valid Persian version questionnaire containing some questions regarding income, education, occupation, family number, house ownership, car ownership, the number of states, the number of traveling abroad in the last year, the number of traveling inside the country, the number of rooms at home and having modern furniture at home.[24] Thereafter, participants were categorized in three groups based on the tertiles of socioeconomic scores: weak (score < 33%), moderate (33 < score < 66%), and strong (score > 66). Other demographic variables (like smoking) were assessed by using a demographic questionnaire.

Statistical analysis was done on 107 elderly subjects. Normal distribution of variables was checked by Kolmogorov-Smirnov test and histogram. General characteristics of participants were compared across the tertiles of dairy intakes by using descriptive statistics. Analysis of variance was performed to find significant differences in continues variables, and Pearson's chi-square test was used to compare categorical variables across the tertiles of dairy intakes. Dietary intakes were adjusted for daily energy intake as a covariate and were compared using analysis of covariance.

To determine the association of dairy consumption and cardiometabolic risk factors, we used multiple logistic regressions in crude and various adjusted models. First, we controlled the confounding effect of sex, smoking, and socioeconomic status. Model II was further controlled for dietary variables including energy, fat, fruit, vegetables, fiber and red meat. Model III was additionally adjusted for BMI. In all statistical analysis, we considered low median of biochemical markers as reference and assessed the risk of being in high median in comparison with low median across the tertiles of dairy. For high-density lipoprotein cholesterol (HDL-C), high median was considered as reference. All statistical analyses were done by SPSS software (version 18, SPSS Inc., Chicago, IL, USA). $P < 0.050$ was considered significant.

## Results

Mean ± standard deviation (SD) dairy intake in the study population was 588.02 ± 418.88 g/d. General characteristics of participants are indicated in table 1. Participants in the highest tertile were taller than others ($P = 0.026$). Despite small differences in the means of age, BMI, systolic blood pressure (SBP) and diastolic blood pressure (DBP), they were not significantly different across the tertiles of dairy.

Table 2 shows dietary intakes of participants across the tertiles of dairy products. Participants in the top tertile consumed lower amounts of protein, fat, SFA, and cholesterol. Conversely, most of key micronutrients, including potassium, calcium, zinc, acid folic, vitamin C and A, were consumed in greater amounts by those. Although individuals in the top tertile consumed more carbohydrate, their dietary fiber intake was also higher in comparison with those in the lowest.

Table 3 presents the mean and SD of biochemical markers. Serum concentrations of FBS, hs-CRP, fibrinogen TG, total cholesterol, LDL-C, and HOMA-IR were not significantly different across the tertiles of dairy.

**Table 1.** General characteristics of participants across the tertiles of dairy intake

| Variables | Dairy tertile | | | P* |
|---|---|---|---|---|
| | 1 ( < 334.06) | 2 (334.06-689.12) | 3 (> 689.12) | |
| Age (year) (mean ± SD) | 61.54 ± 1.24 | 64.83 ± 1.19 | 63.28 ± 1.03 | 0.132 |
| Male (%) | 78.0 | 86.0 | 89.0 | 0.391 |
| Married (%) | 88.9 | 97.3 | 94.4 | 0.223 |
| Smoker (%) | 13.9 | 16.2 | 8.4 | 0.636 |
| Family history (%) | 38.5 | 40.9 | 38.9 | 0.986 |
| Height (cm) (mean ± SD) | 168.45 ± 1.44 | 164.91 ± 1.30 | 169.94 ± 1.27 | 0.026 |
| BMI ($kg/m^2$) (mean ± SD) | 26.00 ± 0.75 | 26.04 ± 0.61 | 25.91 ± 0.60 | 0.991 |
| SBP (mmHg) (mean ± SD) | 12.64 ± 0.26 | 12.47 ± 0.26 | 12.84 ± 0.30 | 0.995 |
| DBP (mmHg) (mean ± SD) | 7.91 ± 0.16 | 7.64 ± 0.14 | 7.93 ± 0.16 | 0.303 |

BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; SD: Standard deviation
*By using one-way analysis of variance (ANOVA)

**Table 2.** Energy-adjusted of dietary intakes across the tertiles of dairy intakes

| Variables | Dairy tertile | | | P* |
|---|---|---|---|---|
| | 1 (< 334.06) (mean ± SE) | 2 (334.06-689.12) (mean ± SE) | 3(> 689.12) (mean ± SE) | |
| Protein (g/d) | 230.86 ± 17.92 | 174.24 ± 17.59 | 122.68 ± 18.04 | < 0.001 |
| Carbohydrate (g/d) | 253.33 ± 17.40 | 312.42 ± 17.07 | 396.13 ± 17.52 | < 0.001 |
| Fat (g/d) | 77.60 ± 2.69 | 72.80 ± 2.64 | 61.90 ± 2.71 | < 0.001 |
| Cholesterol (mg/d) | 587.32 ± 41.90 | 440.68 ± 41.17 | 227.20 ± 42.30 | < 0.001 |
| SFA (g/d) | 20.21 ± 0.95 | 20.04 ± 0.93 | 17.00 ± 0.96 | 0.038 |
| Potassium (mg/d) | 3886.95 ± 125.13 | 4473.20 ± 126.00 | 5473.16 ± 126.00 | < 0.001 |
| Iron (mg/d) | 36.66 ± 12.38 | 15.65 ± 12.15 | 14.40 ± 12.46 | 0.365 |
| Calcium (mg/d) | 798.14 ± 81.80 | 1258.56 ± 80.31 | 2339.10 ± 23.01 | < 0.001 |
| Magnesium (mg/d) | 398.30 ± 23.44 | 379.10 ± 23.01 | 417.94 ± 23.60 | 0.520 |
| Phosphorus (mg/d) | 2285.48 ± 96.10 | 2277.64 ± 95.21 | 2569.55 ± 97.65 | 0.061 |
| Zinc (mg/d) | 10.49 ± 0.48 | 10.50 ± 0.47 | 13.41 ± 0.48 | 0.006 |
| Selenium (µg/d) | 5.76 ± 3.34 | 0.50 ± 3.28 | 0.23 ± 3.36 | 0.392 |
| Vitamin A (RAE/d) | 1104.61 ± 99.30 | 1409.18 ± 97.50 | 1510.08 ± 99.10 | 0.014 |
| Vitamin E (mg/d) | 10.14 ± 0.57 | 9.65 ± 0.56 | 7.26 ± 0.58 | 0.001 |
| Folic acid (µg/d) | 283.85 ± 19.70 | 378.07 ± 19.35 | 476.13 ± 19.80 | 0.001 |
| Vitamin C (mg/d) | 159.11 ± 15.80 | 208.21 ± 15.50 | 254.90 ± 15.92 | < 0.001 |
| Total dietary fiber (g/d) | 14.01 ± 0.99 | 18.14 ± 0.97 | 21.28 ± 0.10 | < 0.001 |

SFA: Saturated fatty acids; RAE: Retinol activity equivalents; SE: Standard error
*By using analysis of covariance (ANCOVA)

**Table 3.** Mean and standard error of biochemical markers across the tertiles of dairy

| Variables | Dairy tertile | | | P* |
|---|---|---|---|---|
| | 1 (< 334.06) (mean ± SE) | 2 (334.06-689.12) (mean ± SE) | 3 (> 689.12) (mean ± SE) | |
| HOMA-IR | 89.64 ± 22.93 | 56.0 ± 12.85 | 73.62 ± 16.64 | 0.409 |
| QUICKI | 0.33 ± 0.008 | 0.35 ± 0.007 | 0.35 ± 0.007 | 0.485 |
| Insulin (UIU/ml) | 15.12 ± 3.24 | 10.91 ± 12.68 | 14.01 ± 2.51 | 0.503 |
| FBS (mg/d) | 123.94 ± 12.18 | 110.69 ± 5.42 | 104.46 ± 5.60 | 0.245 |
| TG (mg/dl) | 157.57 ± 13.07 | 156.53 ± 11.87 | 189.29 ± 33.63 | 0.486 |
| Total cholesterol (mg/dl) | 191.66 ± 8.95 | 194.39 ± 6.77 | 195.63 ± 4.21 | 0.927 |
| LDL-C (mg/dl) | 95.86 ± 4.74 | 100.83 ± 4.24 | 97.66 ± 4.02 | 0.713 |
| HDL-C (mg/dl) | 47.60 ± 1.86 | 51.25 ± 1.81 | 49.57 ± 1.27 | 0.305 |
| hs-CRP (µg/ml) | 5.80 ± 2.55 | 3.05 ± 0.87 | 2.59 ± 0.56 | 0.290 |
| Fibrinogen (mg/dl) | 278.28 ± 11.38 | 280.39 ± 6.84 | 271.59 ± 9.67 | 0.782 |

*Resulted from ANOVA
HOMA-IR: Homeostasis model assessment-insulin resistance; QUICKI: Quantitative insulin sensitivity check index; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol; hs-CRP: High sensitive C-reactive protein; FBS: Fasting blood sugar; TG: Triglyceride; SE: Standard error

Crude and multiple-adjusted odds ratio (OR) and 95% confidence intervals (CI) for being in the high median of biochemical markers are provided in table 4. Higher dairy consumption was not significantly associated with increased risk of insulin resistance (P = 0.990), elevated serum levels of insulin (P = 0.470), hs-CRP (P = 0.460), LDL-C (P = 0.220), HDL-C (P = 0.900), TG (P = 0.140), total cholesterol (P = 0.330) and FBS (P = 0.550) in crude model. After adjustment for potential confounders these associations changed slightly but remained non-significant. Despite a marginal significant inverse association between dairy and elevated fibrinogen concentrations in crude model (P = 0.080), this association was eliminated in adjusted models.

## Discussion

This cross-sectional study could not reveal any significant association between dairy consumption and various cardiometabolic risk factors including inflammation, insulin resistance and lipid profile among elderly individuals.

In a national report of Iran, ischemic heart disease is the second cause of death after injuries, and dietary risks are the most important risk factor to which deaths were attributable among adults.[25]

**Table 4.** Multiple-adjusted odds ratio (OR) and 95% confidence intervals (CI) for being in the high median of all biochemical markers and low median of high-density lipoprotein cholesterol

| Variables | Dairy tertile | | | P* |
|---|---|---|---|---|
| | 1 (< 334.06) | 2 (334.06-689.12) | 3 (> 689.12) | |
| HOMA-IR (> 38.88) | | | | |
| Model I | 1 (Ref) | 0.84 (0.33, 2.17) | 1.00 (0.38, 2.58) | 0.990 |
| Model II | 1 (Ref) | 0.85 (0.32, 2.25) | 0.92 (0.32, 2.49) | 0.950 |
| Model III | 1 (Ref) | 0.98 (0.34, 2.81) | 1.42 (0.39, 5.08) | 0.800 |
| Model IV | 1 (Ref) | 1.21 (0.39, 3.75) | 2.19 (0.54, 8.86) | 0.520 |
| QUICKI (> 0.3399) | | | | |
| Model I | 1 (Ref) | 0.84 (0.33, 2.17) | 1.00 (0.38, 2.58) | 0.990 |
| Model II | 1 (Ref) | 1.17 (0.44, 3.10) | 1.09 (0.40, 2.93) | 0.950 |
| Model III | 1 (Ref) | 1.02 (0.36, 2.93) | 0.71 (0.20, 2.53) | 0.800 |
| Model IV | 1 (Ref) | 0.83 (0.27, 2.56) | 0.46 (0.11, 1.84) | 0.520 |
| Insulin (> 8.85 UIU/ml) | | | | |
| Model I | 1 (Ref) | 0.85 (0.33, 2.19) | 1.42 (0.545, 3.70) | 0.470 |
| Model II | 1 (Ref) | 0.86 (0.33, 2.29) | 1.33 (0.49, 3.62) | 0.660 |
| Model III | 1 (Ref) | 1.02 (0.35, 2.91) | 2.45 (0.67, 8.94) | 0.280 |
| Model IV | 1 (Ref) | 1.16 (0.37, 3.61) | 2.60 (0.66, 10.35) | 0.340 |
| FBS (> 96 mg/dl) | | | | |
| Model I | 1 (Ref) | 1.60 (0.60, 4.10) | 1.00 (0.39, 2.65) | 0.550 |
| Model II | 1 (Ref) | 1.34 (0.49, 3.72) | 0.71 (0.25, 1.97) | 0.450 |
| Model III | 1 (Ref) | 1.43 (0.46, 4.42) | 1.38 (0.38, 5.02) | 0.810 |
| Model IV | 1 (Ref) | 2.01 (0.61, 6.61) | 2.26 (0.54, 9.50) | 0.440 |
| TG (> 139.4 mg/dl) | | | | |
| Model I | 1 (Ref) | 1.60 (0.60, 4.30) | 2.01 (0.80, 5.60) | 0.140 |
| Model II | 1 (Ref) | 1.63 (0.62, 4.28) | 1.90 (0.70, 5.13) | 0.420 |
| Model III | 1 (Ref) | 1.82 (0.62, 5.31) | 1.33 (0.38, 4.66) | 0.540 |
| Model IV | 1 (Ref) | 2.35 (0.75, 7.32) | 1.66 (0.44, 6.27) | 0.330 |
| Total cholesterol (> 193 mg/dl) | | | | |
| Model I | 1 (Ref) | 1.10 (0.40, 2.10) | 1.62 (0.60, 4.30) | 0.330 |
| Model II | 1 (Ref) | 1.19 (0.45, 3.10) | 1.45 (0.54, 3.88) | 0.760 |
| Model III | 1 (Ref) | 1.00 (0.33, 2.99) | 1.17 (0.33, 4.17) | 0.960 |
| Model IV | 1 (Ref) | 0.97 (0.31, 3.01) | 1.34 (0.35, 5.17) | 0.860 |
| LDL-C (> 99.5 mg/dl) | | | | |
| Model I | 1 (Ref) | 1.83 (0.70, 4.80) | 1.85 (0.70, 4.10) | 0.220 |
| Model II | 1 (Ref) | 1.83 (0.70, 4.80) | 1.66 (0.62, 4.46) | 0.430 |
| Model III | 1 (Ref) | 1.10 (0.68, 5.70) | 1.84 (0.54, 6.27) | 0.430 |
| Model IV | 1 (Ref) | 2.03 (0.67, 6.12) | 2.18 (0.59, 8.00) | 0.390 |
| HDL-C (mg/dl) (< 49.5 mg/dl) | | | | |
| Model I | 1 (Ref) | 0.69 (0.25, 1.93) | 0.59 (0.21, 1.63) | 0.900 |
| Model II | 1 (Ref) | 0.69 (0.24, 2.00) | 0.62 (0.21, 1.83) | 0.670 |
| Model III | 1 (Ref) | 0.71 (0.23, 2.20) | 0.53 (0.15, 1.90) | 0.620 |
| Model IV | 1 (Ref) | 0.75 (0.24, 2.41) | 0.46 (0.12, 1.76) | 0.510 |
| hs-CRP (> 2 µg/ml) | | | | |
| Model I | 1 (Ref) | 1.61 (0.62, 4.20) | 1.45 (0.55, 3.82) | 0.460 |
| Model II | 1 (Ref) | 1.67 (0.62, 4.46) | 1.70 (0.62, 4.65) | 0.500 |
| Model III | 1 (Ref) | 1.65 (0.58, 4.71) | 1.48 (0.43, 5.11) | 0.640 |
| Model IV | 1 (Ref) | 1.95 (0.58, 6.54) | 1.54 (0.37, 6.35) | 0.550 |
| Fibrinogen (> 285 mg/dl) | | | | |
| Model I | 1 (Ref) | 0.41 (0.15, 1.01) | 0.40 (0.15, 1.10) | 0.080 |
| Model II | 1 (Ref) | 0.43 (0.15, 1.23) | 0.38 (0.12, 1.15) | 0.180 |
| Model III | 1 (Ref) | 0.36 (0.11, 1.15) | 0.36 (0.09, 1.34) | 0.180 |
| Model IV | 1 (Ref) | 0.38 (0.12, 1.23) | 0.36 (0.09, 1.46) | 0.230 |

HOMA-IR: Homeostasis model assessment; QUICKI: Quantitative insulin sensitivity check index; hs-CRP: High sensitive C-reactive protein; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol; TG: Triglyceride
Model I: Crude; Model II: Adjusted for gender, smoking, socioeconomic; Model III: Additional adjustment for fat, energy intake, fruit, vegetable, dietary fiber and red meat; Model IV: More control for BMI (Body mass index).
*From Mantel-Haenszel extension chi-square test.

In addition, in spite of increased life expectancy, few researches have been conducted among elderly people particularly in the context of diet. To our knowledge, there is no study examining dairy consumption in relation to cardiometabolic risk factors among Iranian elderly. It seems that association between diet and disease is something different among young adults in comparison with elderly that might be attributable to differences in fat mass, fat distribution and the grade of systematic inflammation.[1] Most of available information regarding diet-disease association among Iranian elderly is related to dietary patterns and cancer risks. Although dietary patterns could provide more holistic evaluation of diet-diseases association, assessing health outcomes of individual food groups has its important public health implications. Moreover, epidemiological studies may better reflect the roles of dietary intakes on health status and be more generalizable than clinical trials. Indeed, findings from epidemiologic studies indicate habitual dietary intakes, whereas clinical trials indicate the impact of changes in dietary intakes only for a short term and may be difficult to adhere in long-term.

Dairies contain some beneficial components such as calcium, magnesium, vitamin D and whey protein, which may ameliorate metabolic abnormalities by reducing fat mass and consequently insulin resistance.[26] However, dairy products are one of the main sources of SFA that may override favorable outcomes of dairy. In the present study, we could not assess the associations for various dairy products considering their fat content. It seems that eating high-fat products is more common among Iranian populations. Therefore, SFA content of dairy products might be a concern in this population. However, findings from dietary intakes of the study participants showed that SFA intake was lower in the top tertile of dairy that might be because of less consumption of red meats, as another main source of SFA.

To date, many studies were conducted to examine the associations of dairies and cardiometabolic risk factors, but the evidence is not conclusive. Although some studies have reported beneficial effects for dairies, other studies suggested no association.[15,27] In a meta-analysis of clinical trials, Benatar et al.[15] indicated that low and whole fat dairy foods increased body weight, but did not significantly changed waist circumference, HOMA-IR, fasting blood glucose, LDL-C, HDL-C, systolic and DBP and CRP. Moreover, analysis of 3 cohorts of US adults showed that only yogurt reduced the risk of diabetes type 2 while total dairy and other dairy foods were not significantly related to the risk of diabetes.[27]

The associations of dairy products consumption and inflammatory biomarkers are inconsistent either in clinical trails[28,29] or in observational studies.[30,31] A recent systematic review on clinical trials indicated that dairy products consumption could not significantly influence low-grade systematic inflammation.[32] Findings from a cross-sectional study suggested inverse association between dairy consumption and systematic inflammation,[30] but another one failed to find significant relation for total dairy consumption in a representative sample of Iranian female.[31]

However, in this study, after subgroup analysis based on fat content of dairy products, low-fat and high-fat products were differently correlated with inflammatory biomarkers. We were not able to do such subgroup analysis because of small sample size, and larger studies are required to indicate if low-and high-fat dairy products are differently related to inflammatory biomarkers. Similar discrepancy is also observed for the effects of dairies on insulin sensitivity, as the main component of metabolic syndrome. A systematic review on short-and long-term interventions indicated that only one study has found negative association between dairy and insulin sensitivity, whilst others have reported no significant or positive relation.[33]

The lack of significant difference across the tertiles of dairy for various metabolic disorders might be attributable to low content of vitamin D in our dairy products. On the other hand, because of non-fortification of dairy products with vitamin D, vitamin D deficiency is now known as a public health concern among Iranian populations. However, consuming greater dairy products could not compensate vitamin D deficiency, and thereby could not exert their beneficial effects. There are more reasons for our non-significant findings. First, fat content of dairy products may modify their associations with metabolic profile. Second, various dairy products, including, milk, yogurt, cheese, fermented or non-fermented dairy products may influence their physiological impacts. For example, in a cross-sectional study among elderly women, only yogurt was inversely associated with common carotid artery intima-media thickness,[34] while in another cross-sectional study among adolescents, negative correlation was observed between cardiometabolic risk

factors and milk, but not yogurt, total dairy products, and cheese.[35] Moreover, body weight and composition may also affect the health benefits of dairy products.[36] More studies specifically designed to examine various types of dairy products in different BMI categories and age groups particularly elderly are warranted.

Despite neutral association between dairy product consumption and metabolic abnormalities in this population, consuming higher amounts of dairy may still be useful. Our findings suggest that individuals in higher tertile of dairy had better micronutrients intakes than those in the lowest. These findings are supported by previous research,[37] and could be relevant findings in elderly individuals to provide adequate nutrients intake.

Several limitations need to be taken into account in the interpretation of our findings. The major concern of the present study is the cross-sectional design that could not reveal causal-inference associations. It is possible that individuals with abnormal metabolic profile modify their dietary intakes and have healthier food choices. Second, using FFQ to assess dietary intakes is another limitation of our study. Since FFQ is a retrospective to assess dietary intakes, recall of dietary intakes might have been biased and consequently lead to misclassification. Although we tried to control known confounding factors, controlling all residual confounders in our study, as in all observational studies, is inevitable.

Given the aforementioned limitations, we found a neutral association between dairy products and different cardiometabolic risk factors. However, since dairy products are essential contributors of micronutrients and protein, they should be consumed in recommended amounts by dietary guidance. Clinical trials are needed to prove the exact effects of dairy products on health outcomes particularly in elderly who may limit their dairy consumption.

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## Conflict of Interests

Authors have no conflict of interests.

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