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Dairy Food Intake and Cardiovascular Health: The Maine-Syracuse Study

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Abstract

Inconsistent findings have been reported regarding the influence of dairy food consumption on risk for cardiovascular disease, particularly with regard to the fat content of dairy food. The aim of this study was to examine the relationship between dairy food consumption and ideal cardiovascular health, as recently defined by the American Heart Association (AHA). Data were analyzed from 972 participants in the Maine-Syracuse Longitudinal Study (MSLS) in the USA. Self-reported intakes of milk, cheese, yogurt, dairy desserts, ice-cream and cream were obtained from a food frequency questionnaire. Four health behaviors (smoking, body mass index, physical activity, diet), and three health factors (total cholesterol, blood pressure, fasting plasma glucose) were measured. A total Cardiovascular Health Score (CHS) was determined by summing the total number of health metrics at ideal levels. Analyses were conducted to examine intakes of individual dairy products and total dairy food in relation to the CHS and to each individual health metric. Yogurt, milk and total dairy food intakes were positively associated with cardiovascular health as indexed by seven health behaviors and factors, controlling for demographic variables and total food intake. Those who consumed dairy foods more frequently, particularly yogurt, also consumed fewer 'non-recommended' foods, engaged in more physical activity, and did not smoke.

Keywords: Dairy foods; Cardiovascular health

Introduction

Cardiovascular disease (CVD) accounted for one of every three deaths in the USA in 2009 and is estimated to cost $312 billion annually, comprising healthcare, medication, and lost productivity costs [1,2]. The American Heart Association (AHA) recently defined levels of four health behaviors (not smoking, engaging in sufficient physical activity, consuming a healthy diet with appropriate energy balance as reflected by normal body mass index), and three health factors (optimal total cholesterol, blood pressure, and fasting blood glucose), to identify ideal cardiovascular health [3]. This concept, with clearly defined levels for poor, intermediate and ideal health for each behavior and factor, was described to promote substantial CVD reduction by 2020. Research has subsequently confirmed the importance of these metrics of cardiovascular health, finding inverse associations between ideal cardiovascular health and all-cause and CVD mortality [4,5], and cardiovascular events [5-8]. However, the most recent data indicate that significant risk factor reduction has not occurred [2,9], and substantial progress is needed to impact upon the burden of CVD.

It is well recognized that diet is an integral part of CVD prevention [3]. A number of recent systematic reviews have been published regarding dairy food consumption, cardiovascular and other chronic disease risk [10-13]. Huth and Park [10] concluded that the majority of observational studies have not shown an increased risk of CVD associated with dairy food intake, regardless of fat content. Similarly, Kratz et al. [11] failed to find evidence for high fat dairy foods contributing to cardio-metabolic risk. Rice et al. [12] provide evidence that consuming three or more servings of dairy food per day is associated with a reduced risk of CVD and type 2 diabetes, and full fat milk and dairy foods may have beneficial effects on coronary heart disease risk. The most recent review and meta-analysis by Soedamah-Muthu et al. [13] of prospective cohort studies concluded that milk intake may be inversely associated with overall CVD risk, but there was no association between milk consumption and risk of coronary heart disease, stroke or all-cause mortality. This accumulation of evidence is in contrast to findings from the Hoorn study, conducted in the Netherlands where dairy consumption is typically high, of positive associations between high-fat dairy intake and risk of CVD mortality [14]. This is supported by another prospective study conducted in the Netherlands, which showed a slightly increased risk for all-cause and ischemic heart disease mortality in older women with high intakes of dairy fat [15]. However, an Australian study failed to find any association between baseline consumption of dairy foods and risk of CVD mortality in older adults [16].

As the majority of studies have examined dairy food intakes in relation to CVD, disease risk or mortality, the primary objective of the present study was to determine if dairy food intake is related to a more global measure of cardiovascular health, encompassing both health factors and behaviors, as distinct from disease outcome. A secondary objective was to explore associations between dairy food intake and the individual cardiovascular health metrics. Analyses were conducted to test the hypothesis that dairy food intake, including whole fat products, would be positively associated with overall cardiovascular health.

Methods

Participants

The Maine-Syracuse Longitudinal Study (MSLS) was a study of CVD risk factors and cognitive functioning in adults living independently in Syracuse and surrounds in Central New York [17-20]. Exclusion

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criteria were diagnosed alcoholism, psychiatric disorder, and inability to participate due to language barriers. Data for the present study were taken from subjects returning at the sixth study wave (2001-2006) as a broad array of cardiovascular risk factors in addition to dietary intake measures were obtained at this examination. From an initial sample of 1049 adults, we excluded those missing dietary or cardiovascular health data (*n*=34), suffering from acute stroke (*n*=28) or probable dementia (*n*=8), undertaking dialysis treatment (*n*=5), unable to read English (*n*=1), and reporting alcohol abuse after baseline (*n*=1), leaving 972 participants. Further details related to the methods of sampling and data collection appear elsewhere [19,21]. Persons with stroke, dementia and on renal dialysis are excluded in all studies with the MSLS because of deficiencies in cognitive functioning. The excluded persons in these groups were lower in education, higher in age, and more were retired than in the sample used in the present study. The mean age difference was 7.2 years (± 0.8 years); mean education difference was 1.9 years (± 0.2 years); and 51.2% were retired in the combined dementia, stroke, and dialysis group as compared to 39.5% of the sample employed in the present study. All participants gave informed written consent and the study was approved by the University of Maine Institutional Review Board.

Procedure and measures

Detailed self-administered questionnaires were used to gain information on demographic and socioeconomic characteristics. Data collection methods pertaining to the MSLS have been published in detail previously [17,19].

Dietary intake: Dietary intake was assessed using the Nutrition and Health Questionnaire [22]. Participants were required to report how frequently they consume foods and beverages, from six response categories: never, seldom (1 to 3 times per month), once a week, 2 to 3 times a week, 5 to 6 times a week or once or more a day. The dairy foods itemized in the questionnaire were milk, cheese, yogurt and dairy desserts (combined together), and ice-cream and cream (combined together). Participants were asked to stipulate the fat content of milk consumed (whole fat, low fat, skim). The methods used to calculate daily intakes of dairy food and total energy intakes in this sample have been described previously [23]. The daily intakes represent an estimate of the number of times each food was consumed on a daily basis as exact portion sizes were not stipulated (with the exception of milk). Total energy intake was estimated by calculating the sum of all individual foods, in times per day.

Cardiovascular health: Standard assay methods were employed [19] to obtain fasting plasma glucose (mg/dL), total cholesterol (mg/dL), low-density lipoprotein cholesterol (mg/dL), high-density lipoprotein cholesterol (mg/dL), triglycerides (mg/dL), and C-reactive protein (CRP, mg/L), following an overnight fast. Body weight was measured with participants wearing light clothing to the nearest 0.1 kg, and height was measured with a vertical ruler to the nearest 0.1 cm. Body mass index (BMI) was calculated as weight in kilograms divided by height in metres squared. After a supine rest for 15 minutes, five BP measures (GE DINAMAP 100DPC-120XEN, GE Healthcare) were taken in each of three positions: reclining, sitting and standing, and averaged for systolic and diastolic BP. Smoking status (never, former, current) was based on self-report from the Nutrition and Health Questionnaire [22]. Physical activity was measured with the Nurses' Health Study Activity Questionnaire, a valid measure of long-term physical activity levels [24]. Participants are asked to report the average time per week spent at a number of recreational activities, including walking, jogging, swimming, cycling, and other aerobic activity. A MET value for each activity was assigned [25], and then multiplied by the number of hours spent at each activity to obtain MET-hours per week for each activity. Total MET-hours per week was obtained by summing the MET hours for the individual activities. This was converted to MET-minutes per week to enable comparison with the AHA physical activity definitions [3].

Calculation of healthy diet metric: Two food scores were calculated for the diet metric, a Recommended Food Score [26] and a non-Recommended Food Score [27]. These scores were used in place of the AHA healthy diet metric due to the availability of dietary data and to capture a more detailed measure of dietary intakes. The Recommended Food Score comprised 17 food items, based on the recommendations of the 2010 Dietary Guidelines for Americans [28], and included fruit, vegetables, legumes, wholegrain cereal products, fish and nuts, similar items to those used previously [26,29]. One point was assigned for consumption of recommended foods at least once per week, otherwise 0 points were given [26]. A total Recommended Food Score out of 17 was calculated, with a higher score indicating a higher consumption of recommended food items. The non-Recommended Food Score [27] included 11 items that are recommended to reduce [28] such as processed meats, refined grains, solid fats, added sugars and alcohol. Consumption of non-recommended foods at least 2 to 4 times per week was assigned a score of 1; otherwise 0 points were assigned [29,30]. A total non-Recommended Food Score out of 11 was calculated, with a higher value indicating a higher consumption of non-recommended food items. Dairy foods were not included in either score.

Definition of ideal cardiovascular health: Poor, intermediate, and ideal health for six health metrics (smoking, BMI, physical activity, total cholesterol, BP, and fasting plasma glucose) were calculated, using the AHA definitions [3]. Ideal health for each metric are as follows: smoking: never or quit more than 12 months ago, BMI: <25 kg/m^2, physical activity: ≥ 150 minutes per week (equating to ≥ 500 MET-minutes per week), total cholesterol: <200 mg/dL, BP: <120/<80 mmHg, and fasting plasma glucose: <100 mg/dL [3].

For the Recommended Food Score, scores of 0-7, 8-12, and ≥ 13 out of 17 were defined as poor, intermediate, and ideal, respectively. Scores of 5-11, 3-4, and 0-2 out of 11 for the non-Recommended Food Score were defined as poor, intermediate, and ideal. These scores were grouped based on the distribution of scores, in order to create the most equal groups for meaningful comparison. The CHS comprised the sum of components at ideal levels, ranging from 0 (no cardiovascular health components at ideal levels) to 8 (all cardiovascular health components at ideal levels).

Statistical analysis

Independent samples t-tests and Chi square analyses were used to compare the demographic characteristics of those included in the study and those excluded. Multiple ordinary least square regression analysis was used to compare demographic and cardiovascular health variables (metrics as continuous variables) for participants according to total dairy intake. All analyses were conducted using SPSS Statistics (Version 21, Chicago, IL, USA). For the primary analyses, general linear modelling with linear and quadratic trend analyses were used to compare the CHS across increasing intakes of dairy food consumption. Total dairy food intake, and intakes of individual dairy foods (milk, cheese, yogurt/dairy desserts, cream/ice-cream), were examined in relation to CHS. For individual dairy foods, outcomes across 3 intake categories: low (<1 serve per week), medium (≥ 1-5 serves per week), and high (≥ 5 serves per week) were compared. For milk, the three intake categories were as follows: low (<300 mL per day), medium (≥ 300-600 mL per day), and high (≥ 600 mL per day). Low, medium and high consumption categories for total dairy food intake were: <1 serve per day, ≥ 1-3 serves per day, and ≥ 3 serves per day, respectively.

Because we were investigating the associations between dairy food intake and cardiovascular health, all covariates used in the analysis had to be significantly associated (p<.05) with total dairy food intake and the CHS. Two hierarchial sets of covariates were employed: (1) Basic set: adjusted for age, education, gender, total food intake(total daily intakes of all food groups), and (2) Full set: basic model + ethnicity, serum folate (ng/dL), self-rated health (1-5), waist to hip ratio, and intake of remaining dairy products. For example, when assessing the relationship between yogurt intake and CHS, intakes of milk, cheese and ice-cream/cream were included in the fully adjusted set as covariates. The Bonferroni method was used in all analyses to adjust for multiple comparisons among groups.

To explore relationships between the individual health metrics and dairy food intakes (individual products and total all dairy foods), general linear modelling with polynomial trend analyses was used to compare intakes of dairy food (continuous variable) according to level of cardiovasular health (poor, intermediate and ideal) for each metric (adjusted for age, gender, education, and total food intake).

Results

Sample characteristics and dairy food intakes

There were no statistical differences between those who were included versus those who were excluded (due to missing data) in terms of age, gender, education in years, occupation, ethnicity or marital status (data not shown).

Table 1 shows the demographic, and cardiovascular health variables for MSLS (N=972) participants across increasing intakes of total dairy food. There was a significant positive linear association between dairy food consumption and physical activity time, Recommended Food Score and overall CHS. The quadratic trend component was not statistically significant. There was a statistically significant inverse association between amount of dairy food intake and number of cigarettes smoked per week and diastolic BP (mmHg). Table 2 describes the self-reported

	Total dairy intake						
Variable	Low: <1 serve/day *n*=171		Medium: ≥1-3 serves/day *n*=538		High: ≥3 serves/day *n*=263		*p* (linear)
	M or %	SD	M or %	SD	M or %	SD	
Age, years	58.6	11.1	62	13	64.4	13	<0.001
Gender							0.32
Males	19.8		53.9		26.3		
Females	16.1		56.4		27.6		
Education, years	14.4	2.7	14.7	2.7	14.7	2.8	0.47
Race							0.002
Caucasian	16.5		55.5		28		
African American	31.5		53.4		15.1		
Cardiovascular Health metrics							
Smoking, no cigarettes/ week	20.7	60.5	6.5	27	7.9	33.1	<0.001
BMI, kg m^{-2}	29.8	6.1	29.4	6	28.8	5.5	0.1
Physical activity, mins/week[a]	207	298	253	322	289	368	0.027
Total cholesterol, mg/dL	201.8	36.2	200.9	42.1	201.8	36.6	0.94
Systolic BP, mmHg	130.5	1.7	130.8	0.9	131.2	1.3	0.73
Diastolic BP, mmHg	72.2	10.3	70.1	9.5	69.9	10.7	0.019
Fasting blood glucose, mg/dL	99.4	27.9	99.4	28.9	97.8	26.7	0.56
RFS[b]	7.9	3.1	9	2.5	9.6	2.6	<0.001
non-RFS[c]	2.7	1.3	2.6	1.4	2.7	1.3	0.73
Total CHS, 0-8	3.6	1.6	3.9	1.4	3.9	1.4	0.024
Proportion of sample with CHS 0/8	1.2		0.2		0.4		
Proportion of sampe with CHS 8/8	0		0		0.8		
Other health measures							
Waist:hip	0.9	0.09	0.87	0.09	0.88	0.09	0.02
CRP, mg/dL	0.49	0.66	0.41	0.45	0.42	0.41	0.19
Triglycerides, mg/dL	143	97.5	146.4	124.2	136.3	93.4	0.5
Folic acid, ng/dL	14.4	5.4	15.2	5.5	16.4	5.2	0.001
Plasma homocysteine, μmol/L	10.2	3.8	10	3.9	9.6	2.7	0.13
Depression, CES-D score[d]	8.1	7.7	7.6	6.9	7.2	6.3	0.41
Self-rated health, 1-5[e]	3.4	0.8	3.6	0.8	3.7	0.8	0.002
Alcohol intake, standard drinks/week	4.5	9.8	3.1	5.8	2.6	4.2	0.006
Total food intake, serves/ day	12.4	4.3	14.3	3.9	17.4	4.9	<0.001
% Obese (BMI ≥ 30 kg/ m^2)	43.5		40.4		31.8		0.024
% Diabetes[f]	13.5		12.8		11		0.7
% Hypertension[g]	62		61.7		60.8		0.96
% CVD[h]	15.2		16.2		9.9		0.05

BMI: Body Mass Index; BP: Blood Pressure; CES-D: Center for Epidemiologic Studies Depression Scale; CHS: Cardiovascular Health Score;
CRP: C-reactive protein; CVD: cardiovascular disease; M: mean; non-RFS: non-Recommended Food Score; RFS: Recommended Food Score;
SD: Standard Deviation
[a]Includes moderate and intense physical activity
[b]RFS: 0-17, higher scores indicate higher intake of recommended foods
[c]non-RFS, 0-11: higher scores indicate higher intake of non-recommended foods
[d]CES-D: higher scores indicates greater number of depressive symptoms
[e]Rated from 1 (very poor) to 5 (excellent)
[f]Fasting plasma glucose ≥ 126 mg/dL or taking anti-diabetic medication
[g]Systolic BP ≥ 140 mmHg and/or diastolic BP ≥ 90 mmHg or taking anti-hypertensive medication
[h]Includes myocardial infarction, coronary artery disease, heart failure, angina pectoris, transient ischemic attack

Table 1: Demographic, cardiovascular and health variables for Maine-Syracuse Longitudinal Study participants (N=972) according to total dairy food intake (milk, cheese, yogurt, dairy desserts, cream, ice-cream).

Dairy food	Dairy intakes, % of sample		
	Low: <1 serve/ week	Medium: ≥ 1-5 serves/ week	High: ≥ 5 serves/ week
Total yogurt	54.8	35.0	10.2
Total cheese	17.2	67.1	15.7
Total ice-cream & cream	47.3	45.8	6.9
	0-300 mL/day	>300-600 mL/day	>600 mL/day
Total milk	45.6	27.8	26.6
Fat-free/low fat milk	56.8	20.6	22.6
Whole fat milk	97	1.7	1.4
	Low: <1 serve/ day	Medium: ≥ 1-3 serves/ day	High: ≥ 3 serves/ day
Total milk, cheese, yogurt	24.2	53.4	22.4
Total dairy food (milk, cheese, yogurt, cream, ice-cream)	17.6	55.3	27.1

Table 2: Self-reported intakes of dairy foods for Maine-Syracuse Longitudinal Study participants.

intakes of milk, cheese, yogurt and dairy desserts, cream and ice-cream, and total dairy food.

Dairy food consumption and cardiovascular health

Positive associations were found between the CHS and the following outcomes: total yogurt, low fat milk, and total milk intakes ($p<.05$ for linear trend) (Table 3). This was true with adjustment for age, education, gender, and total food intake. Those who consumed milk or yogurt at least weekly had a significantly higher CHS than those who never or rarely consumed these products. Total intake of milk, cheese and yogurt was positively associated with the CHS. This significant increase in the CHS with increasing intakes of dairy food remained with the addition of cream and ice-cream (total dairy = milk, cheese, yogurt, cream and ice-cream).

With the full set of covariates (statistical control for the basic model and for ethnicity, folic acid, self-rated health, waist: hip, remaining dairy products), positive associations between the CHS and the following remained: yogurt, total milk, cheese and yogurt, and total dairy food (milk, cheese, yogurt, cream and ice-cream) ($p<.05$ for linear trend for all) (Table 3 and Figure 1).

Dairy food	Covariate set[a]	Low <1 serve/ week		Medium ≥ 1-5 serves/ week		High ≥ 5 serves/ week		*p* linear trend
		M	SE	M	SE	M	SE	
Total cheese	Basic	4.1	0.11	3.7[d]	0.05	3.9	0.12	0.20
	Full	4.1	0.1	3.8[d]	0.05	3.7	0.11	0.032
Total yogurt	Basic	3.7	0.06	4.0[d]	0.08	4.2[d]	0.14	0.001
	Full	3.7	0.06	3.9	0.07	4.1[d]	0.13	0.006
Total ice-cream & cream	Basic	3.8	0.07	3.8	0.07	3.6	0.17	0.20
	Full	3.8	0.06	3.8	0.06	3.6	0.16	0.23
Total milk[b]	Basic	3.7	0.07	4.0[d]	0.08	3.9d	0.09	0.016
	Full	3.9	0.1	3.7	0.07	3.9	0.06	0.74
Fat-free/low fat milk	Basic	3.7	0.06	3.9	0.1	4.0[d]	0.1	0.004
	Full	3.8	0.09	3.7	0.07	3.9	0.07	0.47
Whole fat milk[c]		*n* too small to perform						
Total dairy food intakes		Low		Medium		High		
		<1 serve per day		≥ 1-3 serves per day		≥ 3 serves per day		
Total milk, cheese, yogurt	Basic	3.5	0.09	3.9[d]	0.06	4.1[d]	0.1	<0.001
	Full	3.7	0.09	3.8	0.06	4	0.09	0.047
Total dairy food (milk, cheese, yogurt, cream, ice-cream)	Basic	3.5	0.11	3.8[d]	0.06	4.0[d]	0.09	<0.001
	Full	3.7	0.11	3.8	0.06	4	0.09	0.04

M: Mean; MSLS: Maine-Syracuse Longitudinal Study; SE: Standard Error

[a]Basic covariate set: adjusted for age, education, gender, total food intake; Full covariate set: basic + ethnicity, folic acid, self-rated health, waist: hip, remaining dairy products

[b]Low intake = 0-300 mL/day, medium intake = >300-600 mL/day, high intake = >600 mL/day

[c]n too small to perform comparison

[d]Significantly different from low intake group

Table 3: Multivariate-adjusted mean and SE for Cardiovascular Health Score across increasing intakes of dairy food (N=972).

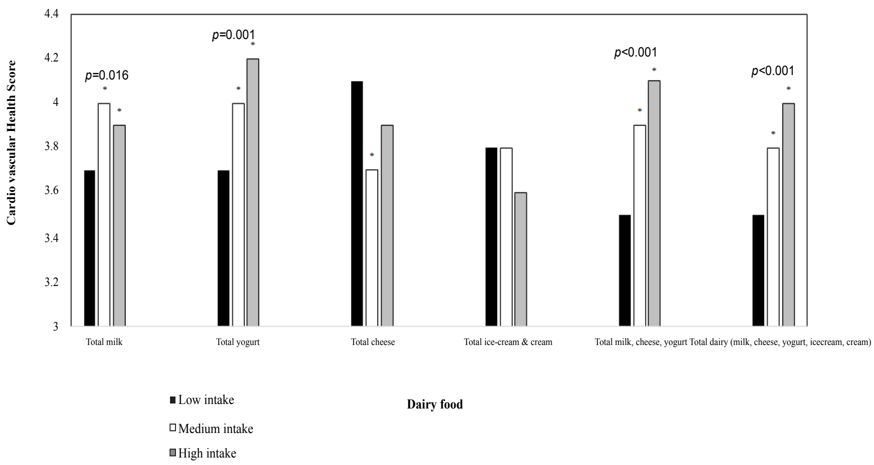

Figure 1: Multivariate-adjusted mean Cardiovascular Health Score across increasing intakes of milk, yogurt, cheese, ice-cream/cream, and total dairy food intake (adjusted for age, education, gender, and total food intake).
*$p<.05$, mean score significantly different from mean score of low intake group. For milk, yogurt, cheese, and ice-cream: low intake = <1 serve per week, medium intake = ≥ 1-5 serves per week, high intake = ≥ 5 serves per week. For total dairy food intake: low intake = <1 serve per day, medium intake = ≥ 1-3 serves per day, high intake = ≥ 3 serves per day.

Dairy food consumption and individual cardiovascular health metrics

Relationships between mean intakes of dairy foods according to poor, intermediate and ideal level of cardiovascular health for the individual metrics are shown in Table 4 (basic model shown, significant findings only). Those with ideal levels on the non-Recommended Food Score (those who consumed fewer 'non-recommended' items) had significantly higher intakes of yogurt, total and low fat milk, and lower intakes of cream/ice-cream and whole fat milk (all p<.001 for linear trend). Overall, those that consumed non-recommended foods least frequently had higher intakes of total dairy foods, than those with more frequent consumption of non-recommended items (p<.001 linear trend). All of these associations between dairy food intake and the non-Recommended Food Score remained significant with further statistical adjustment (full covariate set, data not shown). Ideal levels on the Recommended Food Score (those who consumed recommended food items more frequently) also had significantly higher intakes of yogurt (p<.001 for linear trend, basic and full sets).

Those who had never smoked (ideal levels for smoking) had significantly higher intakes of yogurt, and total dairy foods than current smokers. Similarly, those who met the ideal health definition for physical activity (at least 150 minutes per week of activity), consumed more total milk, yogurt and total dairy food than those who did not meet this recommendation. Those with ideal BP consumed more yogurt but less whole fat milk than those with poor BP levels. With further adjustment (full covariate set), positive associations between yogurt intakes and better health levels for physical activity and BP remained (data not shown).

Discussion

To our knowledge, this is the first study to examine the frequency of dairy food intake in relation to a constellation of cardiovascular risk factors and behaviors, as indexed by the AHA construct of cardiovascular health. Overall, total dairy food intakes in this sample were low, with only 22.4% of the sample meeting the recommendations in the 2010 Dietary Guidelines for Americans, of three cups of fat-free or low-fat milk and milk products per day [28]. Nearly one-quarter of the sample consumed less than one serve per day. Milk was the most frequently consumed dairy product, with the majority of the sample consuming low fat milk (76.8%).

This study found positive associations between intakes of yogurt, low fat milk and total dairy food intake with cardiovascular health. Specifically, those who consumed at least five serves per week of milk or yogurt had a significantly higher CHS than those with intakes less than this.

The CHS was highest in those with intakes of at least three serves of dairy products (milk, cheese or yogurt) per day. This significant linear trend observed between increasing dairy food intake and cardiovascular health remained with full adjustment for potential confounders. Interestingly, this association remained when high fat dairy products, ice-cream and cream, were included; the CHS was highest in those with the highest intakes of total dairy foods.

The whole fat in dairy foods has typically been perceived by the public as a negative element of dairy foods, largely due to its high saturated fat content, link to increased LDL cholesterol and subsequent risk for CVD [31], despite evidence to the contrary [12,32]. However national dietary guidelines, including those in the US, Australia and

Dairy product	Health metric	Level of cardiovascular health						*p* linear trend
		Poor		Intermediate		Ideal		
		M	SE	M	SE	M	SE	
Total yogurt[b]	Smoking	1.0	0.19	1.5	0.08	1.6	0.09	0.017
	Physical activity	0.76	0.18	1.5[e]	0.10	1.6[e]	0.08	<0.001
	BP	1.2	0.11	1.6[e]	0.10	1.6[e]	0.11	0.006
	RFS	0.98	0.12	1.6[e]	0.07	2.3[ef]	0.20	<0.001
	non-RFS	0.8	0.20	1.3[e]	0.09	1.7[ef]	0.09	<0.001
Fat-free/low fat milk[b]	non-RFS	3.6	0.76	6.6	0.35	8.3[ef]	0.33	<0.001
Whole fat milk[b]	Smoking	1.2	0.26	0.42[e]	0.11	0.42[e]	0.13	0.008
	Physical activity	0.99	0.25	0.46	0.14	0.43	0.11	0.04
	BP	0.7	0.14	0.52	0.13	0.27	0.14	0.044
	non-RFS	1.5	0.27	0.46[e]	0.13	0.33[e]	0.12	<0.001
Total milk[b]	Physical activity	7.8	0.69	6.8	0.38	8.1[ef]	0.29	0.021 (*p* overall)
	non-RFS	5.1	0.75	7 .0	0.35	8.6	0.32	<0.001
Total cream/ ice-cream[b]	non-RFS	2 .0	0.16	1.6	0.08	1.2ef	0.07	<0.001
Total milk, cheese, yogurt[c]	Smoking	1.6	0.11	2.0[e]	0.05	2.0[e]	0.05	0.006
	Physical activity	1.9	0.1	1.9	0.06	2.1[f]	0.04	0.018 (*p* overall)
	non-RFS	1.4	0.11	1.8[e]	0.05	2.2[ef]	0.05	<0.001
Total dairy food[c, d]	Smoking	1.8	0.11	2.3[e]	0.05	2.2[e]	0.05	0.003
	Physical activity	2.1	0.1	2.1	0.06	2.3[f]	0.04	0.023 (*p* overall)
	non-RFS	1.7	0.11	2.1[e]	0.05	2.4[ef]	0.05	<0.001

BP: Blood Pressure; M: Mean; non-RFS: non-Recommended Food Score; RFS: Recommended Food Score; SE: Standard Error
[a]All adjusted for age, gender, education, total food intake
[b]Mean serves per week
[c]Mean serves per day
[d]Total dairy food = milk, cheese, yogurt, cream, ice-cream
[e]Significantly different from poor group
[f]Significantly different from intermediate group

Table 4: Mean dairy food intakes according to level of cardiovascular health for each health metric[a].

many European countries, continue to recommend the consumption of low fat milk and other dairy products [28,33,34]. The current study is consistent with recent literature showing no association between high fat dairy food intake and CVD risk [11].

The selection of low fat or high fat dairy foods to consume may reflect other lifestyle and dietary choices. Dairy food intake in the present study was associated with positive lifestyle behaviors. Those with higher intakes of yogurt and milk (total and low fat), but lower intakes of ice-cream and whole fat milk, consumed fewer 'non-recommended' items, e.g., foods high in sugar and saturated fat. Those with a high yogurt intake also consumed other recommended food items more frequently. Similarly, those who met the ideal health definition for physical activity consumed more total milk, yogurt and total dairy food than those who did not. With regard to smoking, the mean intakes of yogurt and total dairy food (including ice-cream/cream) were highest in non-smokers. Other studies have similarly found associations between higher intakes of dairy foods and positive health behaviors, including more physical activity, lower levels of smoking and intakes of alcohol and soft drinks, and higher intakes of whole grains, fish, and fruit and vegetables [15,16,35].

Making simple lifestyle changes in dietery choices will become increasingly important as the number of people living with chronic CVD increases [36]. Increasing dairy food consumption may be one such strategy. Nearly 25% of the present sample consumed at least four 'non-recommended' food items at least three times per week. Modifying poor dietary habits, a major predictor to the overweight and obesity condition, is of critical importance.

The effect of dairy calcium on energy regulation and body weight may be the predominant mechanism by which dairy products exert beneficial effects on cardiovascular health. Several human studies have demonstrated that dietary calcium increases faecal fat excretion by forming insoluble calcium-soaps with fatty acids in the intestine, decreasing fatty acid absorption, resulting in increased fat excretion and weight loss [37-39]. Increased dietary calcium intake from dairy foods may also increase fat oxidation, via the regulation of the calcitrophic hormones, parathyroid hormone (PTH) and 1,25-dihydroxyvitamine D (1,25$(OH)_2$D). Increasing dietary calcium can suppresses circulating PTH and 1,25$(OH)_2$D, with a corresponding increase in lipolysis and fat oxidation [40-45]. Findings to date suggest the impact of calcium on adiposity may be dependent upon energy intake, and likely enhanced in a state of negative energy balance. Beneficial effects on BP have been ascribed to the intake of low-fat dairy products, based on findings from the Dietary Approaches to Stop Hypertension (DASH) trial [46], with minerals (calcium, potassium and phosphorus) most likely playing a role in this antihypertensive effect [47-49]. Magnesium from dairy has also been has also been inversely associated with reduced odds of obesity and metabolic disturbances [50]. In contrast, negative effects of dairy food consumption in relation to CVD risk have previously been attributed to the saturated fat in dairy foods, however it is important to note that there is recent evidence to support the contrary [32].

There are a number of strengths to the present study. The healthy diet score defined by the American Heart Association was expanded to measure the intake of a greater number of foods (in line with the current national guidelines) and to obtain a greater indication of dietary variety. Most importantly, and for the first time, the intake of dairy products has been related to a composite score reflecting both traditional cardiovascular risk factors (glucose, cholesterol, BP), and lifestyle behaviors (smoking, physical activity and diet), as opposed to CVD or mortality risk. This has been examined in a large, community-based sample, including participants across a wide age range.

Limitations were as follows. The study was cross-sectional and thus employed a measure of dietary intake at one point in time. As with all nutritional research which is reliant upon self-reported measures of dietary intakes, biases may result from inaccurate reporting of intakes, and there were several limitations with the questionnaire used. Milk was the only dairy product in which the fat content was stipulated. Yogurt and dairy desserts were combined together, as were ice-cream and cream. The frequency categories for food intakes were restricted in the high intake range, and we therefore cannot specifically speak to the relationships between cardiovascular risk factors/behaviors and dairy food at high consumption levels. Nor can we conclude that the positive associations between dairy intake and cardiovascular health may be generalized to all dairy products consumed on their own, as low cheese consumption was associated with a higher CHS than intermediate and high consumption. Finally, the questionnaire did not permit calculation of total energy intake, and so total food intake was used as a proxy. Due to the cross-sectional nature of the study, and the positive associations between dairy food intake and healthier lifestyle options, we are unable to make any conclusions regarding causality between higher dairy food intakes and better cardiovascular health.

Longer term intervention studies are needed to further examine the relationships between dairy food intake (with precise measures of the type and quantities of dairy foods consumed as well as energy intake), differences in the fat content of dairy foods, health behaviors, and cardiovascular risk. Our findings were unchanged in sensitivity analyses excluding those on calcium supplementation, but this is another consideration for future studies.

Conclusions

In summary, frequent dairy food intake was associated with better cardiovascular health, as indexed by seven health factors and behaviors. Total dairy food intake was strongly correlated with other positive health behaviors, including non-smoking, engaging in more physical activity, and less frequent consumption of unhealthy foods. In particular, yogurt intake was positively associated with the global CHS and the health behaviors that it is comprised of. High fat dairy products did not detrimentally influence the association with overall cardiovascular health. This study highlights the potential role of increasing dairy food intake in adults as a strategy to promote cardiovascular health.

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