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 [4]. However, the most recent data indicate that inverse associations between dairy food consumption, cardiovascular and other chronic disease risk [10-13]. Huth and Park [10] concluded that the beneficial effects of 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 criteria included: (1) any history of cancer within the past 5 years; (2) any history of serious cardiovascular, pulmonary, liver disease, stroke, or cognitive impairment; (3) history of diabetes or impaired fasting glucose; and (4) severe psychiatric illness. The majority of the participants were white (98.8%), with a mean age of 74.8 years and a mean BMI of 26.4 kg/m2. The study was approved by the Institutional Review Board of the University of Maine at Orono. All participants provided written informed consent.

Participants were divided into three groups based on their dairy food intake: low (<1 serving/day), medium (1-2 servings/day), and high (>2 servings/day). The primary outcome measure was the Cardiovascular Health Score (CHS), which is a global measure of cardiovascular health, encompassing both health factors and behaviors, as distinct from disease outcome. The CHS was calculated as the sum of the total number of health metrics at ideal levels.

Results

The results of the study are presented in Table 1. The main finding was that dairy food intake was positively associated with ideal cardiovascular health, as indexed by 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.

Discussion

The results of the study support the hypothesis that dairy food intake, including whole fat products, 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. However, the results also show that dairy food intake is not 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.

Conclusion

In conclusion, the results of the study support the hypothesis that dairy food intake, including whole fat products, 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. However, the results also show that dairy food intake is not 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.

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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
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,
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/m², 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

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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 cardiovasular health, all covariates used in the analysis had to be significantly associated (p<0.05) with total dairy food intake and the CHS. Two hierarchical 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 cardiovascular health (poor, intermediate and ideal) for each metric (adjusted for age, gender, education, and total food intake).

Results

Sample characteristics and dairy foods 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 intake. The Bonferroni method was used in all analyses to adjust for multiple comparisons among groups.

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).

### Cardiovascular Health metrics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low: &lt;1 serve/day</th>
<th>Medium: 1-3 serves/day</th>
<th>High: ≥3 serves/day</th>
<th>p (linear)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>58.6 ± 11.1</td>
<td>62 ± 13</td>
<td>64.4 ± 13</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td>0.32</td>
</tr>
<tr>
<td>Males</td>
<td>19.8 ± 53.9</td>
<td>56.4 ± 27.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>16.1 ± 56.4</td>
<td>67.1 ± 15.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education, years</td>
<td>14.4 ± 2.7</td>
<td>14.7 ± 2.7</td>
<td>14.7 ± 2.8</td>
<td>0.47</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td>0.002</td>
</tr>
<tr>
<td>Caucasian</td>
<td>16.5 ± 5.5</td>
<td>28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>31.5 ± 5.4</td>
<td>15.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>20.7 ± 60.5</td>
<td>6.5 ± 7.9</td>
<td>28.9 ± 33.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Physical activity, min/week</td>
<td>207 ± 298</td>
<td>253 ± 322</td>
<td>289 ± 368</td>
<td>0.027</td>
</tr>
<tr>
<td>Total cholesterol, mg/dL</td>
<td>20.1 ± 36.2</td>
<td>200.9 ± 42.1</td>
<td>201.8 ± 36.6</td>
<td>0.94</td>
</tr>
<tr>
<td>Systolic BP, mmHg</td>
<td>130.5 ± 1.7</td>
<td>130.8 ± 0.9</td>
<td>131.2 ± 1.3</td>
<td>0.73</td>
</tr>
<tr>
<td>Diastolic BP, mmHg</td>
<td>72.2 ± 10.3</td>
<td>70.1 ± 9.5</td>
<td>69.9 ± 10.7</td>
<td>0.019</td>
</tr>
<tr>
<td>Fasting blood glucose, mg/dL</td>
<td>99.4 ± 27.9</td>
<td>99.4 ± 28.9</td>
<td>97.8 ± 26.7</td>
<td>0.56</td>
</tr>
<tr>
<td>RFS³</td>
<td>7.9 ± 3.1</td>
<td>9 ± 2.5</td>
<td>9.6 ± 2.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>non-RFS²</td>
<td>2.7 ± 1.3</td>
<td>2.6 ± 1.4</td>
<td>2.7 ± 1.3</td>
<td>0.73</td>
</tr>
<tr>
<td>Total CHS, 0-8</td>
<td>3.6 ± 1.6</td>
<td>3.9 ± 1.4</td>
<td>3.9 ± 1.4</td>
<td>0.024</td>
</tr>
</tbody>
</table>

### Dietary food

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low: &lt;1 serves/ week</th>
<th>Medium: ≥1 serves/ week</th>
<th>High: ≥5 serves/ week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total yogurt</td>
<td>54.8 ± 35.0</td>
<td>10.2 ± 8.5</td>
<td></td>
</tr>
<tr>
<td>Total cheese</td>
<td>17.2 ± 67.1</td>
<td>15.7 ± 12.8</td>
<td></td>
</tr>
<tr>
<td>Total ice-cream &amp; cream</td>
<td>47.3 ± 45.8</td>
<td>6.9 ± 5.8</td>
<td></td>
</tr>
<tr>
<td>Total milk</td>
<td>45.6 ± 27.8</td>
<td>26.6 ± 20.6</td>
<td></td>
</tr>
<tr>
<td>Whole fat milk</td>
<td>97 ± 1.7</td>
<td>1.4 ± 0.6</td>
<td></td>
</tr>
<tr>
<td>Total milk, cheese, yogurt, dairy desserts, cream, ice-cream</td>
<td>24.2 ± 53.4</td>
<td>22.4 ± 25.8</td>
<td></td>
</tr>
</tbody>
</table>
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).

<table>
<thead>
<tr>
<th>Dairy food</th>
<th>Covariate set</th>
<th>Low &lt;1 serve/week</th>
<th>Medium ≥ 1-5 serves/week</th>
<th>High ≥ 5 serves/week</th>
<th>$p$ linear trend</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SE</td>
<td>M</td>
<td>SE</td>
<td>M</td>
</tr>
<tr>
<td>Total cheese</td>
<td>Basic</td>
<td>4.1</td>
<td>0.11</td>
<td>3.7*</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>4.1</td>
<td>0.11</td>
<td>3.8*</td>
<td>0.05</td>
</tr>
<tr>
<td>Total yogurt</td>
<td>Basic</td>
<td>3.7</td>
<td>0.06</td>
<td>4.0*</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>3.7</td>
<td>0.06</td>
<td>3.9</td>
<td>0.07</td>
</tr>
<tr>
<td>Total ice-cream &amp; cream</td>
<td>Basic</td>
<td>3.8</td>
<td>0.07</td>
<td>3.8</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>3.8</td>
<td>0.07</td>
<td>3.8</td>
<td>0.06</td>
</tr>
<tr>
<td>Total milk$^a$</td>
<td>Basic</td>
<td>3.7</td>
<td>0.07</td>
<td>4.0*</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>3.9</td>
<td>0.1</td>
<td>3.7</td>
<td>0.07</td>
</tr>
<tr>
<td>Fat-free/low fat milk</td>
<td>Basic</td>
<td>3.7</td>
<td>0.06</td>
<td>3.9</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>3.8</td>
<td>0.09</td>
<td>3.7</td>
<td>0.07</td>
</tr>
<tr>
<td>Whole fat milk$^c$</td>
<td>$n$ too small to perform</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 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...
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 dietary 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 calcitrrophic hormones, parathyroid hormone (PTh) and 1,25-dihydroxyvitamin D (1,25(OH)2D). Increasing dietary calcium can suppresses circulating PTh and 1,25(OH)2D, 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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References

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