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Dairy food intake, diet patterns, and health: Findings from the Maine-Syracuse Longitudinal Study

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A R T I C L E I N F O

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A B S T R A C T

This study compared the intake of yogurt and other dairy foods in relation to other dietary habits, and associations with cardiovascular health indicators. Comparative analyses of dietary intakes and cardiometabolic health indicators were conducted in participants from the Maine-Syracuse Longitudinal Study, conducted in 2001-2006 ($n = 699$). Participants (10.2% of sample) who consumed yogurt more frequently ($\geq$ 5 serves per week) also consumed more fruit, vegetables, nuts, and fish, but fewer sweets, sugar-sweetened soft drinks, and alcohol. The yogurt-healthy food score was significantly inversely associated with fasting plasma glucose ($p = 0.044$), waist circumference ($p = 0.004$), and smoking ($p = 0.004$), and significantly positively associated with physical activity ($p < 0.001$). In addition, the yogurt-healthy food score was associated with protection against MetS abdominal obesity (OR: 0.80, 95% CI: 0.66-0.07, $p = 0.02$). The yogurt-healthy dietary pattern was significantly associated with a better cardiometabolic profile.

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1. Introduction

There is now considerable evidence that dairy foods may be of benefit to many aspects of health, including lower prevalence and incidence of type 2 diabetes (T2DM) (Talaei, Pan, Yuan, & Koh, 2018; Tong, Dong, Wu, Li, & Qin, 2011), metabolic syndrome (MetS) (Azadbakht, Mirmiran, Esmaillzadeh, & Azizi, 2005a; Crichton, Bryan, Buckley, & Murphy, 2011), obesity (Crichton & Alkerwi, 2014; Parikh & Yanovski, 2003), hypertension (McGrane et al., 2011; Park & Cifelli, 2013), and inflammation (Panagiotakos, Pitsavos, Zampelas, Chrysohoou, & Stefanadis, 2010), as well as better cognitive functioning (Crichton, Elias, Dore, & Robbins, 2012; Park & Fulgoni, 2013). Three recent systematic reviews conclude that the consumption of some forms of dairy products show favorable or neutral (neither beneficial nor detrimental) associations with cardiovascular-related outcomes (Alexander et al., 2016; Drouin-Chartier et al., 2016a, b). The most recent scientific evidence supports the consumption of regular-fat milk, cheese, and yogurt within an overall healthy dietary pattern (Astrup et al., 2016), whilst highlighting the further systematic examination of the effects of dietary patterns that include regular-fat milk, cheese, and yogurt on human health.

Of the dairy foods, yogurt in particular has been of recent interest possibly because it is nutrient dense, providing protein and bioactive peptides, calcium, magnesium, potassium, phosphorus, vitamin D, and possibly added bacterial cultures (Cormier et al., 2016; Panahi & Tremblay, 2016; Panahi, Fernandez, Marette, & Tremblay, 2017b). Others have shown yogurt to be associated with healthy eating and other healthy lifestyle behaviors, lower anthropometric indicators, a healthier cardiometabolic risk profile, reduced risk of weight gain, obesity, T2DM, and cardiovascular disease (CVD) (Cormier et al., 2016; Panahi & Tremblay, 2016; Panahi et al., 2017a,b; Tian et al., 2017; Tremblay & Panahi, 2017; Wu & Sun, 2017). The research to date therefore suggests that yogurt consumption may be beneficial to cardiometabolic health, particularly when consumed as part of a high quality diet (Panahi et al., 2017b).

This benefit of yogurt consumption has recently been demonstrated in a study including over 55,000 women and 18,000 men from the Nurses' Health Study (NHS) and the Health Professionals Follow-Up Study (HPFS), respectively (Buendia et al., 2018). Men and women with prevalent high blood pressure (BP) who consumed at least two serves per week of yogurt were found to be

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at lower risk for developing CVD. These associations were stronger for participants with a higher yogurt intake in combination with an overall ‘heart-healthy’ dietary pattern, as measured by Dietary Approaches to Stop Hypertension (DASH) diet scores (Buendia et al., 2018). The DASH diet, which is characterized by a diet high in fruit, vegetables, and low-fat dairy products, has been previously associated with reductions in BP and the risk for coronary heart disease, stroke, and MetS (Azadbakht, Mirmiran, Esmaillzadeh, Azizi, & Azizi, 2005b; Fung et al., 2008).

As recognized in the literature (Panahi & Tremblay, 2016), we do not consume foods in isolation, and more attention needs to be paid to overall food patterns in relation to health outcomes (Panahi et al., 2017b). As there is considerable evidence for the association between yogurt and a wide-ranging number of health benefits, observational studies examining yogurt consumption in combination with other foods in relation to cardiometabolic health outcomes appears to be important (Elias, Wade, & Crichton, 2018). To expand what is known in this area, we have utilized data from a prominent health study: the Maine-Syracuse Longitudinal Study (MSLS). The MSLS has collected measures on dairy food intake, CVD risk factors, health behaviors, and demographic variables. Using MSLS data previously, we have found relationships between higher intakes of yogurt and cardiovascular health, as measured by a cardiovascular health score (Crichton & Elias, 2014). The aims of this study were to: (i) examine the relationship between dairy food intakes (yogurt in particular) and intakes of other foods; and (ii) explore relationships between the dietary patterns found with a number of cardiovascular health indicators. We hypothesize that those who consume higher amounts of dairy foods, and in particular yogurt, will also consume higher amounts of other healthy foods such as fruit, vegetables, grains, fish, and nuts and these individuals with healthier diets will exhibit a better cardiometabolic profile.

2. Methods and materials

2.1. Participants

The MSLS is a community-based study of aging, cardiovascular risk factors, and cognitive functioning in adults, aged 23-98 years residing in Central New York state, USA (Dore, Elias, Robbins, Budge, & Elias, 2008; Elias et al., 2006, 2009; Robbins, Elias, Elias, & Budge, 2005). At initial recruitment, the sole exclusions were institutionalized people, diagnosed alcoholism, and psychiatric disorder requiring institutionalization. Other exclusions have been employed on a study-by-study basis across the series of studies conducted with this sample of individuals.

The data for the present study were taken from subjects returning for the 6th (2001-2006) study wave when dietary intake measures were first obtained. Beginning with a sample of 776 individuals, participants were excluded from the present analysis for the following reasons: missing dietary or cardiovascular health data ($n = 34$), acute stroke ($n = 28$), probable dementia ($n = 8$), hemo-dialysis ($n = 5$), inability to read English ($n = 1$), and alcohol abuse after baseline ($n = 1$), leaving 699 participants within an age range of 23-70 years. All participants provided informed written consent. The MSLS was approved by the University of Maine Institutional Review Board (reference number: 2005-07-04).

2.2. Dietary assessment

Dietary intake was assessed using the Nutrition and Health Questionnaire (Kroke et al., 1999). Participants were required to report how frequently they consumed foods and beverages, from six response categories: never, seldom, once a week, 2 to 3 times a week, 5 to 6 times a week, or once or more a day. The dairy foods included in the questionnaire were milk, cheese, yogurt, dairy desserts, and ice-cream and cream (combined). Participants were asked to stipulate the fat content of milk consumed − whole fat, low fat (1-2% fat), skim (0% fat) − but the fat content of cheese and yogurt were not specified. The daily intakes represent an estimate of the number of times each food was consumed daily as exact portion sizes were not stipulated (except for milk). Total energy intake was estimated by calculating the sum of all individual foods, in times per day (Crichton et al., 2012).

2.3. Clinical assessment

Participants underwent physical and anthropometric measurements and blood tests. Body weight, height, body mass index (BMI), and BP measures were assessed as described previously (Dore et al., 2008; Elias et al., 2006; Robbins et al., 2005). Standard assay methods were employed (Elias et al., 2006) to obtain fasting plasma glucose (mg dL^{-1}) and total cholesterol (mg dL^{-1}). In addition, participants completed self-administered questionnaires to gain information on lifestyle, demographic, and socioeconomic characteristics. Standardized laboratory protocols for data collection (i.e., anthropometric testing, venepuncture, reporting of risk factors) were used.

Physical activity was measured with the validated Nurses' Health Study Activity Questionnaire (Wolfe et al., 1994). Dietary intake was assessed using the Food Frequency Questionnaire (FFQ) component of the Nutrition and Health Questionnaire (Kroke et al., 1999). Smoking status was based on self-report from the same questionnaire (Kroke et al., 1999). At the conclusion of each wave, participants were informed of any new risk factors detected at that examination and advised to consult their physician for treatment.

2.4. Statistical analyses

According to the type of variable (continuous or categorical), the Mann-Whitney test or Chi-square tests were used to compare demographic variables and other health variables. Analysis of variance (ANOVA) were used to examine associations between intakes of dairy foods (low fat and whole fat milk, cheese, and yogurt) with the other main food groups and beverages: grains, fruit, meat, fish, vegetables, nuts, sweets, sugar-sweetened and diet soft drinks, and alcohol. For a basic demographic covariate model, statistical adjustment was made for age, gender, education, ethnicity, and total energy intake. Effect sizes (Cohen's d) (Cohen, 1988) were calculated for significant associations.

Individual dairy foods were categorized into 3 groups: low (< 1 serve per week), medium (≥ 1 to 5 serves per week), and high (≥ 5 serves per week). Further, participants were categorized into one of three groups according to their total dairy food intake: low (< 1 serve per day), medium (≥ 1 to 3 serves per day), and high (≥ 3 serves per day). These categories were selected to provide meaningful information about how much of these dairy foods are possibly required for cardiometabolic benefits. In additions, serves per day were used as this measurement method aligns with most national dietary guidelines. Comparisons of three groups allows for a determination of trends or non-linear associations.

A score was calculated based on total intakes of yogurt, fruit, vegetables, and fish. A score of 1 was assigned to those who consumed higher amounts of these foods (≥ 5 serves per week of yogurt, ≥ 2 serves per day of fruit, ≥ 5 serves per day of vegetables, ≥ 3 serves per week of fish), and a score of 0 for those who consumed less than these amounts. These cut-offs are based on recommended intakes for these foods (USDA/USDHHS, 2010). The total was summed to give a ‘yogurt-healthy food’ score out of 4.

Analysis of covariance (ANCOVA) were also used to examine associations between the yogurt-healthy food score with a number of cardiovascular health outcomes: fasting plasma glucose, BMI, waist circumference, systolic and diastolic BP, HDL- and LDL-cholesterol, triglycerides, physical activity, and smoking. For a basic demographic covariate model, statistical adjustment was made for age, gender, education, ethnicity, and total energy intake. Effect sizes (Cohen's d) were calculated for significant associations (Cohen, 1988). Linear and quadratic trends were tested. While the yogurt-healthy food score offers a four-point scale (one for each healthy food added to yogurt), the ANCOVA performed used only three levels of response, since only eight individuals attained a score of 3 and no individual attained a score of 4. Therefore, the range of responses was 0-2 for our study.

Using the same set of covariates described above, we also compared the yogurt-healthy food score according to the presence or absence of T2DM, CVD, hypertension, and MetS abdominal obesity using logistic regression analyses. SPSS version 21 was used for all analyses. p-Values of < 0.05 (two-tailed test) were considered statistically significant.

3. Results

Table 1 displays the demographic, cardiovascular health, and other health variables, according to yogurt intake. Significantly more females than males consumed at least 1 serve of yogurt per week. Those participants who did consume at least 1 weekly serve had significantly lower BMI, waist and hip circumference, systolic and diastolic BP, fasting plasma glucose, plasma homocysteine, and triglyceride levels, and higher HDL-cholesterol compared to those who consumed less than 1 serve per week. The higher yogurt consumers also undertook significantly more physical activity and had a lower prevalence of T2DM and hypertension than the less frequent consumers.

Table 2 shows the self-reported intakes of dairy foods (milk, yogurt, cheese, and total intakes). Inspection of individual dairy products showed that participants consumed milk frequently, with 40.2% drinking milk at least five times per week. Participants were more likely to consume low fat milk frequently compared with whole milk. Cheese consumption was higher than yogurt consumption (65% ≥ 1-5 serves per week versus 54.6% < 1 serves per week).

Yogurt and dairy dessert intake were positively associated with intakes of fruit, fish, vegetables, and nuts, and inversely associated

Table 2
Self-reported intakes of dairy foods, expressed as percentage of the sample consuming low, medium, and high quantities.[a]

Dairy food	Low	Medium	High
Total milk	17.2	42.5	40.2
Low fat	25.0	38.1	36.9
Whole fat	92.3	7.7	n too small
Total yogurt	54.6	35.2	10.2
Total cheese	17.2	65.5	17.3
Total milk, cheese, yogurt	27.5	52.8	19.7
Total dairy food	20.9	55.5	23.6

[a] Low, medium, and high defined as < 1 serve, ≥ 1-5 serves, and ≥ 5 serves per week, respectively, for individual dairy foods and < 1 serve, ≥ 1-3 serves, and ≥ 3 serves per day, respectively, for combined total of milk, cheese, and yogurt, and total dairy food (milk, cheese, yogurt, cream, ice-cream). Low fat milk includes skim, 1%, and 2% fat milk.

Table 1
The association between yogurt intake and demographic, cardiovascular health, and other health variables in the Maine-Syracuse Longitudinal Study ($n = 701$).[a]

Variable	Yogurt intake (serves per week)				p
	< 1 ($n = 379$)		≥1 ($n = 322$)		
	M	SD	M	SD	
Age (years)	58.42	0.50	56.17	0.57	0.004
Education (years)	14.49	0.14	15.13	0.15	0.001
Smoking (cigarettes per day)	1.48	0.29	1.23	0.29	0.629
BMI (kg/m^2)	30.14	5.74	29.17	5.73	0.026
Physical activity (MET hours/week)	18.78	1.21	24.37	1.71	0.001
Total cholesterol (mg/dL)	200.26	38.86	204.20	38.15	0.177
Systolic BP (mmHg)	130.15	21.87	123.73	18.33	<0.001
Diastolic BP (mmHg)	71.58	9.91	68.75	9.22	<0.001
Fasting plasma glucose (mg/dL)	101.85	1.76	93.42	0.98	<0.001
Waist circumference (cm)	98.12	0.79	92.15	0.77	<0.001
Hip circumference (cm)	110.06	12.65	108.06	11.05	0.028
HDL cholesterol (mg/dL)	52.16	0.79	55.37	0.84	0.001
LDL cholesterol (mg/dL)	120.81	33.95	124.59	33.26	0.139
Triglycerides (mg/dL)	138.21	3.66	122.69	3.68	0.001
Plasma homocysteine (umol/L)	9.84	0.16	9.08	0.16	<0.001
Total energy intake	13.83	0.23	15.21	0.25	<0.001
Alcohol intake (standard drinks per day)	0.54	0.05	0.43	0.05	0.361
Race					
Caucasian (%)	92.08		90.68		0.509
Other (%)	7.92		9.32		
Gender					
Males (%)	49.08		30.44		<0.001
Females (%)	50.92		69.56		
Obese (%)	45.12		39.13		0.110
T2DM (%)	14.51		8.70		0.018
Hypertension (%)	63.85		46.27		<0.001
CVD (%)	13.46		9.94		0.151

[a] Yogurt intake was calculated from the Nutrition and Health Questionnaire. Except for percentages, data are expressed as mean and standard deviation (SD). Physical activity is expressed as metabolic equivalent hours per week; total energy intake was measured in total serves per day all food groups. Obese defined as BMI 30 kg/m^2; T2DM, type 2 diabetes, i.e., fasting plasma glucose 126 mg/dL or taking anti-diabetic medication; hypertension defined as systolic BP 140 mmHg and/or diastolic BP 90 mmHg or taking anti-hypertensive medication; CVD includes myocardial infarction, coronary artery disease, heart failure, angina pectoris, and transient ischemic attack.

with intakes of grains, sweets, and sugar-sweetened soft drinks $p < 0.07$. (Table 3; small ($d = 0.32$-0.47) to medium ($d = 0.51$-0.63) effect sizes). Low fat milk consumption was associated with a lower intake of sugar-sweetened soft drinks, sweets, meat, and alcohol (Table 4; small ($d = 0.20$-0.38) to medium ($d = 0.57$) effect sizes). Those who consumed whole fat milk had significantly lower intakes of fruit, fish, and vegetables, but consumed more sweets and sugar-sweetened soft drinks (Table 5; small ($d = 0.34$-0.45) to medium ($d = 0.65$) effect sizes). Cheese consumption was positively associated with meat consumption and diet soft drinks and inversely associated with intakes of $p < 0.08$ and 0.09. sugar-sweetened soft drinks (Table 6; small ($d = 0.26$-0.38) to medium ($d = 0.52$) effect sizes).

All analyses for the yogurt healthy food score were done with linear and quadratic trend analysis if the overall omnibus test (test of differences among means) was statistically significant. While the yogurt-health score itself can range from 0 to 4, only eight individuals attained a score of 3 and none attained a score of 4. Therefore, Table 7 summarizes these data for three levels of response: 0, 1, and 2.

Table 3
The association between yogurt and dairy dessert intake and other dietary habits.[a]

Dietary variable (serves per day unless indicated otherwise)	Yogurt and dairy dessert intake (serves per week)						p	Effect size (Cohen's d)
	< 1 ($n = 382$)		≥1-5 ($n = 246$)		≥ 5 ($n = 71$)			
	M	SE	M	SE	M	SE		
Total grains	3.8	0.08	3.5[a]	0.09	3.1[ab]	0.17	<0.001	0.47
Total fruit	1.4	0.04	1.5	0.05	1.7[a]	0.10	0.01	0.37
Total meat	2.1	0.04	2.0	0.05	2.1	0.10	0.2	
Total fish (serves per week)	1.3	0.05	1.3	0.06	1.6[ab]	0.11	0.02	0.32
Total vegetables	2.5	0.05	2.7[a]	0.07	3.0[ab]	0.12	<0.001	0.51
Total nuts (serves per week)	1.2	0.08	1.3	0.10	1.8[ab]	0.18	0.03	0.39
Total sweets	2.8	0.09	2.6	0.11	1.7[ab]	0.21	<0.001	0.63
Regular soft drinks	0.56	0.06	0.41	0.07	0.13[a]	0.14	0.01	0.37
Diet soft drinks	0.62	0.06	0.53	0.07	0.43	0.14	0.4	
Total alcohol (mL per day)	6.0	0.55	5.4	0.68	2.7[a]	1.28	0.07	

[a] Data expressed as adjusted means (M) and standard error (SE); means adjusted for age, education, gender, ethnicity, and total energy intake. Superscripts a and b indicate significantly different from < 1 serve per week intake group and ≥ 1-5 serves per week intake group, respectively.

Table 4
The association between low fat milk intake and other dietary habits.[a]

Dietary variable (serves per day unless indicated otherwise)	Low fat milk intake (serves per week)						p	Effect size (Cohen's d)
	< 1 ($n = 173$)		≥1-5 ($n = 263$)		≥ 5 ($n = 255$)			
	M	SE	M	SE	M	SE		
Total grains	3.5	0.11	3.9[a]	0.09	3.5[b]	0.09	0.005	0.28
Total fruit	1.4	0.06	1.4	0.05	1.5	0.05	0.7	
Total meat	2.2	0.06	2.1	0.05	1.9[ab]	0.05	<0.001	0.38
Total fish (serves per week)	1.3	0.07	1.3	0.06	1.3	0.06	0.6	
Total vegetables	2.5	0.08	2.7[a]	0.06	2.6	0.07	0.1	
Total nuts (serves per week)	1.4	0.12	1.3	0.09	1.2	0.10	0.6	
Total sweets	3.0	0.13	3.0	0.11	2.0[ab]	0.11	<0.001	0.57
Regular soft drinks	0.63	0.09	0.56	0.07	0.27[ab]	0.07	0.002	0.31
Diet soft drinks	0.59	0.09	0.57	0.07	0.55	0.07	0.9	
Total alcohol (mL per day)	5.8	0.80	6.8	0.66	4.0[b]	0.67	0.01	0.26

[a] Data expressed as adjusted means (M) and standard error (SE); means adjusted for age, education, gender, ethnicity, and total energy intake. Superscripts a and b indicate significantly different from < 1 serve per week intake group and ≥ 1-5 serves per week intake group, respectively.

Table 5
The association between whole fat milk intake and other dietary habits.[a]

Dietary variable (serves per day unless indicated otherwise)	Whole fat milk intake (serves per week)				p	Effect size (Cohen's d)
	< 1 ($n = 645$)		≥ 1 ($n = 54$)			
	M	SE	M	SE		
Total grains	3.6	0.06	3.6	0.20	0.9	
Total fruit	1.5	0.03	1.2[a]	0.12	0.02	0.36
Total meat	2.1	0.03	2.2	0.11	0.2	
Total fish (serves per week)	1.3	0.04	0.98[a]	0.12	0.006	0.34
Total vegetables	2.7	0.04	2.3[a]	0.14	0.03	0.39
Total nuts (serves per week)	1.3	0.06	1.1	0.21	0.3	
Total sweets	2.6	0.07	3.4[a]	0.24	0.001	0.45
Regular soft drinks	0.41	0.04	1.1[a]	0.15	<0.001	0.65
Diet soft drinks	0.59	0.04	0.35	0.17	0.2	
Total alcohol (mL per day)	5.6	0.41	3.9	1.5	0.3	

[a] Data expressed as adjusted means (M) and standard error (SE); means adjusted for age, education, gender, ethnicity, and total energy intake. Superscript a indicates significantly different from < 1 serve per week intake group.

Table 6
The association between cheese intake and other dietary habits.[a]

Dietary variable (serves per day unless indicated otherwise)	Cheese intake (serves per week)						p	Effect size (Cohen's d)
	< 1 (n = 120)		≥ 1-5 (n = 458)		≥ 5 (n = 121)			
	M	SE	M	SE	M	SE		
Total grains	3.9	0.13	3.6	0.07	3.4[a]	0.13	0.08	
Total fruit	1.5	0.08	1.5	0.04	1.3[b]	0.08	0.09	
Total meat	2.0	0.07	2.0	0.04	2.4[ab]	0.07	<0.001	0.52
Total fish (serves per week)	1.4	0.08	1.3	0.04	1.2	0.08	0.3	
Total vegetables	2.6	0.10	2.7	0.05	2.6	0.10	0.6	
Total nuts (serves per week)	1.4	0.14	1.2	0.07	1.6[b]	0.14	0.03	0.26
Total sweets	2.8	0.16	2.7	0.08	2.4	0.16	0.1	
Regular soft drinks	0.73	0.11	0.46[a]	0.05	0.27[a]	0.11	0.01	0.38
Diet soft drinks	0.26	0.11	0.62[a]	0.05	0.69[a]	0.10	0.04	0.37
Total alcohol (mL per day)	5.0	0.98	5.3	0.49	6.4	0.99	0.6	

[a] Data expressed as adjusted means (M) and standard error (SE); means adjusted for age, education, gender, ethnicity, and total energy intake. Superscripts a and b indicate significantly different from < 1 serve per week intake group and ≥ 1–5 serves per week intake group, respectively.

Table 7
The association between the yogurt-healthy food score and cardiometabolic health indicators.[a]

Cardiometabolic health indicator	Yogurt-healthy food score						p	Effect size (Cohen's d)
	0 (n = 259)		1 (n = 280)		2 (n = 50)			
	M	SE	M	SE	M	SE		
Fasting plasma glucose (mg/dL)	102.61	1.97	95.85[a]	1.82	93.93	4.23	0.044	0.43
Waist circumference (cm)	97.94	0.95	93.55[a]	0.88	92.43[a]	2.05	0.004	0.40
Physical activity (hours per week)	17.41	1.87	22.01	1.72	37.81[ab]	4.02	<0.001[c]	0.64
Systolic BP (mmHg)	131.50	1.37	130.05	1.26	127.60	2.94	0.49	
Diastolic BP (mmHg)	71.02	0.70	70.85	0.64	71.04	1.48	0.98	
BMI (kg/m^2)	30.00	0.39	29.13	0.36	28.19	0.84	0.12	
Triglycerides (mg/dL)	152.16	7.73	142.33	7.08	110.60[a]	16.52	0.09	
HDL-cholesterol (mg/dL)	51.49	1.00	54.16	0.92	55.13	2.14	0.13	
LDL-cholesterol (mg/dL)	121.07	2.33	123.04	2.10	120.61	4.89	0.78	
Smoking (cigarettes per day)	2.48	0.39	0.77[a]	0.36	−0.01[a]	0.84	0.004	0.44

[a] Data expressed as adjusted means (M) and standard error (SE); means adjusted for age, education, gender, ethnicity, and total energy intake. Superscripts a and b indicate significantly different from 0 yogurt-healthy food score group and 1 yogurt-healthy food score group, respectively; superscript c denotes significant linear and quadratic trends.

Table 7 shows the yogurt-healthy food score was significantly, positively associated with physical activity (hours per week) and HDL-cholesterol and inversely associated with fasting plasma glucose, smoking (cigarettes per day), BMI, triglycerides, and waist circumference (zero order correlations, all $p < 0.05$). With the addition of age, education, gender, ethnicity, and total energy intake to the regression model as covariates, the yogurt-healthy food score remained inversely associated with fasting plasma glucose, waist circumference, and smoking, and positively associated with physical activity.

Linear trends only ($p = 0.40$-0.44) were observed for fasting plasma glucose, waist circumference, and smoking. However, when the linear trend is controlled for, a statistically significant quadratic trend ($p < 0.001$) was observed for physical activity. These trends can be seen by inspection of the means in Table 7. Fig. 1, a box and whisker plot, helps to illustrate the second order trend for physical activity in relation to an increase in the yogurt-healthy food score. As may be seen by inspecting the means in Table 7 and Fig. 1, the major increase in physical activity occurs at 2, the highest yogurt-healthy food score, with a small increase but very little difference between yogurt-healthy food scores of 0 and 1.

Logistic regression analyses using the same covariate set were conducted for variables with a binary outcome. The yogurt-healthy food score was not associated with an increased risk for T2DM, CVD, or hypertension (all $p > 0.05$), but was associated with protection against of MetS abdominal obesity (OR: 0.80, 95% CI: 0.66-0.07, $p = 0.02$), adjusted for the demographic covariates and total energy intake.

4. Discussion

We observed associations between the intake of dairy products, especially yogurt and other foods, notably, increased intakes of

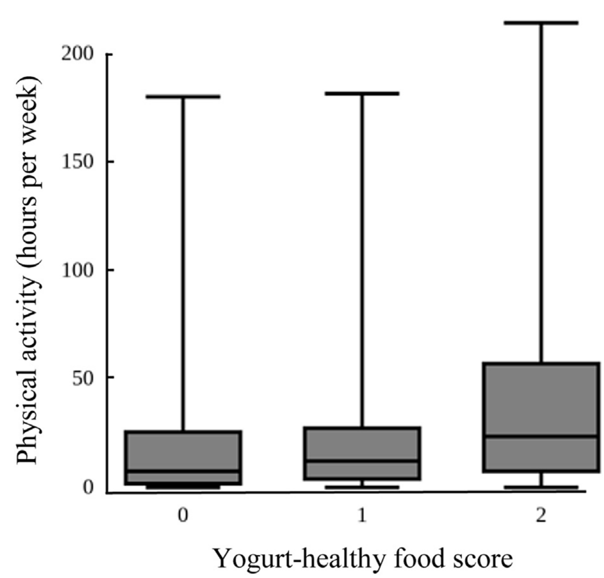

Fig. 1. The quadratic trend observed for the association between yogurt-healthy food score and physical activity; as the yogurt-healthy food score increases, there is a modest increase in physical activity that peaks then slopes downward.

fruit, fish, vegetables, and nuts and lower intakes of grains, sweets, sugar-sweetened soft drinks, and alcohol. Of additional interest, low fat milk intake was associated with other healthier choices (less meat, sweets, sugar-sweetened soft drinks, and alcohol), whilst consumers of whole fat milk displayed less healthy choices, with lower intakes of fruit, fish, and vegetables and higher intakes of sweets and sugar-sweetened soft drinks.

There is a growing evidence base for the health effects of yogurt with studies examining yogurt consumption in relation to a wide-ranging number of health outcomes including cardiovascular and metabolic health, diabetes, cancer, weight management, and gastrointestinal health (Glanville, Brown, Shamir, Szajewska, & Eales, 2015). Using MSLS data previously, we have found relationships between higher intakes of yogurt and cardiovascular health, as measured by a cardiovascular health score (CHS) (Crichton & Elias, 2014). In this study, total yogurt consumption was positively associated with the CHS, three health behaviors (smoking, physical activity, diet), and two health factors (waist circumference, fasting plasma glucose). Those who consumed yogurt at least weekly had a significantly higher CHS than those who never or rarely consumed yogurt. Total intake of dairy (milk, cheese, and yogurt) was also positively associated with the CHS (Crichton & Elias, 2014). Examining the individual components of the CHS (see Tables 3–6), those with higher intakes of yogurt consumed more 'recommended foods' and fewer 'non-recommended foods' (based on the American Dietary Guidelines; USDA/USDHHS, 2010). The also engaged in had higher levels of physical activity, smoked less, had smaller waist circumferences, and had lower fasting plasma glucose levels (see Table 7).

The finding that yogurt consumers also appear to select other foods that are more in line with nutritional recommendations (fruits, vegetables, fish, nuts, whole grains, and dairy) is consistent with other research (Panahi et al., 2017b). Using data drawn from the Canadian-based INFOGENE study, Cormier et al. (2016) found that yogurt was a statistically significant part of a 'prudent' dietary pattern, characterized by higher intakes of fruit, vegetables, nuts, non-hydrogenated fats, legumes, and fish. Non-consumers of yogurt had a negative mean prudent dietary pattern score, reflecting differences in the ways these two groups eat. Obese or overweight yogurt consumers had a better cardiometabolic profile as indexed by lower triglycerides, insulin levels, and waist circumference than non-consumers (Cormier et al., 2016). These findings also extend to better metabolic health due to the effects of yogurt on the regulation of body weight, energy homeostasis, and glycemic control (Panahi & Tremblay, 2016; Panahi et al., 2017a). Further, yogurt consumers have been shown to be more physically active, smoke less, have higher education, and had more knowledge of nutrition compared with non-consumers (Panahi et al., 2017b).

In the present study, the healthier dietary pattern (higher yogurt, fruit, vegetables, nuts, and fish) was associated with a better cardiometabolic profile (higher HDL-cholesterol and lower fasting plasma glucose, BMI, triglycerides, and waist circumference) and healthier lifestyle habits (higher levels of physical activity and less smoking). After adjustment for age, education, gender, ethnicity, and total energy intake, the yogurt-healthy food score remained inversely associated with fasting plasma glucose, waist circumference, and smoking, and positively associated with physical activity.

The effect sizes reported in the present paper for the various analyses generally ranged from small to medium. These effect sizes are consistent with the existing literature indicating positive associations between yogurt, dairy foods, and cardiometabolic health (Cormier et al., 2016; Crichton & Elias, 2014; Panahi & Tremblay, 2016; Panahi et al., 2017a). It is important to note that small effect sizes, while indicating less impact on the individual or in a clinical setting, are not to be dismissed as irrelevant or unimportant. Improvement in risk in the population as a whole from increased yogurt consumption, and consumption in dairy food alone, can have a major impact on the health of the population.

Cormier et al. (2016) showed that overweight or obese individuals who were consumers of yogurts exhibited a more favorable cardiometabolic profile including lower plasma triglyceride and insulin levels and reduced waist circumference than non-consumers within the same range of BMI. In a similar vein, the beneficial effects of a high yogurt consumption, in combination with higher DASH diet scores (high in fruit, vegetables, and low fat dairy) on risk of CVD was recently observed in participants with hypertension in a US-based study (Buendia et al., 2018). Obesity and hypertension are prevalent in the sample (42% and 55%, respectively). This collection of research together implies that perhaps the benefits of yogurt are more pronounced in those with a poorer cardiometabolic health profile, such as being overweight or having an elevated BP. It may be hypothesized that relations between dietary patterns and cardiometabolic health are less likely to be observed if there is little variation in the levels of cardiometabolic health indicators and conditions.

Panahi and Tremblay (2016, 2017) summarized the epidemiological and clinical evidence supporting the positive role of yogurt on health behaviors and metabolic health variables, and the potential mechanisms of action by which yogurt may facilitate body fat loss, decrease food intake, increase satiety, and decrease the glycemic and insulin response. Protein and calcium are key nutrients in yogurt that may be attributable to the health benefits of yogurt via their respective roles in increasing satiety and controlling body weight (Cormier et al., 2016; Panahi & Tremblay, 2016). Of particular relevance is the suggestion that the association between saturated fatty acids and cardiometabolic health variables may in fact be nullified or attenuated when they are consumed as part of complex food matrices such as in milk, cheese, and yogurt (Astrup, 2014; Drouin-Chartier et al., 2016b). This may be further enhanced when individuals consume dairy products in conjunction with other healthy foods such as fruit and vegetables.

Dairy has been pivotal to nutrition and important to the survival of many populations in the world for a very long time (Craig et al., 2005). The assessment of nutritional patterns revealed that yogurt consumption appears to be associated with other healthier dietary habits, such as greater intakes of fruit, vegetables, fish, and nuts, adding to the current literature. This pattern of healthy eating was associated with a better cardiometabolic profile. Randomized controlled trials addressing key research gaps in this area are needed to further explore and confirm relations between healthy dietary patterns, including yogurt and other dairy foods, and cardiometabolic health.

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References

Alexander, D. D., Bylsma, L. C., Vargas, A. J., Cohen, S. S., Doucette, A., Mohamed, M., et al. (2016). Dairy consumption and CVD: A systematic review and meta-analysis. *British Journal of Nutrition, 115*, 737–750.

Astrup, A. (2014). Yogurt and dairy product consumption to prevent cardiometabolic diseases: Epidemiologic and experimental studies. *American Journal of Clinical Nutrition, 99*, 1235S–1242S.

Astrup, A., Rice Bradley, B. H., Brenna, J. T., Delplanque, B., Ferry, M., & Torres-Gonzalez, M. (2016). Regular-fat dairy and human health: A synopsis of symposia presented in Europe and North America (2014–2015). *Nutrients, 8*. Article 463.

Azadbakht, L., Mirmiran, P., Esmaillzadeh, A., & Azizi, F. (2005a). Dairy consumption is inversely associated with the prevalence of the metabolic syndrome in Tehranian adults. *American Journal of Clinical Nutrition, 82*, 523–530.

Azadbakht, L., Mirmiran, P., Esmaillzadeh, A., Azizi, T., & Azizi, F. (2005b). Beneficial effects of a Dietary Approaches to Stop Hypertension eating plan on features of the metabolic syndrome. *Diabetes Care, 28*, 2823–2831.

Buendia, J. R., Li, Y., Hu, F. B., Cabral, H. J., Bradlee, M. L., Quatromoni, P. A., et al. (2018). Regular yogurt intake and risk of cardiovascular disease among hypertensive adults. *American Journal of Hypertension, 31*, 557–565.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ, USA: L. Erlbaum Associates.

Cormier, H., Thifault, E., Garneau, V., Tremblay, A., Drapeau, V., Perusse, L., et al. (2016). Association between yogurt consumption, dietary patterns, and cardio-metabolic risk factors. *European Journal of Nutrition, 55*, 577–587.

Craig, O. E., Chapman, J., Heron, C., Willis, L. H., Bartosiewicz, L., Taylor, G., et al. (2005). Did the first farmers of central and eastern Europe produce dairy foods? *Antiquity, 79*, 882–894.

Crichton, G. E., & Alkerwi, A. (2014). Whole-fat dairy food intake is inversely associated with obesity prevalence: Findings from the observation of cardiovascular risk factors in Luxembourg study. *Nutrition Research, 34*, 936–943.

Crichton, G. E., Bryan, J., Buckley, J., & Murphy, K. J. (2011). Dairy consumption and metabolic syndrome: A systematic review of findings and methodological issues. *Obesity Reviews, 12*, e190–e201.

Crichton, G., & Elias, M. F. (2014). Dairy food intake and cardiovascular health: The Maine-syracuse study. *Maine-Syracuse Longitudinal Papers, 33*.

Crichton, G. E., Elias, M. F., Dore, G. A., & Robbins, M. A. (2012). Relation between dairy food intake and cognitive function: The Maine-Syracuse Longitudinal Study. *International Dairy Journal, 22*, 15–23.

Dore, G. A., Elias, M. F., Robbins, M. A., Budge, M. M., & Elias, P. K. (2008). Relation between central adiposity and cognitive function in the Maine-syracuse study: Attenuation by physical activity. *Annals of Behavioral Medicine, 35*, 341–350.

Drouin-Chartier, J. P., Brassard, D., Tessier-Grenier, M., Cote, J. A., Labonte, M. E., Desroches, S., et al. (2016a). Systematic review of the association between dairy product consumption and risk of cardiovascular-related clinical outcomes. *Advances in Nutrition, 7*, 1026–1040.

Drouin-Chartier, J. P., Cote, J. A., Labonte, M. E., Brassard, D., Tessier-Grenier, M., Desroches, S., et al. (2016b). Comprehensive review of the impact of dairy foods and dairy fat on cardiometabolic risk. *Advances in Nutrition, 7*, 1041–1051.

Elias, M. F., Robbins, M. A., Budge, M. M., Abhayaratna, W. P., Dore, G. A., & Elias, P. K. (2009). Arterial pulse wave velocity and cognition with advancing age. *Hypertension, 53*, 668–673.

Elias, M. F., Robbins, M. A., Budge, M. M., Elias, P. K., Brennan, S. L., Johnston, C., et al. (2006). Homocysteine, folate, and vitamins B6 and B12 blood levels in relation to cognitive performance: The Maine-syracuse study. *Psychosomatic Medicine, 68*, 547–554.

Elias, M. F., Wade, A. T., & Crichton, G. E. (2018). Yogurt intake and risk of cardiovascular disease among hypertensive individuals: Is it time for a clinical trial? *American Journal of Hypertension, 31*, e5–e6.

Fung, T. T., Chiuve, S. E., McCullough, M. L., Rexrode, K. M., Logroscino, G., & Hu, F. B. (2008). Adherence to a DASH-style diet and risk of coronary heart disease and stroke in women. *Archives of Internal Medicine, 168*, 713–720.

Glanville, J. M., Brown, S., Shamir, R., Szajewska, H., & Eales, J. F. (2015). The scale of the evidence base on the health effects of conventional yogurt consumption: Findings of a scoping review. *Frontiers in Pharmacology, 6*. Article 246.

Kroke, A., Klipstein-Grobusch, K., Voss, S., Moseneder, J., Thielecke, F., Noack, R., et al. (1999). Validation of a self-administered food-frequency questionnaire administered in the European prospective investigation into cancer and nutrition (EPIC) study: Comparison of energy, protein, and macronutuient intakes estimated with the doubly labeled water, urinary nitrogen, and repeated 24-h dietary recall methods. *American Journal of Clinical Nutrition, 70*, 439–447.

McGrane, M. M., Essery, E., Obbagy, J., Lyon, J., Macneil, P., Spahn, J., et al. (2011). Dairy consumption, blood pressure, and risk of hypertension: An evidence-based review of recent literature. *Current Cardiovascular Risk Reports, 5*, 287–298.

Panagiotakos, D. B., Pitsavos, C. H., Zampelas, A. D., Chrysohoou, C. A., & Stefanadis, C. I. (2010). Dairy products consumption is associated with decreased levels of inflammatory markers related to cardiovascular disease in apparently healthy adults: The ATTICA study. *Journal of the American College of Nutrition, 29*, 357–364.

Panahi, S., Doyon, C. Y., Despres, J. P., Perusse, L., Vohl, M. C., Drapeau, V., et al. (2017a). Yogurt consumption, body composition, and metabolic health in the Quebec Family Study. *European Journal of Nutrition, 57*, 1591–1603.

Panahi, S., Fernandez, M. A., Marette, A., & Tremblay, A. (2017b). Yogurt, diet quality and lifestyle factors. *European Journal of Clinical Nutrition, 71*, 573–579.

Panahi, S., & Tremblay, A. (2016). The potential role of yogurt in weight management and prevention of type 2 diabetes. *Journal of the American College of Nutrition, 35*, 717–731.

Parikh, S. J., & Yanovski, J. A. (2003). Calcium intake and adiposity. *American Journal of Clinical Nutrition, 77*, 281–287.

Park, K. M., & Cifelli, C. J. (2013). Dairy and blood pressure: A fresh look at the evidence. *Nutrition Reviews, 71*, 149–157.

Park, K. M., & Fulgoni, V. L. (2013). The association between dairy product consumption and cognitive function in the National Health and Nutrition Examination Survey. *British Journal of Nutrition, 109*, 1135–1142.

Robbins, M. A., Elias, M. F., Elias, P. K., & Budge, M. M. (2005). Blood pressure and cognitive function in an African-American and a Caucasian-American sample: The Maine-syracuse study. *Psychosomatic Medicine, 67*, 707–714.

Talaei, M., Pan, A., Yuan, J. M., & Koh, W. P. (2018). Dairy intake and risk of type 2 diabetes. *Clinical Nutrition, 37*, 712–718.

Tian, S., Xu, Q., Jiang, R., Han, T., Sun, C., & Na, L. (2017). Dietary protein consumption and the risk of type 2 diabetes: A systematic review and meta-analysis of cohort studies. *Nutrients, 9*. Article 982.

Tong, X., Dong, J. Y., Wu, Z. W., Li, W., & Qin, L. Q. (2011). Dairy consumption and risk of type 2 diabetes mellitus: A meta-analysis of cohort studies. *European Journal of Clinical Nutrition, 65*, 1027–1031.

Tremblay, A., & Panahi, S. (2017). Yogurt consumption as a signature of a healthy diet and lifestyle. *Journal of Nutrition, 147*, 1476S–1480S.

USDA/USDHHS. (2010). *US department of agriculture and US department of health and human services: Dietary guidelines for Americans 2010* (7th ed.). Washington, DC, USA: US Government Printing Office.

Wolf, A. M., Hunter, D. J., Colditz, G. A., Manson, J. E., Stampfer, M. J., Corsano, K. A., et al. (1994). Reproducibility and validity of a self-administered physical-activity quesionnaire. *International Journal of Epidemiology, 23*, 991–999.

Wu, L., & Sun, D. (2017). Consumption of yogurt and the incident risk of cardiovascular disease: A meta-analysis of nine cohort studies. *Nutrients, 9*. Article 315.