Original Article

Dairy intake and cognitive health in middle-aged South Australians

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Background: Consumption of low fat dairy foods may decrease the risk of obesity, type 2 diabetes, hypertension, and all cardiovascular risk factors linked with increased probability of cognitive impairment. Aim: To examine associations between dairy intake and self-reported cognitive function and psychological well-being, and to test the novel hypothesis that dairy consumption may benefit cognitive health via its positive effects on cardiometabolic health. Methods: Retrospective cross-sectional analyses were undertaken on data from food frequency questionnaires and self-reported health of 432 men and 751 women, aged 39 to 65 years. Health measures included cardiometabolic health indicators, cognitive and memory functioning, mental health, anxiety, stress, depression and self-esteem; assessed by standardised questionnaires. Results: Regression analyses, adjusted for total energy intake and other health confounders, showed that consumption of low fat yogurt was associated with increased quality of memory recall (p=0.029) and greater social functioning (p=0.045) in men. Consumption of low fat cheese was associated with greater social functioning (p=0.021) and decreased stress (p=0.042) in women. Intakes of whole fat dairy products, including ice-cream and cream, were associated with increased depression, anxiety, stress, cognitive failures, poorer memory functioning and general health (all p<0.05). There was no association between cardiometabolic health indicators and dairy consumption. Conclusions: Low fat dairy may have beneficial effects on social functioning, stress and memory, while whole fat dairy may be associated with poorer psychological well-being. Dietary intervention trials are needed to establish whether there is a direct effect of dairy consumption on cognitive and psychological health.

Key Words: dairy products, milk, cognition, mental health, metabolic syndrome

INTRODUCTION

There is a growing amount of literature describing associations between dairy intake and cardiometabolic health. Observational, epidemiological and intervention trials indicate that dairy consumption may have positive effects on body weight,[1,2] blood pressure (BP),[3-5] type 2 diabetes,[6,7] and the metabolic syndrome (MetS).[3,8-12] These same disorders that are risk factors for cardiovascular disease (CVD) are suggested to also increase the likelihood of reduced cognitive function in later life.[13-19]

If dairy consumption can improve cardiometabolic health, a beneficial consequence of this may be the reduction in risk for cognitive decline. In Australia, as in other parts of the world, the health and economic burden of significant cognitive impairment is enormous. In addition to the personal losses experienced by dementia sufferers and their families, the financial costs to society are substantial, with neurodegenerative disorders costing Australia an estimated 1.4 billion dollars in 2003.[20] An ageing population in combination with a growing incidence of dementia,[21] will increase the financial strain on the health care system. Nutrition is one easily modifiable lifestyle factor than can play a significant role in optimising cognitive performance in later life. Dietary factors such as the B-vitamins, antioxidants, MUFAs, omega-3 and omega-6 PUFAs are reported to enhance cognition,[22-24] while high energy and saturated fat intakes may increase the risk for cognitive decline.[25,26] Any impact that dairy foods may have on cognitive health has not been a focus of research. This is a novel research question that has not been explored to date.

The aim of the present study was therefore to cross-sectionally examine relationships between dairy consumption and the health of South Australian adults. While cognitive health was the main focus of the present study, other measures of physical health and some indicators of cardiometabolic health were included to gain a more complete picture of overall health and well-being in the sample.

MATERIALS AND METHODS

Subjects

Pre-existing data from 1183 middle-aged men and women was used to examine associations between dairy intake,

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and self-reported cognitive and memory function, self-esteem, stress, anxiety, mood, and psychological well-being. Letters of invitation were sent to a random selection of 4155 men and women, aged 40 to 60 years, within the South Australian Electorates of the Australian Electoral Rolls. The letter invited the recipient to participate in a study on nutrition, health and psychological well-being in midlife. They were informed that information about dietary intake, health and daily stresses would be gathered from two booklets of questionnaires. As voting is compulsory in Australia, and the Australian Electoral Rolls contain 98% of the adult population eligible to vote, this procedure was expected to result in a near random representative sample of the South Australian population. This age group was selected as there is evidence to suggest that cognitive decline induced by cardiometabolic risk factors may commence in mid-life.[16,17,27] Media publicity generated interest from an additional 478 volunteers. An information sheet and set of questionnaires were sent to 1461 individuals who expressed an interest in participating. Of these, 1204 (82.4%) returned completed questionnaires. Based on dietary information provided, 21 were excluded; 5 were largely incomplete and 16 reported either an overestimation or underestimation of daily intake (<4000 kJ or >17000 kJ). The final sample with complete questionnaire and dietary intake data totalled 1183 participants (751 women and 432 men).

Demographic measures

Demographic measures included gender, age, marital status, education and employment history.

Cognitive and psychological health measures

Self-appraised cognitive function were assessed by the Cognitive Failures Questionnaire (CFQ).[28] The CFQ measures cognitive-based mistakes on everyday tasks in perception, memory, or motor function. The CFQ is scored from 0 to 100, with higher scores indicating more frequent mistakes. The Memory Functioning Questionnaire (MFQ)[29] was used to examine five dimensions of self-reported everyday memory functioning: frequency of memory problems, frequency of poor reading recall, quality of recall, seriousness of forgetting, and retrospective functioning, with possible totals of 126, 70, 28, 126, and 35, respectively. Higher levels of perceived memory functioning are reflected by higher scores.

The Medical Outcomes Study 36-Item Short Form Health Survey (SF-36)[30] was used to measure the impact of emotional health on role performance and social functioning, mental health, vitality and general health, with possible totals of 6, 10, 30, 24 and 20, respectively. Higher scores indicate better health status. The Spielberger State-Trait Anxiety Inventory, Form Y (STAI-Y)[31] is a commonly used measure of state and trait anxiety. A total score for each anxiety scale is calculated from 20 to 80, with higher scores indicating greater anxiety. The Perceived Stress Scale (PSS)[32] measures the extent to which individuals rate situations in their lives as unpredictable, uncontrollable, and overloading, all key components of stress. A total score ranging from 0 to 56 is obtained, with higher scores indicating higher perceived stress. The Center for Epidemiological Studies-Depression Scale (CES-D)[33] assesses depressive symptoms experienced in the preceding week in samples not expected to be clinically depressed, and as such was deemed appropriate for the present study. A total score from 20 to 80 is calculated, with higher scores indicating more frequent depressive mood. The Bachman revision of the Rosenberg Self-Esteem Scale (RSE-B)[34] was used to measure perceived self-worth, usefulness and competence. Total scores range from 10 to 50, with higher scores indicating higher self-esteem.

Other health measures

Self-reported health measures included height and weight, smoking history (number of cigarettes per day), alcohol intake (number of alcoholic drinks per week), exercise habits (hours of exercise per week), self-rated health (from 1=poor, to 5=excellent), and number of recent hospitalisations. In addition, a 'health score' was calculated by the researchers as an indication of the overall health status of these subjects. This score ranged from 0-5, with a higher score reflecting better health. One point was gained for each of the following: a total energy intake within the recommended range for gender, age and activity level, saturated fat consumption of less than 30 g per day, an intake of at least 2 serves of fruit and 5 serves of vegetables per day, non-smoker, and a minimum of 90 minutes of exercise per week. These factors are well known to have a significant impact on health status.

Participants were requested to list any ongoing medical conditions and any medications they were taking. The self-reported presence of CVD, diabetes, or cerebrovascular disease, or use of medications for hypertension, hypercholesterolemia, inflammation, or diabetes, were used as indicators of cardiometabolic health. BMI was calculated from self-reports of height and weight and used as an indicator of obesity. A number of studies examining associations between cardiometabolic factors and cognition have used information on: self-reported use of anti-hypertensive medications as an indicator of hypertension, use of diabetes medication or self-reported diabetes for glucose intolerance,[13,35,36] and BMI as an indicator for overweight and obesity.[12,17,37,38]

Assessment of dairy intake

Dairy intake was calculated using a self-completed, quantified food frequency questionnaire (FFQ) which requests information relating to food choices, preparation, portion size, quantity and consumption of 215 different food and beverage items.[39] This form of the FFQ is regularly updated and has been used extensively with Australian population samples and national dietary surveys (1988, 1993 and 1998). It has been shown to have a high repeatability and consistency with other dietary intake measurement techniques, and has good reliability when assessed against protein and urinary measures.[40-43] Detailed information on milk (including flavoured milk, milkshakes, milk added to breakfast cereals, and milk added to hot and cold drinks), cheese (regular, cottage, ricotta), ice-cream, cream, yogurt and dairy desserts, and the fat content of each item were analysed from the FFQ.

Raw scores for each dairy food (total amount, whole fat and reduced fat) in serves per month were re-coded into serves per day. Using standardised serving sizes and nutrient composition for each product extracted from the Foodworks Professional nutritional program (Xyris, Qld, Australia), serves per day were converted into absolute amounts (in g or mL). Total daily milk intake from all sources was calculated, categorised into whole fat, reduced fat and skim. The macronutrient and micronutrient intake provided from each individual dairy product and from total dairy was calculated and the proportions of these nutrients provided by dairy, as a proportion of total daily intake were subsequently determined.

Statistical analysis

Data were analysed with SPSS version 15.0 (SPSS Inc, Chicago, IL). All outcome measures were assessed for normality. A visual inspection of the cognitive functioning and psychological outcome scores showed the data were approximately normally distributed. Distributions of scores for dairy intake were positively skewed due to the large number of participants with low dairy intakes, therefore log transformations were applied. This did not normalise data and so the raw data was used in all analyses.

ANOVA was used to explore gender differences in demographic variables, and all health measures. Means for all dairy food intakes were adjusted for total energy intake and univariate ANCOVA was used to assess for significant differences in macronutrient and dairy food intake between men and women.

To assess for any differences in diet and health characteristics between high and low dairy consumers, subjects were categorised into quartiles (based on one 250 g serve of milk) according to average daily dairy intake. Quartiles 1-4 were the same for men and women: <250 (<1 serve, low intake), 250 to <500 (1-2 serves, medium intake), 500 to 750 (2-3 serves, medium to high intake) and >750 g per day (>3 serves, high intake). These quartiles were selected in order to categorise dairy intake in a meaningful way. Mean intakes for all nutrients were adjusted for total energy intake by including this as a covariate. Significant differences in dietary characteristics across quartiles of dairy intake were assessed using ANCOVA. Chi-square test was used to detect any significant differences in the distribution of subjects across quartiles of dairy intake with regard to cardiometabolic health indicators. ANOVA was used to detect any differences in the calculated health score or BMI across quartiles of increasing dairy intakes.

Hierarchial linear regression was used to explore relationships between absolute dairy intake and proportions of macronutrients in diet and dairy with all cognitive functioning and psychological well-being measures. Each model was adjusted for demographic and lifestyle factors which were independently correlated with at least one outcome measure. The confounders most frequently included were age, number medications, number of medical conditions, number of recent hospitalisations, and perceived (self-rated) health.

RESULTS

The mean age was 51.2 years for men and 50.3 years for women (Table 1). Men had a significantly higher BMI and consumed more alcohol and cigarettes than women. Women had higher self-rated health than men but took more medications. Women reported more cognitive failures, anxiety (state and trait) and depressive symptoms, poorer mental health and vitality, but higher self-esteem and overall general health than men (Table 2).

Table 3 shows that men had an average daily energy intake of 9832 kJ (2349 kcal), significantly larger than the 8263 kJ (1974 kcal) of women. Energy intake from dairy as a proportion of total energy was similar for men and women, however women consumed significantly more total protein, dairy protein, total carbohydrate and dairy carbohydrate than men. Average daily dairy consumption by Australian men and women was low, with the majority of the sample (78%) consuming less than two serves of dairy per day (Table 4). Intake of whole fat dairy was significantly higher among men than women. Of individual dairy products, men consumed significantly more whole fat milk and whole fat ice-cream than women. Women consumed significantly more low fat dairy than men, specifically, more low fat cheese, yogurt, and dairy

Table 1. Descriptive statistics and gender differences for demographic variables and health measures

	All n=1183		Men n=432		Women n=751	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	50.6(39-65)	5.79	51.2*(40-65)	5.79	50.3*(39-65)	5.78
Education (years)	13.2	3.66	13.8***	4.05	12.9***	3.37
BMI (kg/m^2)	26.5	4.55	27.0**	3.91	26.2**	4.86
Number of medications	1.06	1.39	0.95*	1.31	1.12*	1.43
Number of medical conditions	0.96	1.10	0.95	1.07	0.97	1.13
Hospitalisations in last year	0.18	0.54	0.16	0.45	0.19	0.59
Alcohol (standard drinks per week)	6.08	9.80	9.55***	13.5	4.09***	6.04
Physical activity (hours exercise per week)	3.37	2.99	3.52	3.19	3.29	2.87
Self-rated health (1=poor to 5=excellent)	3.27	1.01	3.17**	1.03	3.33**	0.99
Calculated 'health score' (0-5, 5=greater health)	3.44	1.09	3.23***	1.06	3.57***	1.09
Smoking, n, %						
Yes	137	11.6	54	12.5	83	11.1
No	1046	88.4	378	87.5	668	88.9
Cigarettes per day (smokers)	18.4	10.9	22.2**	11.7	15.8**	9.61

BMI = Body mass index

**p*<0.05, ***p*<0.01, ****p*<0.001, mean values were significantly different between men and women, based on ANOVA

Table 2. Gender differences for cognitive and psychological health measures

	All n=1183		Men n=432		Women n=751	
	Mean	SD	Mean	SD	Mean	SD
Cognitive failures	34.6	13.2	32.9**	12.8	35.6**	13.3
Memory functioning						
Frequency of memory problems	93.9	14.4	94.8	14.5	93.5	14.3
Frequency of poor reading recall	55.8	10.9	56.3	10.7	55.5	11.1
Quality of recall	19.1	5.25	19.0	4.97	19.2	5.41
Seriousness of forgetting	83.0	23.1	81.9	22.3	83.6	23.5
Retrospective functioning	23.3	6.84	23.8	6.41	23.0	7.07
SF-36 health survey						
Role-emotional	5.41	1.01	5.48	0.98	5.38	1.03
Social functioning	8.64	1.76	8.73	1.66	8.58	1.82
Mental health	23.5	4.07	23.8*	3.97	23.3*	4.12
Vitality	15.7	3.98	16.2**	3.81	15.4**	4.05
General health	15.7	3.30	15.4*	3.37	15.9*	3.25
Self-esteem	17.1	6.34	16.5**	5.91	17.5**	6.55
Depression	32.9	9.85	31.8**	9.16	33.4**	10.2
Perceived stress	22.3	7.53	21.7	7.40	22.6	7.59
State anxiety	37.7	12.2	36.1***	11.6	38.7***	12.5
Trait anxiety	36.7	10.7	35.7*	10.7	37.2*	10.7

$^*p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$, mean values were significantly different between men and women, based on ANOVA

desserts.

Dietary patterns and cardiometabolic health indicators according to total dairy intake are presented in Table 4. As dairy consumption increased across quartiles, total carbohydrate, total protein and saturated fat intakes increased, while consumption of total fat, MUFA, and PUFA all decreased in a linear pattern. Indicators of cardiometabolic health did not vary significantly between low and high consumers of dairy.

Cheese intake has previously been associated with decreased cognitive impairment in a population of late middle-age to elderly people. Significant associations between macronutrient and dairy food intakes and psychological health measures are shown in Table 5. In men, higher protein intake (as a proportion of total energy intake) was associated with lower perceived stress scores. Analyses of individual dairy foods found that low fat yogurt consumption was positively associated with memory performance (quality of recall) and with social functioning in men. In women, low fat cheese consumption was positively associated with social functioning and negatively associated with perceived stress levels.

Whole fat and total ice-cream intake were significantly associated with increased depression, anxiety and stress scores, and poorer memory functioning amongst men. Total cream and whole fat cream were associated with poorer general health and increased cognitive failures. Whole fat milk was associated with poorer social functioning. In women, higher intakes of total cheese, and both low fat and total cream were associated with poorer memory performance (quality of recall and retrospective functioning). These relationships were not mediated by cardiometabolic health, and remained significant after adjustment for demographic and lifestyle factors.

DISCUSSION

The present study did find limited support for the novel hypothesis that dairy consumption may be related to cognitive and psychological health. Our cross-sectional findings suggest that the consumption of some low fat dairy products (yogurt and cheese) may be positively associated with some measures of cognitive and psychological health (memory, social functioning, stress) in middle-aged men and women. It is acknowledged that the effect sizes were small and statistically significant because of the large sample size. However, there is some consistency in the results found. A number of whole fat dairy products, namely ice-cream, cheese and cream, were consistently associated with poorer psychological outcomes for men and women. Due to the cross-sectional nature of the study, we can not be sure of the causal direction of these relationships, however the findings warrant further research exploring dairy and cognition.

Cheese intake has previously been associated with decreased cognitive impairment in a population of late middle-age to elderly people.[44] While the underlying mechanism is unclear, components in cheese including MUFA, PUFA, the amino acid tyramine, and antioxidants such as vitamins A and B2 may be involved.[44] Antioxidant compounds have been effective in slowing age-related neuronal changes by mitigating the long-term effects of oxidative stress[24,45] and subsequently linked to better cognitive function.[46-48] Tyramine, found in most hard cheeses, sour cream and yogurt, may also play a part in the association between cheese, stress and social functioning, as it is involved in the release of stored monoamines associated with mood regulation.[44] While only present in cheese in small quantities, MUFA and PUFA may contribute to the protective effect of cheese. The replacement of saturated fatty acids with MUFA and PUFA has been shown to lower LDL-cholesterol levels, increase HDL levels, and lower the ratio of total to HDL-cholesterol, a more favourable blood cholesterol profile.[49] As high LDL-cholesterol is suggested to play a role in the expression of AD-related pathology,[50] the ability of MUFA and PUFA to increase the oxidation of LDL-cholesterol may protect against cognitive decline.[23]

Conversely, high dietary intakes of saturated fat have been associated with an increased risk of impaired cognitive function in middle-aged people cross-sectionally,[51] and prospectively in elderly populations.[26,52] As ice-cream, cheese and cream each supply between 7 and 28 g of saturated fat per 100 g, saturated fat may provide the link between stress and depression, intake of high fat dairy products and risk of cognitive decline in the present study. This hypothesis is supported by Eskelinen and colleagues[14] who found that high saturated fat intakes from milk products (spreads included) in mid-life (mean age

Table 3. Gender differences for mean daily intake of macronutrients and dairy products, controlling for total energy intake

	All n=1183		Men† n=432		Women† n=751	
	Mean	SD	Mean	SEM	Mean	SEM
Energy						
Total from diet (MJ)‡	8.84	2.61	9.83***	2.69	8.26***	2.39
Total from dairy (MJ)	1.11	0.72	1.08	0.03	1.13	0.02
% of energy from dairy	12.5	6.70	12.1	0.33	12.7	0.25
Fat						
Saturated fat (g)	30.7	13.8	30.9	0.40	30.6	0.30
MUFA (g)	29.5	11.9	29.8	0.30	29.4	0.23
PUFA (g)	16.2	7.75	15.6**	0.30	16.6**	0.22
Total fat from diet (g)§	81.8	31.0	81.4	0.67	82.0	0.50
Total fat from dairy (g)	12.7	10.5	13.2	0.45	12.4	0.34
% of fat from dairy	15.1	9.81	15.6	0.48	14.8	0.36
% of total energy	33.8	5.92	33.8	0.29	33.9	0.21
Protein						
Total from diet (g)	88.0	26.5	85.0***	0.67	89.7***	0.50
Total from dairy (g)	17.9	11.3	16.4***	0.50	18.8***	0.38
% of protein from dairy	20.0	10.2	19.0*	0.50	20.5*	0.38
% of total energy	17.1	2.69	16.6***	0.13	17.4***	0.10
Carbohydrate						
Total from diet (g)	243	76.1	240*	1.76	245*	1.32
Total from dairy (g)	20.3	14.8	19.0*	0.68	21.0*	0.51
% of carbohydrate from dairy	8.32	5.43	7.97	0.27	8.52	0.20
% of total energy	44.2	6.56	43.5**	0.32	44.6**	0.24
Total dairy (g/day)						
Whole fat	121	192	142**	8.79	109**	6.59
Reduced fat	226	227	188***	1.10	248***	8.32
Total	347	243	330	11.1	357	8.32
Milk (ml/day)						
Whole fat	88.2	176	110**	8.22	75.6**	6.16
Reduced fat	120	178	118	8.86	122	6.64
Skim	50.4	131	42.1	6.49	55.2	4.86
Total	259	218	270	10.2	252	7.65
Cheese (g/day)						
Whole fat	15.7	23.9	15.9	1.14	15.7	0.85
Reduced fat	6.04	18.7	3.58**	0.92	7.45**	0.69
Total	22.7	27.1	20.4*	1.28	24.1*	0.96
Ice-cream (g/day)						
Whole fat	5.66	11.2	7.72***	0.53	4.48***	0.40
Reduced fat	1.79	6.43	1.56	0.32	1.93	0.24
Total	7.47	12.1	9.28***	0.58	6.42***	0.44
Yogurt (g/day)						
Whole fat	10.2	40.1	7.29	1.96	11.9	1.47
Reduced fat	40.2	70.4	18.4***	3.40	52.7***	2.55
Total	53.0	78.6	26.0***	3.75	68.5***	2.81
Cream (g/day)						
Whole fat	1.13	3.13	1.17	0.15	1.12	0.12
Reduced fat	0.25	1.45	0.16	0.07	0.30	0.05
Total	1.40	3.37	1.34	0.17	1.43	0.12
Dairy desserts (g/day)	7.22	17.4	4.23***	0.84	8.94***	0.63

MUFA = Monounsaturated fatty acids
PUFA = Polyunsaturated fatty acids
†Mean values and standard error of the mean, after adjustment for total energy intake
‡Mean values and standard deviations
§Other fats (trans fats and un-identifiable fatty acids) were not included in the dietary analysis food database
*p<0.05, **p<0.01, ***p<0.001, mean values were significantly different between men and women, based on ANCOVA

50.2 years) was associated with poorer global cognitive function and prospective memory, and with an increased risk of mild cognitive impairment in later life (mean age 71.1 years). To further explore relationships between fat content of dairy and cholesterol intakes, analyses found that individuals who consumed more than three serves per day of whole fat dairy, with total energy intake controlled for, had significantly higher cholesterol intakes (327.6 g per day) than those who consumed less than this ($p<0.01$, data not shown). This positive association did not remain when comparing intakes of reduced fat dairy. This finding suggests that the fat content of dairy may be a determining factor in the relationship between dairy consumption, hypercholesterolemia and subsequent risk of CVD or cognitive decline. Despite the accumulating evidence that low fat dairy may reduce, rather than increase, the risk of CVD,[53,54] there was no relationships found between dairy intake and any of the self-reported cardiometabolic health indicators. In the absence of any clinical measures, this study is unable to confirm or refute the hypothesis that a

Table 4. Dietary and health characteristics according to total daily dairy intake

Total daily dairy intake	Low <1 serve/day (<250 g)		Low-medium 1-2 serves/day (250-499 g)		Medium-high 2-3 serves/day (500-750 g)		High >3 serves/day (>750 g)		*p*-value for trend†
	n	%	n	%	n	%	n	%	
	468	40	454	38	186	16	75	6	
Medical conditions									
Cardiovascular disease	97	21.3	100	22.6	33	18	15	20.3	0.65
Diabetes	10	2.2	17	3.8	4	2.2	3	4.1	0.42
Mental health disorder	35	7.7	39	8.8	17	9.3	12	16.2	0.13
Medications									
Cholesterol	32	7.1	35	7.9	10	5.5	2	2.7	0.37
Anti-inflammatory	26	5.7	27	6.1	9	5	3	4.1	0.89
Anti-depressant	33	7.3	33	7.4	15	8.3	9	12.3	0.49
Anti-anxiolytic	10	2.2	4	0.9	1	0.6	4	5.5	<0.05
Anti-hypertensive	57	12.6	72	16.2	19	10.5	12	16.4	0.19
Insulin	7	1.5	12	2.7	2	1.1	1	1.4	0.47
	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	
Health score (0-5)‡	3.7	1.1	3.4	1.1	3.1	1.1	3.0	0.9	<0.001
BMI (kg/m^2)‡	26.5	4.8	26.6	4.7	26.5	4.3	26.3	4.4	0.42
Daily intake									
Total energy (MJ)	7.9	2.2	8.9	2.4	10.0	2.6	11.2	3.0	<0.001
Total protein (g)	83.4	0.6	88.5	0.6	93.4	1.0	100	1.5	<0.001
Total carbohydrate (g)	236	1.7	246	1.7	247	2.6	254	4.2	<0.001
Total fat (g)§	84.9	0.6	80.5	0.6	79.7	1.0	75.2	1.6	<0.001
Saturated fat (g)	30.3	0.4	30.2	0.4	31.8	0.6	32.9	1.0	<0.01
MUFA (g)	31.4	0.3	28.9	0.3	28.3	0.4	25.0	0.7	<0.001
PUFA (g)	17.7	0.3	16.0	0.3	14.4	0.4	12.0	0.7	<0.001
Total sugar (g)	123	1.7	136	1.7	143	2.7	156	4.2	<0.001
Natural sugar (g)	71.3	1.3	82.7	1.3	90.4	2.1	105	3.3	<0.001
Refined sugar (g)	52.1	1.56	52.8	1.6	52.7	2.5	51.1	3.9	0.97
Cholesterol (mg)	224	4.3	231	4.3	236	6.8	261	10.8	<0.05
Calcium (mg)	826	11.9	1077	11.8	1354	18.8	1754	29.9	<0.001
Magnesium (mg)	335	3.2	360.1	3.1	379.3	5.0	404	7.9	<0.001
Potassium (mg)	3748	39.2	4085	38.7	4289	61.6	4667	98.1	<0.001
Sodium (mg)	2780	32.4	2721	32.0	2680	51.0	2631	81.2	0.22
Macronutrient intake derived from dairy (%)									
Energy	6.9	0.2	13.3	0.2	19.2	0.3	25.4	0.5	<0.001
Fat	10.2	0.4	15.7	0.4	21.2	0.6	27.3	1.0	<0.001
Protein	11.2	0.3	21.8	0.3	30.4	0.5	37.5	0.8	<0.001
Carbohydrate	3.3	0.1	9.2	0.1	14.4	0.2	19.7	0.3	<0.001

BMI = Body mass index
MUFA = monounsaturated fatty acids
PUFA = polyunsaturated fatty acids
†Pearson chi-square for medical conditions and medications; ANOVA for health score and BMI; ANCOVA for dietary data, adjusted for total energy intake
‡Mean values and standard deviations
§Other fats (trans fats and un-identifiable fatty acids) were not included in the dietary analysis food database

Table 5. Influence of dairy and macronutrient intake on cognitive functioning and psychological well-being†

Dairy product/ macronutrient	Cognitive functioning/ psychological well-being outcome	R	R square change	F change	Beta
Males (n=432)					
% protein from diet	Perceived stress scale[1]	0.41	0.01	4.73*	- 0.10*
% carbohydrate from diet	SF-36 Vitality[2]	0.54	0.01	4.10*	- 0.08*
% carbohydrate from dairy	MFQ - Frequency of common memory problems[3]	0.24	0.01	5.85*	- 0.11*
% PUFA from dairy	State anxiety[4]	0.46	0.01	3.97*	0.09*
	Depression scale[5]	0.41	0.01	4.81*	0.10*
Reduced fat yogurt	SF-36 - Social functioning[6]	0.44	0.01	4.05*	0.09*
	MFQ - Quality of recall[7]	0.28	0.01	4.81*	0.10*
Total yogurt	MFQ - Quality of recall[7]	0.29	0.01	6.36*	0.12*
Reduced fat milk	MFQ - Frequency of poor reading recall[8]	0.26	0.01	3.86*	- 0.09*
Whole fat milk	SF-36 - Social functioning[6]	0.44	0.01	3.91*	- 0.09*
Whole fat ice-cream	Depression scale[5]	0.42	0.02	7.94**	0.13**
	State anxiety[4]	0.47	0.01	6.03*	0.11*
	Perceived stress scale[1]	0.41	0.01	4.83*	0.10*
	MFQ - Frequency of common memory problems[3]	0.23	0.01	4.62*	- 0.10*
	MFQ - Retrospective functioning[3]	0.29	0.01	4.89*	- 0.10*
Total ice-cream	Depression scale[5]	0.42	0.01	6.29*	0.11*
	State anxiety[4]	0.46	0.01	4.60*	0.09*
	MFQ - Frequency of common memory problems[3]	0.25	0.01	7.88**	- 0.13**
	MFQ - Frequency of poor reading recall[8]	0.26	0.01	4.75*	- 0.10*
	MFQ - Retrospective functioning[3]	0.29	0.01	5.94*	- 0.11*
Whole fat cream	SF-36 -General health[9]	0.65	0.01	6.45*	- 0.09*
	Cognitive failures[10]	0.32	0.01	4.05*	0.09*
Total cream	SF-36 -General health[9]	0.65	0.01	5.09*	- 0.08*
Total reduced fat dairy	MFQ - Frequency of poor reading recall[8]	0.26	0.01	4.86*	- 0.11*
Females (n=751)					
Reduced fat cheese	SF-36 - Social functioning[11]	0.42	0.01	5.38*	0.08*
	Perceived stress scale[12]	0.36	0.01	4.15*	- 0.07*
Total cheese	MFQ - Quality of recall[13]	0.22	0.01	4.58*	- 0.08*
Reduced fat cream	MFQ - Quality of recall[13]	0.22	0.01	4.18*	- 0.07*
	MFQ - Retrospective functioning[14]	0.27	0.01	5.37*	- 0.08*
Total cream	MFQ - Retrospective functioning[14]	0.27	0.01	3.99*	- 0.07*

MFQ = Memory Functioning Questionnaire
PUFA = Polyunsaturated fatty acids
SF-36 = Medical Outcomes Study 36-Item Short Form Health Survey
†Multivariate models adjusted for age, medications, medical conditions, recent hospitalisations, perceived health
*p<0.05, **p<0.01
[1] Model adjusted for self-rated health, age, number of medical conditions, medications, and exercise minutes.
[2] Model adjusted for self-rated health, number of medical conditions, medications, and recent hospitalisations, BMI and exercise minutes.
[3] Model adjusted for self-rated health, number of medical conditions and medications.
[4] Model adjusted for self-rated health, age, number of medical conditions, medications, and recent hospitalisations, and exercise minutes.
[5] Model adjusted for self-rated health, age, number of medical conditions and medications, and cigarettes smoked.
[6] Model adjusted for self-rated health, age, number of medical conditions, medications, recent hospitalisations, and cigarettes smoked.
[7] Model adjusted for self-rated health, number of medical conditions and alcoholic drinks.
[8] Model adjusted for self-rated health, number of medical conditions and medications, and alcoholic drinks.
[9] Model adjusted for self-rated health, number of medical conditions, medications, and recent hospitalisations, and BMI.
[10] Model adjusted for self-rated health, number of medical conditions, medications, and recent hospitalisations.
[11] Model adjusted for self-rated health, number of medical conditions, medications, recent hospitalisations, age, BMI, exercise minutes, and total energy intake.
[12] Model adjusted for self-rated health, number of medical conditions, age, BMI, and total energy intake.
[13] Model adjusted for self-rated health and alcoholic drinks.
[14] Model adjusted for self-rated health, number of medical conditions, medications, recent hospitalisations, and total energy intake.

high dairy intake may improve cardiometabolic health.

The low intake of dairy in the present study (347.1 g per day or 1.4 serves), is consistent with patterns of intake amongst adults in the United States and Canada (1.5 servings per day),[55,56] and in the United Kingdom, where milk consumption has fallen by 33% during the past 25 years.[57] This average intake falls below the Australian Dietary Guidelines recommendation o 2-3 serves per day of dairy products.[58] This widespread decline in dairy consumption has coincided with a dramatic increase in the consumption of fast food and soft drinks in the western world,[59] which raises concern for the health of the population for a number of reasons. The impact on total energy consumption from this shift in drinking habits may contribute in part to the world-wide obesity epidemic. Secondly, milk and other dairy products provide over half of the dietary intake of calcium in most parts of the world.[57] Calcium is essential for the development, maintenance, structure and strength of bones and for neuromuscular and cardiac function. Individuals with chronic inadequate intakes of calcium are at risk of osteoporosis or bone fracture. Particularly concerning is the low intake by women in the present study; the average intake of 1054 mg per day is well below the recommended dietary intake of 1300 mg for women aged over 50 years.[60] In addition to the effects of calcium on bone health, recent research is shifting to the role that dairy derived whey protein may play in reducing metabolic risk.[61] Data from the present study indicates the need for further education of consumers highlighting the importance of dairy as the predominant source of calcium and an important source of protein.

There are several considerations that should be made when interpreting the findings of the current study. The homogeneity of dairy intake may have limited our ability to detect a significant difference in health outcome between low and high dairy consumers. Despite efforts to control for background and lifestyle factors, residual confounding cannot be ruled out. Due to the cross-sectional nature of the study, conclusions about cause and effect are unable to be drawn. The inherent errors involved in the self-reporting of health measures should also be considered. Self-reported nutritional intake can lead to underestimation or overestimation of true associations, and measurement at only one point may not reflect long-term consumption patterns. Those who are more interested or concerned about their health may be more likely to participate in health research, and subsequent reporting may be biased by pre-existing cognitive or psychological problems.

These early findings offer some support to the novel hypothesis that dairy consumption may influence cognition. Long-term dietary intervention trials are needed to build upon this early, observational research and determine whether there is a direct relationship between dairy consumption and cognitive health. Examining diet and cognition within a young to middle-aged group may help to recognise the critical time periods when adequate nutrient intake is most important to slow or prevent disease progression.

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AUTHOR DISCLOSURES

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Original Article

Dairy intake and cognitive health in middle-aged South Australians

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澳洲南澳省中年人的乳製品攝取與認知功能健康

背景：攝取低脂乳製品可能會降低肥胖、第二型糖尿病、高血壓以及所有與增加認知功能受損機會相關的心血管危險因子。目的：檢測乳製品的攝取與自述認知功能及心理安適之間的相關，並且檢定新的假說：乳製品的攝取經由它對於心血管代謝健康的正向效應可能會對認知功能有助益。方法：藉由年齡為 39 至 65 歲的 432 位男性與 751 位女性的飲食頻率問卷及自述健康狀況的資料進行回溯性橫斷分析。健康狀況的測量包括：心血管代謝健康狀況指標、認知及記憶功能、心理健康、焦慮、壓力、沮喪及自尊心等，藉由標準化的問卷來進行評估。結果：調整總熱量的攝取及其他健康干擾因子的迴歸分析結果顯示，在男性方面，攝取低脂優格與提昇記憶回想(p=0.029)以及較佳的社會功能(p=0.045)有關。在女性方面，攝取低脂乳酪與較佳的社會功能(p=0.021)及降低壓力(p=0.042)有相關。全脂乳製品的攝取，包括：冰淇淋以及鮮奶油，與增加沮喪、焦慮、壓力、認知功能受損、較差的記憶功能及整體健康有關(所有的 p 值皆小於 0.05)。但心血管代謝健康狀況指標與乳製品的攝取則無關。結論：雖然全脂乳製品可能與較差的心理安適有關，但是低脂乳製品可能對社會功能、抗壓及記憶力是有助益的。需要飲食介入試驗來探討乳製品的攝取是否對認知功能與心理健康有直接的效應。

關鍵字：乳製品、牛奶、認知功能、心理健康、代謝症候群