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Nut consumption is associated with better nutrient intakes: results from the 2008/09 New Zealand Adult Nutrition Survey

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Abstract

A limited number of studies have examined associations between nut consumption and nutrient intakes or diet quality. None has investigated these associations in the Southern Hemisphere. The purpose of this study was to examine associations between nut consumption and nutrient intakes among adult New Zealanders. Data from the 24-h recalls of 4721 participants from the cross-sectional 2008/09 New Zealand Adult Nutrition Survey (2008/09 NZANS) were used to determine whole nut intake and total nut intake from all sources as well as nutrient intakes. Regression models, both unadjusted and adjusted for potential confounders, were used to estimate differences in nutrient intakes between those consuming and those not consuming nuts. From adjusted models, compared with non-whole nut consumers, whole nut consumers had higher intakes of energy and percentage of energy from total fat, MUFA and PUFA, whereas percentage of energy from SFA and carbohydrate was lower (all $P \leq 0{\cdot}025$). After the additional adjustment for energy intake, whole nut consumers had higher intakes of dietary fibre, vitamin E, folate, Cu, Mg, K, P and Zn (all $P \leq 0{\cdot}044$), whereas cholesterol and vitamin B_{12} intakes were significantly lower (both $P \leq 0{\cdot}013$). Total nut consumption was associated with similar nutrient profiles as observed in whole nut consumers, albeit less pronounced. Nut consumption was associated with better nutrient profiles, especially a lower intake of SFA and higher intakes of unsaturated fats and a number of vitamins and minerals that could collectively reduce the risk for chronic disease, in particular for CVD.

Key words: **Nut intake: Nutrient intakes: Population surveys: CVD**

Nuts are rich in unsaturated fatty acids, vitamins, minerals and bioactive compounds, which collectively are likely to contribute to their well-recognised health properties, in particular to reduce CVD risk[1–3]. If consumed in sufficient amounts, the nutrients present in nuts are likely to improve diet quality, which should translate into overall improved health outcomes for nut consumers compared with non-nut consumers.

Although individual nuts differ in types and amounts of nutrients, all nuts are considered to be nutrient dense[3,4]. Nuts are generally rich sources of *cis*-unsaturated fatty acids, fibre and plant protein including arginine[3,5]. In addition, individual nuts can contribute important amounts of folate, vitamin E, Ca, Mg, Cu, Zn, Se and K. Nuts also contain bioactive substances such as phytosterols, antioxidants and phenolic compounds, which are further likely to contribute positively to health outcomes[6]. Thus, frequent nut consumption is likely to make important contributions towards a healthy diet. Indeed O'Neil *et al.*[7] showed that tree nut consumption improved nutrient intake and diet quality in the National Health and Nutrition Examination Survey (NHANES) 1999–2004 cohort. In particular, the diets of tree nut consumers contained greater amounts of dietary fibre, vitamin E, Ca, Mg and K and lower amounts of Na compared with non-consumers. Using the Healthy Eating Index-2005, diet quality was found to be higher in nut consumers. This was also seen in their analysis of the NHANES 2005–2010 cohort[8]. In addition, this group found similar improvements in diet quality when assessing 'out-of-hand' tree nut consumers[9]. 'Out-of-hand' consumers, defined as those who ate at least 7 g/d of nuts solely as nuts and not as part of other products, were studied because they were thought to make a more conscious decision to eat nuts. These consumers had higher intakes of energy, MUFA, PUFA, dietary fibre, Cu and Mg and lower intakes of carbohydrate, cholesterol and Na when compared with non-consumers. Similarly, King *et al.*[10] reported that nuts

Abbreviations: 2008/09 NZANS, 2008/09 New Zealand Adult Nutrition Survey; NHANES, National Health and Nutrition Examination Survey; %TE, percentage of total energy.

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made an important contribution to the diets of both nut consumers and nut snackers (individuals who consume nuts as snacks).

In support of these findings, intervention studies have reported improvements to nutrient profiles resulting from the addition of nuts to participants' diets without any other dietary advice. Increases in *cis*-unsaturated fat, vegetable protein, dietary fibre, vitamin E, Cu and Mg have been observed[11–13].

To date, no research has examined the nutrient contribution of nuts to the New Zealand diet, where dietary patterns may differ from countries where nut intake patterns have been previously described[7,9,10]. Traditionally, New Zealand diets have contained more meat and butter than that of other countries that are part of the Organisation for Economic Co-operation and Development, and, although declining over the last few decades, bread, potatoes and beef remain major sources of energy and nutrients[14]. This differs substantially from a Mediterranean eating pattern common to a number of European countries[15]. Compared with the USA, a greater percentage of energy is consumed from foods prepared at home in New Zealand, as opposed to fast food and restaurant food[16]. Also, unlike in the USA, fortification of flour with folic acid is not mandatory, and fortification of foods with vitamin D is uncommon[17,18]. In addition, New Zealand soils are low in Se and I, meaning intakes of these micronutrients are relatively low[19]. Therefore, the aim of this study was to compare the nutrient profiles of nut consumers with that of non-nut consumers in a cross-section of the New Zealand population.

Methods

Study population

The 2008/09 New Zealand Adult Nutrition Survey (2008/09 NZANS) was a cross-sectional survey of New Zealanders aged 15 years and over, carried out from October 2008 to October 2009. A full description of the study design and methods is available elsewhere[20], and only a summary is presented here. Participants were recruited using a three-stage process where 607 meshblocks were selected using a probability-proportional-to-size design. A meshblock is defined as a small geographical area within New Zealand defined by Statistics New Zealand. Each meshblock contains about 110 people in urban areas and sixty in rural areas. After random selection of a household, random selection of a participant within the household occurred. Oversampling of Māori and Pacific people and age groups 15–18 and 71 years was used in order to achieve adequate numbers for subgroup analyses by ethnicity and age.

Informed, written consent was obtained from each participant, or from the guardian of participants aged <18 years, before interviews. Ethical approval was gained from the New Zealand Health and Disability Multi-Region Ethics Committee (MEC/08/04/049). This study was conducted according to the guidelines laid down in the Declaration of Helsinki.

Dietary assessment

Survey data were collected at participants' homes by trained interviewers using computer-assisted personal interview software. An interviewer-administered multiple-pass 24-h diet recall method was used to collect quantitative information on all foods and drinks the participant consumed the previous day (from midnight to midnight). It included all foods and drinks consumed, both at and away from home.

In the first stage of the recall, a 'quick list' of all foods, beverages and dietary supplements consumed during the preceding day was obtained. In the second stage, detailed descriptions of all the foods and beverages consumed were collected. Information on any additions made to food before eating was also collected. In the third stage, estimates of the amounts of all foods and beverages consumed were obtained. The amount eaten was described by volume wherever possible (e.g. cups or tablespoons). In addition, food photographs, shape dimensions, food portion assessment aids (e.g. dried beans) and packaging information were used. Finally, in the fourth stage, the foods were reviewed and the information collected was checked. Any additions and changes were made at this point. Repeat interviews were conducted on 1180 participants, but these were not used here.

Determination of nut consumption

For the purpose of this analysis, the term 'nuts' included tree nuts, mixed nuts and peanuts. Chestnuts, coconut and coconut products were not included in this analysis as their nutrient profiles differ from the aforementioned 'nuts'. Tree nuts include almonds, Brazil nuts, cashews, hazelnuts, macadamias, mixed nuts, pecans, pine nuts, pistachios and walnuts. Nut intake was assessed using the 24-h recall data from the 2008/09 NZANS, and nut consumption was subsequently divided into three categories: (i) whole nuts including tree nuts, mixed nuts and peanuts eaten whole as part of a snack (e.g. mixed-nut snacks) or as an addition to a food/meal (e.g. almonds sprinkled on a salad); (ii) nut butters including those made from peanuts and tree nuts (e.g. peanut butter, hazelnut spread); and (iii) other sources including tree nuts, peanuts and mixed nuts eaten as ingredients in recipes or as part of commercial products (e.g. breakfast cereals, snack bars, satay). 'Total nuts' encompass whole nuts, nut butters and nuts from hidden sources. Participants who reported consuming zero quantity of any nuts in their 24-h recall were classified as 'non-nut consumers'. 'Whole nut consumers' were participants who reported consuming any amount of whole nuts, and 'total nut consumers' were participants who reported consuming any of whole nuts, nut butters and/or hidden sources of nuts.

Demographic variables

Demographic variables were selected *a priori* after reviewing the literature. Variables included sex, age category (15–18, 19–30, 31–50, 51–70, 71+ years), prioritised ethnicity, New Zealand Index of Deprivation (NZDep06), education, BMI and smoking status.

Ethnicity. Self-reported ethnicity was categorised into one of three ethnic groups based on a priority classification system using the coding prioritisation order (from highest to lowest) of Māori, Pacific and New Zealand European and Other.

New Zealand Index of Deprivation. NZDep06 is an area-based measure of deprivation, which uses nine variables from the New Zealand Census reflecting specified dimensions of both material and social deprivation. Each meshblock in New Zealand is given a score between 1 and 10, with a score of 1 reflecting the least deprived areas and 10 the most deprived. For the purpose of the 2008/09 NZANS, these scores were divided into quintiles where quintile 1 represents the 20 % least deprived and quintile 5 the 20 % most deprived areas.

Education. Participants were asked to report their highest school-level qualification and where appropriate their highest post-school qualification. Three groups comprising no formal school qualification, secondary school qualification only or post-school qualification (including trade certificates and university degrees) were used for these analyses.

Smoking status. Information was collected on smoking status during the interview, and participants were classified as a never smoker, ex-smoker or current smoker.

Anthropometric measurements

Trained interviewers carried out height and weight measurements in duplicate. Standing height was measured using a stadiometer (Seca 214) and weight using electronic scales (Tanita HD-351). BMI was calculated as weight (kg)/height squared (m^2). The WHO BMI cut-offs were used to categorise BMI status in participants aged 19 years and over (underweight: $<18{\cdot}5\,kg/m^2$; normal range: $18{\cdot}5$–$24{\cdot}99\,kg/m^2$; overweight: ≥ 25–$29{\cdot}99\,kg/m^2$; obese: $\geq 30\,kg/m^2$). Relatively few individuals were classified as underweight (*n* 58), and this category was combined with the normal weight category. The Cole age- and sex-specific BMI cut-offs were used to categorise BMI status in those aged 15–18 years[21,22].

Statistical analysis

The complex survey design described above was accounted for in all analyses presented here. This includes incorporating both weights and clustering. The weights used were post-stratification weights for the questionnaire component of the 2008/09 NZANS and are intended to reflect the New Zealand population aged 15 years and above.

Log transformations were made where this improved residual normality and/or homoscedasticity. Variables that were log transformed are presented as geometric means with differences reported as the percentage of difference between the geometric means. Unadjusted and adjusted differences for nutrient intakes between nut consumers and non-nut consumers are presented. Adjusted regression models included sex, age group, prioritised ethnicity, BMI category, NZDep06 quintile, education and smoking status. We also adjusted for energy intake in a third model for each intake outcome to determine the effects of nuts on nutrient intake, independent of energy. This is both to adjust for any potential confounding between micronutrient intakes and health by physical activity and metabolic efficiency (not measured in this study) not accounted for through including BMI in the models and to acknowledge that some nutrients are required in absolute amounts irrespective of energy, and others are required in relative amounts.

Stata Statistical Software 12.1 (StataCorp LP) was used for all statistical analyses. All statistical tests were two-sided and $P<0{\cdot}05$ was considered statistically significant.

Results

Characteristics of the sample

Table 1 describes the characteristics of the 2008/09 NZANS sample and that of total and whole nut consumers. A total of 4721 participants were recruited and completed a 24-h diet recall.

Nut intake

We had previously described the nut intakes of New Zealanders[23]. In brief, the percentage of the population consuming whole nuts and total nuts on the day of the 24-h recall was 6·9 % (*n* 240) and 28·9 % (*n* 1167), respectively. Among whole nut consumers, the mean portion size was 40 (95 % CI 33, 47) g/d for whole nuts, and, among consumers of any nut, the mean portion size was 18 (95 % CI 16, 20) g/d for total nuts.

Nutrient intakes among whole nut consumers compared with non-whole nut consumers

When adjusted for potential confounders (not including energy intake), reported energy intakes and total fat expressed both in absolute terms and as a percentage of total energy (%TE) were significantly higher among whole nut consumers compared with non-whole nut consumers (all $P<0{\cdot}001$) (Table 2). When examining the different types of fat, SFA as %TE was significantly lower among whole nut consumers compared with non-whole nut consumers ($P=0{\cdot}025$). Conversely, both MUFA and PUFA when expressed in absolute amounts and as %TE were significantly higher in whole nut consumers (all $P<0{\cdot}001$). Carbohydrate intakes expressed as %TE ($P<0{\cdot}001$) were significantly lower among whole nut consumers, whereas protein intakes did not differ ($P=0{\cdot}165$). Dietary fibre intake was significantly higher in whole nut consumers ($P<0{\cdot}001$).

In terms of micronutrients, overall intakes were higher among whole nut consumers. When adjusted for potential confounders (not including energy intake), intakes of thiamin, riboflavin, niacin, vitamin B_6, total folate, vitamin C, vitamin E, Ca, Cu, Fe, Mg, P, K, Se and Zn were all significantly higher among whole nut consumers compared with non-whole nut consumers (all $P<0{\cdot}011$).

When intakes were further adjusted for energy intake, dietary cholesterol was significantly lower among whole nut consumers ($P<0{\cdot}001$), although dietary fibre remained significantly higher ($P<0{\cdot}001$). Of the micronutrients, folate, vitamin E, Cu, Mg, P, K

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Table 1. Characteristics of survey participants in the 2008/09 New Zealand Adult Nutrition Survey
(Numbers and percentages)

	All survey participants		Total nut consumers		Whole nut consumers	
Demographic variables	*n*	Survey weighted (%)	Survey weighted (%)	*P**	Survey weighted (%)	*P*†
Total population	4721					
Sex				0·183		0·351
Male	2066	48·6	45·4		43·7	
Female	2655	51·4	54·6		56·4	
Age (years)				0·005		<0·001
15–18	699	7·0	7·4		1·8	
19–30	718	19·7	16		10·3	
31–50	1344	36·7	42·1		43	
51–70	895	27·1	25·9		36·3	
71+	1065	9·6	8·6		8·7	
Ethnicity				<0·001		<0·001
NZEO	2980	84·3	88·2		93·6	
Māori	1040	11·1	11·3		4·9	
Pacific	701	4·6	4·8		1·5	
NZDep06 quintile				<0·001		0·032
Q1 (least deprived)	664	20·2	21·7		28·5	
Q2	829	21·4	24·1		25·1	
Q3	761	21·3	24·8		19·7	
Q4	1072	19·0	18·7		14·9	
Q5 (most deprived)	1395	18·1	10·7		11·9	
Highest educational qualification				<0·001		0·023
No school qualification	1217	18·1	13·9		12·0	
School	1413	26·5	25·4		22·6	
Post-school	2057	55·4	60·7		65·5	
BMI (kg/m^2)				0·010		0·070
<25	1409	34·9	39·0		44·4	
25–29·9	1581	37·1	37·9		34·6	
≥30	1513	28·0	23·1		21·0	
Smoking status				<0·001		0·013
Never smoked	2393	50·8	59·9		58·8	
Ex-smoker	1274	26·5	27·6		30·3	
Current smoker	1074	22·8	12·5		10·9	

NZEO, New Zealand European and Other; NZDep06, New Zealand Index of Deprivation; Q, quintile.
* *P* value for difference between all survey participants and total nut consumers.
† *P* value for difference between all survey participants and whole nut consumers.

and Zn remained higher among whole nut consumers compared with non-whole nut consumers (all $P \le 0·044$). Conversely, vitamin B_{12} intake was significantly lower among whole nut consumers ($P = 0·013$).

Nutrient intakes among total nut consumers compared with non-total nut consumers

After adjustment for potential confounders (not including energy intake), mean reported energy intakes were significantly higher among total nut consumers compared with non-total nut consumers ($P < 0·001$) (Table 3). When expressed in absolute terms and as %TE, total fat, MUFA and PUFA were all significantly higher among total nut consumers (all $P < 0·001$). Intakes of SFA and carbohydrate were significantly higher in total nut consumers when expressed in absolute terms (all $P < 0·001$) but not when expressed as %TE (all $P \ge 0·082$). Intakes of dietary fibre were 27 % higher in nut consumers compared with non-nut consumers ($P < 0·001$).

For micronutrients, following adjustment for potential confounders (not including energy intake), the intakes of vitamin A, thiamin, riboflavin, niacin, vitamin B_6, folate, vitamin C, vitamin E, Ca, Cu, Fe, Mg, P, K, Se and Zn were significantly higher among total nut consumers (all $P \le 0·009$).

When intakes were further adjusted for energy intake, dietary fibre remained significantly higher ($P < 0·001$) and dietary cholesterol significantly lower ($P < 0·001$) in total nut consumers compared with non-total nut consumers. Of the micronutrients, vitamin E, Ca, Cu, Fe, Mg and P remained statistically significantly higher among total nut consumers (all $P \le 0·007$).

Contribution of whole nuts to daily energy and nutrient intakes

When the study population was considered collectively, whole nuts contributed relatively minor amounts of energy and nutrients (Table 4). For example, whole nuts contributed only 0·7 %TE, 1·4 % total fat (0·54 %TE), 0·76 % SFA (0·08 %TE), 1·84 % MUFA (0·28 %TE), 2·04 % PUFA (0·15 %TE) and 0·68 % of protein (0·23 %TE). When broken down by sex, these did not differ to a meaningful extent between men and women.

However, among whole nut consumers, whole nuts made a substantial contribution to energy and nutrient intakes. Whole nuts

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Table 2. Mean daily nutrient intake by consumption of whole nuts in the 2008/09 New Zealand Adult Nutrition Survey*
(Mean values and 95 % confidence intervals)

	Non-whole nut consumers (*n* 4481)		Whole nut consumers (*n* 240)							
Nutrients	Mean	95 % CI	Mean	95 % CI	Unadjusted difference	95 % CI	Unadjusted *P*	Adjusted difference	95 % CI	Adjusted *P*†
Energy (kJ)	8160	7978, 8346	9509	8878, 10 186	16·5	8·4, 25·3	<0·001	20·3	12·6, 28·6	<0·001
Protein (g)	77·1	75·3, 78·9	88·1	82·0, 94·7	14·3	5·9, 23·3	0·001	15·3	7·4, 23·7	<0·001
Protein (%TE)	15·8	15·3, 16·0	15·5	14·7, 16·3	−1·8	−7·1, 3·7	0·511	−4·0	−9·4, 1·7	0·165
Total fat (g)	69·7	67·8, 71·6	90·7	83·8, 98·1	30·1	19·7, 41·3	<0·001	35·4	25·5, 46·2	<0·001
Total fat (%TE)	32·1	31·7, 32·6	35·9	34·5, 37·5	11·8	7·1, 16·7	<0·001	12·8	8·0, 17·9	<0·001
SFA (g)	26·6	25·8, 27·4	28·1	25·5, 30·9	5·5	−4·6, 16·6	0·297	11·3	1·3, 22·3	0·027
SFA (%TE)	12	11·8, 12·3	10·9	10·3, 11·6	−9·2	−14·7, −3·3	0·003	−7·0	−12·7, −0·9	0·025
MUFA (g)	24·8	24·1, 25·6	35·4	32·7, 38·4	42·6	31·2, 55·0	<0·001	48·8	37·8, 60·7	<0·001
MUFA (%TE)	11·2	11·0, 11·4	13·8	13·1, 14·5	22·8	16·5, 29·5	<0·001	24·4	17·9, 31·2	<0·001
PUFA (g)	9·4	9·1, 9·7	16·5	15·0, 1·81	75·4	59·4, 93·1	<0·001	76·3	61·0, 93·2	<0·001
PUFA (%TE)	4·2	4·2, 4·3	6·4	6·0, 6·8	51	41·1, 61·3	<0·001	47·3	37·8, 57·5	<0·001
Carbohydrate (g)	223	218, 229	234	214, 257	4·9	−4·7, 15·5	0·327	7·8	−1·5, 17·9	0·102
Carbohydrate (%TE)	45·7	45·2, 46·1	41·2	38·6, 43·9	−9·9	−15·4, −4·0	0·001	−10·3	−15·4, −4·6	0·001
Sugars (g)	95	92, 98	108	98, 119	14·1	2·7, 26·7	0·014	16·7	5·2, 29·4	0·004
Sugars (%TE)	18·5	18·1, 18·9	18·1	16·8, 19·6	−1·8	−9·3, 6·2	0·646	−2·6	−10·2, 5·6	0·526
Cholesterol (mg)	208	200, 216	179	150, 213	−13·9	−28, 2·9	0·099	−11·1	−25·1, 6·4	0·200
Total dietary fibre (g)	20·2	19·7, 20·7	28·8	26·4, 31·3	45·5	30·4, 55·8	<0·001	37·0	25·6, 49·4	<0·001
Vitamin A (μg)	647	624, 670	728	625, 748	12·6	−3·8, 31·8	0·138	9·0	−6·8, 27·5	0·280
Thiamin (mg)	1·15	1·12, 1·19	1·35	1·23, 1·48	17·4	6·6, 29·4	0·001	17·1	6·76, 28·4	0·001
Riboflavin (mg)	1·68	1·63, 1·72	1·9	1·73, 2·09	13·4	2·9, 25·0	0·011	12·5	2·8, 23·1	0·011
Niacin (mg)	15·3	15·1, 16·0	18·9	17·1, 20·8	21·4	10·0, 34·1	<0·001	23·4	12·2, 35·6	<0·001
Vitamin B_6 (mg)	1·52	1·48, 1·57	1·87	1·69, 2·06	22·6	10·8, 35·7	<0·001	22·4	11·1, 34·9	<0·001
Total folate (μg)	284	276, 292	382	345, 422	34·4	21·2, 49·1	<0·001	30·1	17·8, 43·7	<0·001
Vitamin B_{12} (μg)	2·99	2·88, 3·11	2·93	2·54, 3·37	−2·2	−15·3, 12·9	0·759	−2·1	−15·1, 12·9	0·769
Vitamin C (mg)	65·5	62·4, 68·8	95·9	82·1, 112·1	46·4	24·5, 72·1	<0·001	31·8	11·4, 55·9	0·001
Vitamin E (mg)	8·78	8·54, 9·03	14·45	13·32, 15·66	64·5	51·1, 79·2	<0·001	61·6	48·9, 75·2	<0·001
Ca (mg)	721	701, 74	859	774, 953	19·2	7·1, 32·7	0·001	15·8	4·4, 28·5	0·006
Cu (mg)	1·17	1·15, 1·20	1·92	1·76, 2·09	63·5	49·7, 78·6	<0·001	59·5	46·6, 73·5	<0·001
Fe (mg)	10·27	10·03, 10·51	12·85	11·78, 14·03	25·2	14·4, 37·0	<0·001	23·6	13·6, 34·6	<0·001
Mg (mg)	277	271, 283	415	385, 448	40	38·7, 62·2	<0·001	45·7	35·3, 56·9	<0·001
P (mg)	1250	1222, 1278	1571	1464, 1685	25·7	16·7, 35·3	<0·001	24·5	16·2, 33·4	<0·001
K (mg)	2790	2730, 2852	3478	3240, 3733	24·6	15·8, 34·2	<0·001	21·1	13·0, 30·2	<0·001
Se (μg)	44·9	45·4, 46·4	55·9	50·1, 62·4	24·6	11·2, 39·6	<0·001	25·3	11·6, 40·7	<0·001
Zn (mg)	9·53	9·31, 9·76	11·74	10·75, 12·81	23·1	12·3, 34·9	<0·001	24·2	14·4, 34·9	<0·001

%TE, percentage of total energy.
* All variables were log transformed and geometric means are presented, with differences reported as the percentage difference between geometric means.
† Adjustment for age, sex, ethnicity, BMI, New Zealand Index of Deprivation, education and smoking status.

provided about 10 %TE intake for whole nut consumers. Whole nuts also provided about 20 % of total fat intake for nut consumers, contributing about 8 %TE. When examining the different types of fat, it can be seen that whole nuts supplied about 11 % of SFA (contributing 3 %TE), with higher contributions of 27 % (4 %TE) to MUFA and 30 % (2·2 %TE) to PUFA. Whole nuts comprised approximately 10 % of the protein intake of nut consumers, providing 3·4 %TE. When broken down by sex, these did not differ to a meaningful extent between men and women, especially when looked at as percentages of total intake.

Discussion

This was the first study to assess dietary intake in relation to nut consumption, in a cross-sectional survey of a population from the Southern Hemisphere, more specifically New Zealand. This study confirms the results from dietary surveys undertaken in the USA, which show nut consumption is associated with an improvement in nutrient intakes and overall diet quality. Among nut consumers in New Zealand, nuts made a substantial contribution to TE, fat, MUFA, PUFA and dietary fibre. Nut consumers also had a more nutrient-dense diet in terms of micronutrients than did non-nut consumers.

We analysed the data both for whole nut consumers and total nut consumers. It has been previously postulated that ‘out-of-hand’ nut consumers may differ from total nut consumers, in that they make a conscious decision to consume nuts, which may be associated with a desire for a healthier lifestyle[9]. This group is similar to the whole nut consumers in the present study. Given total nut consumption included nuts from other sources, which include confectionery and snacks that contain added sugar, fat and salt, consuming whole nuts might be expected to be associated with improved diet quality compared with other total nut consumers. We found that SFA and carbohydrate when expressed as %TE were significantly lower for whole nut consumers compared with non-whole nut consumers, whereas this difference was not evident when comparing total nut consumers with non-nut consumers. Micronutrient intakes differed between nut consumers and

Table 3. Mean daily nutrient intake by consumption of total nuts in the 2008/09 New Zealand Adult Nutrition Survey*
(Mean values and 95 % confidence intervals)

Nutrients	Non-nut consumers (*n* 3554)		Total nut consumers (*n* 1167)		Unadjusted difference	95 % CI	Unadjusted *P*	Adjusted difference†	95 % CI	Adjusted *P*†
	Mean	95 % CI	Mean	95 % CI						
Energy (kJ)	7937	7735, 8145	9058	875, 9368	14·1	9·5, 18·9	<0·001	16	11·6, 20·6	<0·001
Protein (g)	75·3	73·4, 77·3	84·3	81·2, 87·5	11·8	7·0, 16·9	<0·001	12·6	8·0, 17·3	<0·001
Protein (%TE)	15·8	15·6, 16·1	15·5	15·2, 15·9	−1·8	−4·7, 1·1	0·217	−2·7	−5·6, 0·3	0·078
Total fat (g)	66·9	64·9, 69·0	82	78·8, 85·5	22·7	16·8, 28·8	<0·001	25·3	19·8, 31·1	<0·001
Total fat (%TE)	31·7	31·2, 32·2	34·1	33·5, 34·8	7·7	5·1, 10·4	<0·001	8·4	5·7, 11·2	<0·001
SFA (g)	25·6	24·7, 26·5	29·6	28·3, 31·1	15·9	9·4, 22·7	<0·001	19	12·7, 25·6	<0·001
SFA (%TE)	11·9	11·6, 12·1	12·1	11·8, 12·5	2·0	−1·6, 5·7	0·277	3·3	−0·4, 7·2	0·082
MUFA (g)	23·8	23·1, 24·6	29·9	28·6, 31·3	25·6	19·3, 32·2	<0·001	28·4	22·3, 34·7	<0·001
MUFA (%TE)	11·1	10·8, 11·3	12·2	11·9, 12·5	10·5	7·2, 14·0	<0·001	11·5	8·0, 15·6	<0·001
PUFA (g)	8·8	8·6, 9·1	12·5	11·9, 13·1	41·7	34·2, 49·4	<0·001	42	35·0, 49·3	<0·001
PUFA (%TE)	4·1	4·0, 4·2	5·1	5·0, 5·3	24·7	20·5, 29·1	<0·001	23·3	18·9, 27·9	<0·001
Carbohydrate (g)	216	211, 222	245	236, 254	13·2	8·3, 18·4	<0·001	14	9·2, 18·9	<0·001
Carbohydrate (%TE)	45·4	44·9, 46·0	45·1	44·2, 46·1	−0·6	−3·0, 1·8	0·598	−1·5	−3·8, 0·8	0·201
Sugars (g)	90	87, 94	109	105, 115	21·4	14·7, 28·3	<0·001	21·6	14·9, 28·6	<0·001
Sugars (%TE)	18·1	17·6, 18·7	19·4	18·7, 20·0	6·8	2·3, 11·5	0·003	5·5	1·0, 10·2	0·017
Cholesterol (mg)	208	199, 217	199	185, 214	−4·4	−11·7, 3·5	0·268	−1·9	−9·5, 6·4	0·649
Total dietary fibre (g)	19·2	18·7, 19·8	24·9	23·9, 25·9	29·6	23·5, 35·9	<0·001	26·8	21·1, 32·8	<0·001
Vitamin A (μg)	632	607, 657	705	663, 750	11·7	−3·7, 20·2	0·003	10·5	2·6, 19·1	0·009
Thiamin (mg)	1·12	1·08, 1·16	1·29	1·23, 1·35	15·6	9·2, 22·4	<0·001	15·7	9·3, 22·5	<0·001
Riboflavin (mg)	1·64	1·59, 1·69	1·84	1·77, 1·92	12·7	7·0, 18·6	<0·001	13·5	7·9, 19·3	<0·001
Niacin (mg)	15·2	14·8, 15·7	17·2	16·4, 18·0	12·9	6·7, 19·5	<0·001	13·8	7·8, 20·1	<0·001
Vitamin B_6 (mg)	1·49	1·44, 1·55	1·67	1·58, 1·76	11·9	4·9, 19·4	0·001	11·6	4·8, 18·9	0·001
Total folate (μg)	276	267, 285	327	311, 343	18·5	11·9, 25·6	<0·001	16·2	9·7, 23·0	<0·001
Vitamin B_{12} (μg)	3·01	2·88, 3·15	1·67	1·58, 1·76	−2·8	−10·2, 5·2	0·479	1·9	−9·5, 6·3	0·636
Vitamin C (mg)	62·3	58·8, 65·9	81·4	75·1, 88·2	30·8	18·5, 44·3	<0·001	20·6	9·1, 33·3	<0·001
Vitamin E (mg)	8·33	8·07, 8·59	11·25	10·78, 11·74	35	28·3, 42·0	<0·001	34·3	27·9, 41·2	<0·001
Ca (mg)	687	665, 709	847	809, 887	23·4	17·0, 30·2	<0·001	21·8	15·6, 28·2	<0·001
Cu (mg)	1·11	1·08, 1·14	1·5	1·44, 1·57	35·5	29·0, 42·3	<0·001	33·5	27·2, 40·0	<0·001
Fe (mg)	9·93	9·67, 10·20	11·76	11·29, 12·25	18·4	12·9, 24·2	<0·001	18·1	12·9, 23·6	<0·001
Mg (mg)	263	257, 270	345	332, 358	39·9	25·4, 36·8	<0·001	29·9	24·7, 35·3	<0·001
P (mg)	1205	1175, 1236	1443	1393, 1493	19·7	14·8, 24·7	<0·001	19·5	14·9, 24·3	<0·001
K (mg)	2719	2653, 2787	3133	3020, 3251	15·2	10·3, 20·4	<0·001	14·1	9·5, 18·9	<0·001
Se (μg)	44·2	42·7, 45·9	49	46·5, 51·6	10·7	4·1, 17·7	0·001	11·5	4·9, 18·5	<0·001
Zn (mg)	9·27	9·02, 9·52	10·74	10·31, 11·19	15·9	10·4, 21·7	<0·001	16·8	11·5, 22·3	<0·001

%TE, percentage of total energy.
* All variables were log transformed and geometric means are presented, with differences reported as the percentage difference between geometric means.
† Adjustment for age, sex, ethnicity, BMI, New Zealand Index of Deprivation, education and smoking status.

Table 4. Contribution of whole nuts to daily energy and nutrients overall and for whole nut consumers in the 2008/09 New Zealand Adult Nutrition Survey
(Mean values and 95 % confidence intervals)

Contribution of nuts to energy and nutrients	Total sample (*n* 4721)		Whole nut consumers (*n* 240)	
	Mean	95 % CI	Mean	95 % CI
Energy (kJ)	69	52, 87	1007	832, 1182
Total energy intake (%)	0·7	0·5, 0·9	10·2	8·5, 11·9
Total fat (g)	1·4	1·1, 1·8	20·8	17·4, 24·3
Total fat intake (%)	1·4	1·1, 1·8	21·0	18·1, 23·8
Total energy from fat (%)	0·5	0·4, 0·7	7·8	6·6, 9·1
SFA (g)	0·2	0·2, 0·3	3·2	2·5, 3·8
SFA intake (%)	0·8	0·6, 1·0	11·0	8·8, 13·3
Total energy from SFA (%)	0·1	0·1, 0·1	1·2	0·9, 1·4
MUFA (g)	0·8	0·6, 0·9	10·8	9·1, 12·6
MUFA intake (%)	1·8	1·4, 2·2	26·7	23·3, 30·0
Energy from MUFA (%)	0·3	0·2, 0·4	4·1	3·4, 4·7
PUFA (g)	0·4	0·3, 0·5	5·8	4·8, 6·8
PUFA intake (%)	2·0	1·6, 2·5	29·7	26·1, 33·2
Energy from PUFA (%)	0·2	0·1, 0·2	2·2	1·8, 2·6
Protein (g)	0·6	0·5, 0·8	9·1	7·3, 10·9
Protein intake (%)	0·7	0·5, 0·9	9·8	7·9, 11·7
Energy from protein (%)	0·2	0·2, 0·3	3·4	2·7, 4·0

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non-nut consumers for both whole nut and total nut intakes, although the differences were more pronounced for most nutrients among whole nut consumers.

Tree nuts and peanuts are rich sources of MUFA and PUFA, although low in SFA. This is reflected in the intakes of whole and total nut consumers, where the intake of unsaturated fats was significantly higher among nut consumers both in absolute terms and when expressed as %TE intake. Conversely, when SFA was expressed as %TE, intake was significantly lower in whole nut consumers. Intakes of dietary fibre were also higher among nut consumers compared with non-nut consumers. It is plausible that these intakes may account for much of the beneficial effects of nuts on cardiovascular health observed among nut consumers in both epidemiological[24–27] and clinical studies[28–30].

The 2008/09 NZANS reported that the mean contribution of SFA to daily energy intake among the New Zealand population was 13·1 % for both males and females, which is above the acceptable macronutrient distribution range of <10 %[31]. Conversely, the contribution to daily energy from both MUFA (12·4 and 13·3 % for males and females, respectively) and PUFA (4·8 and 4·9 % for males and females, respectively) was lower than that was reported for SFA. A heart-healthy dietary fatty acid profile promotes predominantly unsaturated fats, with low intakes of SFA. Given the fatty acid composition of nuts, and our data indicating a more favourable dietary fatty acid intake among nut consumers, increasing the nut intake of the general population is likely to result in positive effects on risk factors for chronic disease, in particular CVD.

Nut consumers also had significantly higher intakes of many micronutrients including thiamin, niacin, riboflavin, vitamin B_6, folate, vitamin C, vitamin E, Ca, Cu, Fe, Mg, P, K, Se and Zn. Of these folate, vitamin E, Cu, Mg, P, K and Zn remained significantly higher when additionally adjusted for energy intake. The nutrient compositions of different nuts vary, but particular nuts can be good sources of vitamin E, folate, Mg, Ca, Zn, Cu and Se. Therefore, the inclusion of nuts into the regular diet may improve the adequacy of intake of many of these essential micronutrients. It is important to note that for some of these nutrients the risk of inadequate intake among the New Zealand population was relatively high[31]. For example, the risk of inadequate intake of Ca, Se and Zn was 59, 45 and 25 %, respectively. In addition, it was noted in the USA that tree nut consumers had higher intakes of 'shortfall' nutrients in the USA, including fibre, vitamin E, Ca and Mg[7]. In addition, a recent analysis of the NHANES 2005–2010 cohort using usual intake data found that tree nut consumers were less likely to have inadequate intakes of vitamins A, E and C, folate, Ca, Fe, Mg and Zn compared with non-consumers[8].

Our findings are in general agreement with that of other national nutrition surveys from the USA, which have reported greater intakes of unsaturated fat and a number of micronutrients among nut consumers in comparison with non-consumers[7,9,10]. Using NHANES 1999–2004 data, O'Neil *et al.*[7] reported that intakes of fibre, vitamins A, B_6, C, E and K, thiamin, riboflavin, folate, Ca, Mg, P, Fe, Zn, Cu and Mg were higher, whereas the intake of Na was lower among tree nut consumers compared with non-consumers. Similarly, using data from the What We Eat in America/NHANES 2001–2004, King *et al.*[10] reported that, among individuals reporting consumption of nuts as snacks, nuts contributed between 25 and 35 % of selected nutrients including fat, PUFA, MUFA, linoleic acid, Mg, Cu and vitamin E. This is similar to our study where whole nuts contributed 27 % (4 %TE) to MUFA and 30 % (2·2 %TE) to PUFA intake. King *et al.*[10] also identified nutrients and food components that were consumed in significantly higher quantities by nut consumers compared with non-nut consumers, namely vitamins E and K, folate, β-carotene, lutein, zeaxanthin, Mg, P, Cu, Se, K and Zn. Conversely, vitamin B_{12}, retinol, lycopene and Na were consumed in significantly lower amounts by nut consumers[10]. In our study, vitamin B_{12} was the only nutrient consumed in significantly lower quantities among nut consumers. It is possible that this may reflect the higher rates of nut consumption among vegetarians and vegans.

The results of the present study should be interpreted with several limitations in mind. First, the cross-sectional design of the study means that we cannot draw causal inferences. Although a better diet quality was observed among nut consumers compared with non-nut consumers in our study and others due to the addition of nutrient-dense nuts to the diet, an alternative explanation is that nut consumption may be a marker of a better diet overall or an indicator of particular dietary patterns (such as vegetarianism). Thus, residual confounding where a healthier lifestyle may mediate the association of nuts with diet quality and health outcomes cannot be excluded. Although BMI and smoking status were collected as part of the 2008/09 NZANS, measures of physical activity were not. Nut consumers may simply be more health conscious than non-nut consumers. In addition, dietary intake included only one 24-h diet recall for the majority of participants and therefore may not represent usual nut intake. Under (and potentially over)-reporting can also be an issue given that diet was self-reported. We were unable to discriminate between under-reporters and under-consumers; thus, all participants were included in the analysis. However, rigorous coding of food items collected through a multi-stage process and the use of New Zealand-specific food composition data allow confidence in the collected estimates of intake for both nuts and nutrients. In addition, 24-h recalls yield reasonably accurate group estimates of nutrient intake[32]. Even if there are biases leading to under- or over-reporting of total dietary intakes, there are no reasons to suspect these would affect the associations reported here. Other strengths of the study include its large sample size, permitting precise estimation of effects, and the use of a representative, after weighting, population-based sample.

Conclusions

This is the first study using national data from a population in the Southern Hemisphere, more specifically New Zealand, to examine the effects of nut consumption on dietary intake. In agreement with the results of other studies conducted in the USA, nut consumption was associated with improved nutrient profiles, especially an increase in unsaturated fats and a number of essential vitamins and minerals, which could collectively reduce the risk for chronic disease, in particular for CVD.

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The authors' contributions were as follows: R. C. B., W. P., A. R. G. and E. F. designed and/or conducted the research; R. C. B. performed the statistical analyses with assistance from A. R. G.; C. S., E. F. and R. C. B. managed the dietary analysis; W. P. was the principal investigator of the 2008/09 New Zealand Adult Nutrition Survey; R. C. B., S. L. T., A. R. G. and A. C. wrote the manuscript; all authors reviewed and approved the final manuscript.

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