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THE EFFECT OF REGULAR HAZELNUT CONSUMPTION ON CARDIOVASCULAR RISK FACTORS AND ACCEPTANCE IN MĀORI AND EUROPEAN

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ABSTRACT

Aims Studies reporting reductions in heart disease risk with regular nut consumption comprise populations largely of European descent. Whether the healthful effects of nuts extend to other ethnic groups is largely unknown. This study compared the effects of consuming 30 g/d of hazelnuts on risk factors for cardiovascular disease (CVD) and acceptance amongst Māori and Europeans. Methods Twenty Māori and 19 European participants consumed 30 g/d of hazelnuts for 28 days. Plasma lipids and lipoproteins, apolipoproteins (apo), high sensitivity C-reactive protein (hs-CRP), blood pressure, dietary intake, and body weight were measured at baseline and at the end of the intervention. 'Desire to consume' and 'overall liking' for hazelnuts were assessed daily. Results There were no significant differences in the changes of any of the outcome measurements between Māori and Europeans (P≥0.145). Further, there were no significant changes among participants overall in biochemical indices, blood pressure, body weight, BMI, or body composition (P≥0.114) aside from systolic blood pressure which decreased by 3% (P=0.031) and hs-CRP which increased by 0.21 mg/dl (P=0.047) during the study. However, the hazelnut-enriched diet significantly increased energy, total fat, monounsaturated and polyunsaturated fat intake in study participants (all P≤0.006), with no changes for other nutrients (all P≥0.116) or difference between groups (all P≥0.513). 'Desire to consume' and 'overall liking' remained relatively stable over the 28-day intervention period. Conclusions There was no evidence of difference in effects on CVD risk factors between Māori and European following regular consumption of nuts. It appears both ethnic groups continued to like nuts and wished to consume them daily after consuming nuts for 28-days, suggesting adherence to guidelines to consume nuts regularly is achievable in both populations.

Keywords: Hazelnuts, Ethnicity, Cardiovascular disease risk, Acceptance, Nuts.

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Contribution/ Originality

This study is one of very few studies, which have investigated the effects of nuts on different ethnic groups. Our results suggest that the health benefits and acceptability of nuts seen in predominantly Caucasian populations can be extended to Māori, the indigenous population within New Zealand.

1. INTRODUCTION

Cardiovascular disease is the leading cause of death in many developed countries, including New Zealand (NZ) [1, 2]. In particular the health statistics regarding heart disease are disproportionately worse for the Māori population in NZ, as is also the case for other indigenous populations around the world. For example CVD mortality is more than two and a half times that of non-Māori [3]. In addition, Māori are twice as likely to be hospitalised for CVD compared with non-Māori [3]. Therefore the identification of strategies to reduce risk of CVD in this group is a priority. One strategy is to promote the regular consumption of nuts. Epidemiological evidence suggests that the risk of coronary heart disease is lower in those who regularly consume nuts compared to non-nut consumers [4-6]. In addition, randomised controlled trials consistently show reductions in total and low-density lipoprotein (LDL) cholesterol following nut consumption [7-11]. Effects of frequent nut consumption on triacylglycerol and HDL-C concentrations and blood pressure are less conclusive. Furthermore, some but not all studies report improvements in markers of inflammation [12, 13]. Importantly, although nuts are energy dense, most intervention studies report no significant weight gain with the addition of nuts to the habitual diet [14-18].

For nuts to provide these health benefits they must be consumed regularly and in sufficient quantity. To this end the National Heart Foundation of NZ recommends the daily consumption of 30 g of nuts as part of a heart healthy diet [19]. Only six studies have investigated whether such recommendations are achievable and sustainable [14, 20-24]. Tey et al showed that both 'desire to consume' and 'overall liking' remained stable over five days to 12 weeks of daily consumption of 30 to 42 g of nuts [21, 22, 24]. Similarly, Alper et al have reported continued liking of peanuts after daily consumption of peanuts over 19 weeks [14]. A study by McKiernan, et al. [20] is the only intervention that has investigated the effects of different types of nuts on hedonic ratings using participants from different ethnic groups [20]. However the authors only reported combined group results, where the hedonic ratings did not change from baseline to the end of the study. Collectively these studies indicate that regular nut consumption does not affect acceptance. However the majority of the studies were performed in predominantly Caucasian populations. Therefore it is not known whether the results can be extrapolated to different ethnic groups. Given the high rates of CVD in Māori, regular consumption of nuts may be especially useful for reducing the risk factors for heart disease within this population. Therefore it is important to investigate whether the health benefits and acceptability of nuts seen in predominantly Caucasian

populations can be extended to Māori. The aim of the present study was to compare the effects of consuming 30 g/d of hazelnuts for 4 weeks on risk factors for CVD and acceptance in Māori and European participants.

2. METHODS

2.1. Participants

Participants were recruited from the general public in Dunedin, NZ. The recruitment process involved the distribution of flyers around the University of Otago campus, University Halls of Residence, the Otago Polytechnic campus and through the University of Otago Māori networks. Māori respondents to the advertisements were asked to recruit a friend control of European descent, of the same sex with a similar age (within 1 year) and body mass index (BMI) ($< 1 \ kg/m^2$ difference) to produce comparable groups both in terms of these factors and for other potential confounders. To be eligible, participants were required to be free-living Māori and European males and females aged above 18 years living in Dunedin and surrounding areas. Participants were excluded if they had allergies or intolerances to nuts, were on medication known to affect blood lipid levels, had familial or secondary hyperlipidaemia or a condition known to affect blood cholesterol levels, were a smoker, pregnant or lactating.

The study was approved by the Human Ethics Committee, University of Otago, New Zealand. Written informed consent was obtained from all participants. The trial was registered in the Australian New Zealand Clinical Trials Registry, ACTRN12611000230954.

2.2. Study Design

This single intervention study compared the effects of consuming 30 g/d of hazelnuts for 28 days on risk factors for heart disease and acceptance between Māori and European. The study was based on the National Heart Foundation recommendation for people to consume 30 g/d of nuts [25]. As part of the study, participants were asked to consume 30 g of whole, raw hazelnuts each day for a period of 28 days. No other dietary information was provided.

2.3. Nut Variety

Raw, unsalted Ennis hazelnuts were purchased from a NZ producer (Uncle Joe's Walnuts, Blenheim, NZ). All nuts used in the present study were stored at room temperature in darkness before opening to ensure freshness.

2.4. Compliance

All nuts were individually portioned into daily serving size bags (30 g/d). Compliance was measured by weighing the returned bags and by completion of the home-use sensory test ballot.

2.5. Dietary Assessment

A 24-hour recall was performed by phone at baseline and during the intervention period. Participants were unaware of the day these recalls would be performed. All recalls were analysed to provide an estimate of energy and nutrient intakes using the diet programme Diet Cruncher [26], which utilises the NZ Food Composition Database [27].

2.6. Biochemical Analysis

Fasting venous blood samples were taken at baseline and at the end of the 28-day dietary intervention. Two blood samples were taken during each testing week to account for intra-individual variation in blood cholesterol concentration. A total of 10 mL of blood was collected into Vacutainers (Becton Dickinson Diagnostics, Franklin Lakes, NJ, USA) containing dipotassium EDTA for analysis of plasma lipids, apo A and B100, and hs-CRP. Plasma aliquots were then stored at -80°C until analysis. Plasma total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C) and triacylglycerol (TAG) concentrations were measured in all blood samples by enzymatic methods using kits and calibrators supplied by Roche Diagnostics (Mannheim, Germany) on a Cobas Mira Plus Analyser. HDL-C was measured in the supernatant following precipitation of apo B containing lipoproteins with phosphotungstate-magnesium chloride solution [28] LDL-C concentration was calculated using the Friedewald formula [29]. Apo A1 and apo B100 concentrations were determined by immunoturbidimetry using commercial kits from Roche Diagnostics. Hs-CRP was measured using a Unimate kit from Roche Diagnostics in the Cobas Mira Plus analyser. Calibration and quality control was maintained by participation in the Royal Australasian College of Pathologists Quality Assurance Programme. The coefficients of variation for plasma TC, HDL-C and TAG were 2.3 %, 8.1 % and 0.9 % respectively. The coefficients of variation for measurements of apolipoprotein A1 and B100 was 1.6 % and 2.2 % respectively, and for hs-CRP was 3.3 %.

2.7. Anthropometric Measurements

Height was measured to the nearest millimeter using a stadiometer at baseline. Body weight and composition were measured in the morning in the fasting state at baseline and at week-4. Participants were weighed in light clothing without footwear on a bioelectrical impedance analysis device (Tanita BC-418, Tanita, Tokyo, Japan) that measured to the nearest 0.01 kg.

2.8. Blood Pressure

Blood pressure was measured in triplicate at baseline and the end of the intervention using an Omron blood pressure monitor (Model HEM-907, Omron Healthcare, Hoofddorp, Netherlands) after participants had been seated for five minutes.

2.9. Sensory Testing

'Overall liking' ratings of the hazelnuts were measured in three stages; during a pre-exposure tasting session; a 28-day home-use exposure period; and a post-exposure tasting session.

Pre and post-exposure session. Participants attended a pre-exposure tasting session at baseline and a post-exposure tasting session at the end of the intervention at the sensory laboratory, Department of Food Science, University of Otago. Participants were given a detailed briefing regarding the nature of the study before testing began.

The tasting session involved a 15-minute product assessment acceptability test. Participants were seated in individual sensory booths and presented with six food items including hazelnuts, chocolate, potato crisps, salted peanuts, rice crackers and raisins. The order of presentation of all foods was balanced among participants to avoid biases from any possible order and carry over effects. Before starting the test and between samples, participants were asked to rinse their mouth with water. Participants were asked to taste each food and rate their 'overall liking' on a 150 mm visual analogue scale (VAS) anchored with 'dislike extremely' on the left hand side (0 mm), 'neither like nor dislike' in the middle (75 mm) and 'like extremely' on the right-hand side of the scale (150 mm). Participants were asked to wait at least one minute between foods and not to converse during testing. *Home-use exposure ballots.* During the 28-day home-use exposure period, participants were asked to consume the 30 g daily allowance of hazelnuts at any time of day. Participants were instructed that the nuts were solely for their own personal consumption and should not be shared with others. Nuts were available for family/Whanau/friends upon conclusion of the study. During the exposure period, participants were asked to complete a ballot whenever they consumed the nuts. Firstly, participants were asked to take one hazelnut and rate their 'desire to consume' on a 150 mm VAS anchored with 'strong desire not to consume' on the left-hand side (0 mm) to 'strong desire to consume' on the right-hand side of the scale (150 mm). Next, they were asked to consume the rest of the nuts and rate their 'overall liking' using the same 150 mm VAS that was used in the pre-exposure tasting session.

2.10. Statistical Analysis

In order to have 80% power to detect the smallest interesting difference of 0.3 mmol/L in total cholesterol, using a 2-sided test with the level of significance set to 0.05, assuming a standard deviation of 0.7 and correlations between repeated measures of at least 0.8 (values based on our previous research), 31 participants in each group were required to provide both baseline and follow up measures. Based on our other studies in this area, no loss to follow-up was expected. The outcome variables included biochemical indices, energy and nutrient intakes, body composition, blood pressure, 'desire to consume' and 'liking' of the nuts. As some participants were unable to provide appropriate controls, matching was broken for the purposes of analyses and the two groups compared to ensure they were comparable in terms of matching characteristics. Regression using follow-up values and adjusting for baseline values was used to

compare differences in the change in variables over the intervention period between Māori and European. Paired t-tests were used to compare differences in outcome variables from baseline to the end of the intervention for both groups combined where there was no evidence of between group differences. Standard regression diagnostics were used including histograms of residuals and plots of residuals against fitted values. Where there was evidence of positive skew or heteroscedasticity in the residuals, a log-transformation was investigated and retained where this improved the behaviour of residuals. In an unplanned analysis, Pearson's correlation was used to explore any association between change in weight and change in energy. All statistical analyses were performed using Stata Intercooled version 13.1 (StataCorp, College Station, TX, USA). All tests were two-sided, with the level of statistical significance set at 5%. As the study was intended to be exploratory, no adjustments were made for multiple comparisons, and caution should be taken when interpreting marginal results.

3. RESULTS

3.1. Participant Characteristics

Forty-four participants were recruited for the study in the time available, fewer than the sixty-two indicated in the above power analysis. Of these, one participant withdrew at week three due to over-commitment. A further three participants withdrew from the study due to personal issues unrelated to the study at weeks one and three respectively. One remaining participant was excluded due to their later involvement with the study. A total of 39 participants successfully completed the study. This included 20 Māori (12 females, eight males) and 19 European (14 females, five males). Participants ranged in age from $18 - 34$ years, with a mean (SD) age of 21.4 (2.7). Baseline characteristics were well balanced for the two groups (Table 1) with no evidence of practically meaningful or statistically significant differences (all $P \geq 0.242$).

Table-1. Participant characteristics

	Total (n=39)	Māori ($n = 20$)	European ($n = 19$)	p-value for difference
Female, no. (%)[a]	26 (67)	12 (60)	14 (74)	0.365
Age (years)[b]	21.4 (2.7)	21.6 (3.3)	21.1 (2.0)	0.539
BMI (kg/m²)[c]	25.0 (1.1)	25.5 (1.1)	24.4 (1.1)	0.281
Height (cm)[b]	172.3 (9.4)	173.2 (8.2)	171.3 (10.6)	0.537
Body weight (kg)[c]	73.9 (1.2)	76.3 (1.2)	71.5 (1.2)	0.242

Values are [a]n (%), [b]arithmetic mean (arithmetic SD), or [c]geometric mean (geometric SD).
Tests for differences are χ^2 test for sex and independent sample t-tests otherwise using the [b]original or [c]log scales.

3.2. Compliance

The degree of compliance as assessed by a recount of nut packages and completion of the home-use sensory test ballot was reportedly high: 97.3% for European and 99.3% for Māori.

3.3. Nutrient Intakes

There were no significant differences in the changes of energy and macronutrient intakes between Māori and European groups (Table 2, all $P \geq 0.513$). However, energy intake increased significantly during the intervention compared to baseline ($P=0.006$). In addition, there were significant increases during the nut-enriched diet for total fat ($P<0.001$), MUFA ($P<0.001$) and PUFA ($P=0.002$) intake.

Table-2. Mean daily energy and nutrient intakes at baseline and during the intervention[a]

	Māori (*n* = 18)		European (*n* = 17)		*P* value between groups[b]	Change[c]	
	Baseline	Intervention	Baseline	Intervention		Estimate (95% CI)[d]	*P* value
Energy (kJ)	7213 (5910–8802)	8974 (7126–11301)	7669 (6203–9482)	9029 (7644–10664)	0.820	1.21 (1.06–1.38)	0.006
Carbohydrate (g)	208.9 (178.8–244.0)	235.4 (193.7–286.1)	231.6 (189.9–282.4)	253.9 (207.5–310.7)	0.840	1.11 (0.97–1.27)	0.116
Protein (g)	74.1 (61.0–89.9)	76.8 (62.6–94.3)	82.3 (60.8–111.4)	79.1 (55.6–112.6)	0.788	1.00 (0.85–1.18)	0.999
Total Fat (g)	61.2 (48.5–77.0)	83.2 (70.2–98.5)	56.3 (39.7–79.9)	83.6 (67.7–103.2)	0.840	1.42 (1.17–1.72)	<0.001
SFA (g)	23.2 (18.1–29.7)	26.5 (20.3–34.7)	23.5 (16.4–33.7)	27.8 (21.0–36.9)	0.798	1.16 (0.95–1.43)	0.142
MUFA (g)	20.3 (15.2–27.3)	34.0 (28.8–40.0)	18.5 (12.8–26.9)	33.9 (28.2–40.8)	0.906	1.75 (1.40–2.18)	<0.001
PUFA (g)	9.0 (7.0–11.5)	11.9 (10.2–13.7)	7.3 (4.9–10.8)	11.2 (8.7–14.4)	0.899	1.42 (1.14–1.77)	0.002
Cholesterol (mg)	238.8 (138.3–412.4)	192.8 (113.5–327.6)	172.8 (117.8–253.6)	219.8 (158.1–305.7)	0.513	1.01 (0.68–1.49)	0.972

[a]All values are geometric mean (95% CI)
[b]The between-group results were obtained from regression models comparing follow-up values between ethnic groups adjusting for baseline values on the log-scale
[c]Using data from both groups as there was no evidence of differential changes
[d]Ratio of geometric means. A value of 1.12, for example, would indicate an increase of 12% in the geometric mean from baseline to follow-up.

3.4. Biochemical Indices and Blood Pressure

There were no statistically significant differences in the changes in plasma TC, LDL-C, HDL-C, TC:HDL-C ratio, TAG, apoA1, apoB100, and diastolic blood pressure between Māori and European (all $P \geq 0.145$, Table 3). Moreover there were no statistically significant differences in these variables within the groups from baseline to the end of the intervention (all $P \geq 0.114$) except for systolic blood pressure which decreased by 3% (95% CI 0–6%, $P=0.031$) and hs-CRP which increased by 41% (95% CI 1–98%, $P=0.047$) during the study period.

3.5. Body Weight

Body weight and composition did not significantly differ between the groups (all $P \geq 0.439$, Table 3). Twenty-eight days nut consumption did not result in any significant change in body weight or composition (all $P \geq 0.330$) despite the above change in energy. There was no evidence of a correlation between change in weight and change in energy ($P=0.921$).

Table-3. Biochemical indices, blood pressure, and body composition at baseline and at week-4

	Māori (*n* = 21)		European (*n* = 19)		P value between groups[b]	Change[c]	
	Baseline	Intervention	Baseline	Intervention		Estimate (95% CI)[d]	P value
Body composition							
Body weight (kg)	76.3 (70.4–82.7)	76.3 (70.4–82.7)	71.5 (65.8–77.6)	71.8 (66.0–78.1)	0.476	1.00 (1.00–1.01)	0.456
BMI (kg/m²)	25.5 (23.9–27.2)	25.5 (24.0–27.2)	24.4 (23.3–25.7)	24.4 (23.2–25.6)	0.439	1.00 (0.99–1.01)	0.938
Body fat (%)	26.9 (23.9–30.3)	27.3 (24.7–30.2)	25.9 (21.8–30.7)	26.6 (22.1–32.0)	0.602	1.02 (0.98–1.06)	0.330
Blood pressure							
Systolic (mm Hg)	123.6 (114.9–133.0)	117.1 (109.9–124.7)	120.1 (113.4–127.3)	118.4 (112.1–125.1)	0.213	0.97 (0.94–1.00)	0.031
Diastolic (mm Hg)	67.7 (62.7–73.2)	68.5 (65.3–71.8)	65.5 (60.5–71.0)	65.1 (60.8–69.6)	0.331	1.00 (0.95–1.06)	0.949
Biochemical indices							
TC (mmol/L)	4.14 (3.77–4.54)	4.17 (3.81–4.56)	3.96 (3.63–4.31)	3.93 (3.60–4.30)	0.628	1.00 (0.97–1.03)	0.983
LDL-C (mmol/L)	2.46 (2.17–2.79)	2.42 (2.15–2.74)	2.28 (2.01–2.59)	2.25 (1.97–2.57)	0.919	0.99 (0.94–1.04)	0.556
HDL-C (mmol/L)	1.16 (1.06–1.26)	1.19 (1.06–1.33)	1.16 (1.01–1.32)	1.18 (1.06–1.32)	0.399	1.02 (0.99–1.06)	0.128
TAG (mmol/L)	1.01 (0.84–1.22)	1.04 (0.87–1.25)	0.96 (0.81–1.13)	0.94 (0.78–1.12)	0.445	1.01 (0.95–1.07)	0.834
Apo A (g/L)	1.51 (1.41–1.61)	1.57 (1.48–1.68)	1.51 (1.39–1.66)	1.52 (1.40–1.65)	0.145	1.02 (0.99–1.05)	0.114
Apo B100 (g/L)	0.71 (0.63–0.80)	0.70 (0.62–0.80)	0.65 (0.57–0.74)	0.63 (0.55–0.73)	0.704	0.98 (0.94–1.03)	0.371
Hs-CRP (mg/dL)[e]	0.42 (0.22–0.80)	0.70 (0.39–1.24)	0.69 (0.36–1.31)	0.83 (0.53–1.30)	0.187	1.41 (1.01–1.98)	0.047

[a]All values are geometric mean (95% CI)
[b]The between-group results were obtained from regression models comparing follow-up values between ethnic groups adjusting for baseline values on the log-scale
[c]Using data from both groups as there was no evidence of differential changes
[d]Ratio of geometric means . A value of 1.02, for example, would indicate an increase of 2% in the geometric mean from baseline to follow-up and a value of 0.97 would indicate a decrease of 3%.
[e]Observed zero values were increased to 0.1 prior to analysis

3.6. Sensory Tests

'Overall liking' of hazelnuts at pre- and post-exposure. There was no statistically significant difference in changes in overall liking for hazelnuts between Māori and European (*P*=0.945) (Figure 1). Paired t-test showed no statistically significance differences in 'overall liking' from the pre- to post-exposure sessions (*P*=0.542).
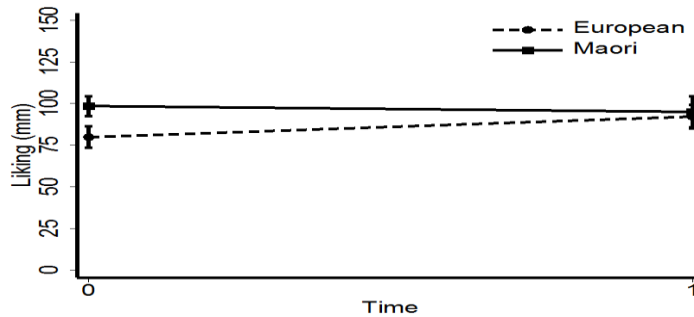
Figure-1. 'Overall liking' for hazelnuts for Māori and European at pre- and post-exposure

'Overall Liking' and 'desire to consume' during exposure period. Overall liking remained relatively stable over the 28-day period in both Māori and European (Figure 2). Liking remained high in both groups over the intervention period (i.e. above the mid-point). The ratings for 'desire to consume' show a similar pattern to the 'overall liking' ratings (Figure 3).
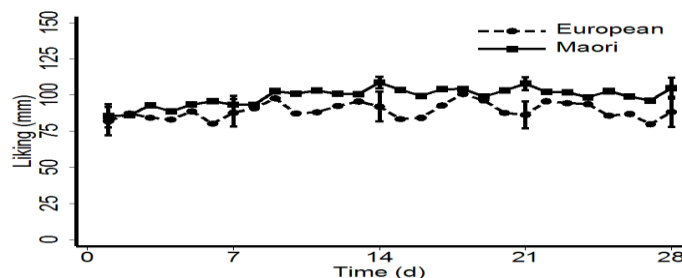
Figure-2. 'Overall liking' for hazelnuts for Māori and European during the exposure period
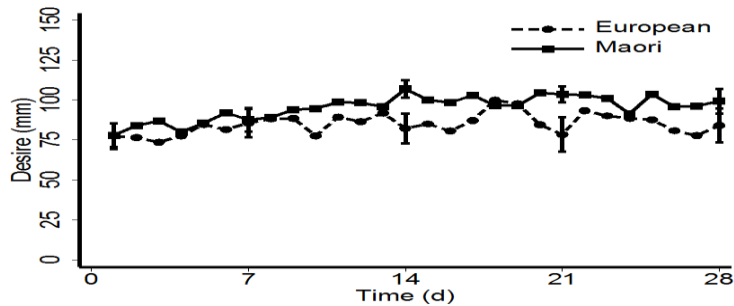
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Figure-3. 'Desire to consume' hazelnuts for Māori and European during the exposure period

4. DISCUSSION

The main finding of this study was that there were no significant differences in changes in risk factors for heart disease and acceptance between Māori and Europeans after consuming nuts daily for 28 days. To the best of our knowledge, this is the first study to compare the health benefits and acceptability of regular nut consumption in two different ethnic groups. It is well documented that, similar to many indigenous populations, Māori have poorer health statistics than those of European descent living in NZ [2]. In terms of heart disease, mortality rates among Māori are more that twice that observed in NZ Europeans [3]. This suggests that the health benefits observed with the regular consumption of nuts in both epidemiological studies and clinical trials might also extend to Māori.

Whereas most previous research has consistently reported that the regular consumption of nuts results in favourable changes in blood lipid and lipoprotein profiles [8-11], our study failed to show changes in these indices, although there was evidence for a reduction in systolic blood pressure alongside an apparent increase in hs-CRP. The cholesterol-lowering properties of nuts are largely due to their unsaturated fat content, but also due to other bioactive compounds [30, 31]. Similar to previous studies, we observed a significant increase in unsaturated fat intake with the addition of nuts to the regular diet [18, 24]. A lack of change for lipids in our study is likely to be due to the fact that the groups studied were both healthy and relatively young. Previously Tey et al reported significant reductions in both total (3.4%) and LDL-C (5.5%) and an increase in HDL-C (3.3%) after consuming 30 g/d of three different forms (whole, sliced and ground) of hazelnuts for 4 weeks each [11]. However the mean age of the study participants was 50 years and mean baseline TC and LDL-C concentrations were 5.8 mmol/L and 4.0 mmol/L respectively. In comparison, in the present study, the mean age was 22 years for Māori and 21 years for Europeans with a mean baseline total cholesterol of 4.1 mmol/L and 4.0 mmol/L and a mean LDL-C of 2.5 mmol/L and 2.3 mmol/L for Māori and Europeans respectively. Given the relatively young age and low baseline TC and LDL-C concentrations of our participants, it is not surprising that we did not see any significant changes. Recent research reported the magnitude of

change in blood cholesterol following regular nut consumption was dependent on the baseline concentrations [32, 33].

We reported a significant reduction in systolic blood pressure with nut consumption over 28 days. A recent epidemiology study reported an inverse association between nut consumption and risk of hypertension in lean individuals [34]. However trials on nut consumption and blood pressure have produced equivocal results with the majority reporting no effect [35, 36]. Although several small intervention studies have reported reductions in blood pressure these need to be repeated in larger trials before any firm conclusions on the effects of nuts on blood pressure can be made.

An unexpected finding of the present study was a statistically significant increase in hs-CRP, which is inconsistent with most of the previous literature. The majority of studies investigating the effects of regular nut consumption on inflammatory markers have reported no significant differences between nut-enriched diets and baseline or a comparison diet [37-45]. One previous study over 8-weeks reported a statistically significant increase in hs-CRP from baseline to the end of study with the addition of walnuts, however this increase did not differ significantly to those consuming cashew nuts or no nuts (control) [46]. Thus our findings on this point should be interpreted with caution.

An important finding of this study was there were no between or within group changes in body weight, despite a reported 21% increase in energy intake during the study. The 30 g of hazelnuts contained approximately 790 kJ and no advice was given regarding substitutions. Although nuts are high in fat and energy dense, a number of studies have shown that their regular inclusion into the diet results in less weight gain than is predicted [14-18]. This is the first study that has shown this in an ethnic group with a higher prevalence of overweight and obesity [3]. There have been several reported reasons for this less-than-predicted weight gain observed with the inclusion of nuts into the regular diet. These include an increase in satiety due to the protein and fibre content of nuts; an increase in energy expenditure due to the high unsaturated fat content; and loss of energy in the faeces as a result of the indigestibility of the cell wall and/or incomplete mastication [47-50].

The acceptance of nuts over the intervention period was similarly high amongst Māori and European. The tasting session results showed that the 'overall liking' of the nuts remained high (i.e. above the midpoint) in both groups after consuming them for 4 weeks. Additionally, and important from a public health viewpoint, 'desire to consume' the nuts also remained stable over the intervention period. These results indicate that both groups not only continued to like the nuts, they also continued to wish to eat the nuts. There was no evidence of monotony (or boredom), a decrease in acceptance for the food, which can lead to the reduction in the intake of the food over time [51]. Therefore this result indicates that the likelihood of adhering to the dietary recommendation to consume nuts regularly is high. Tey et al reported similar results in predominantly European groups, where both liking and desire to consume remained high after

consuming 30 to 42 g/d of nuts for 5 days to twelve weeks [21-24]. Alper et al also showed hedonic ratings for peanuts remained stable over a 19-week intervention [14]. Taken together with the results of the present study, nuts appear to be a food with a relatively high hedonic rating and are resistant to monotony effect, regardless of ethnicity. Thus, nuts can be consumed regularly long-term.

There are several limitations to take into account when interpreting the results of the present study. Firstly, the sample size was smaller than expected which reduced the study's power by a quarter from the planned level. However, the precision of the results from the study are reflected in the widths of the confidence intervals and those presented here suggest that any effects on biochemical indices (other than hs-CRP), blood pressure, and body composition from consuming nuts are likely to be modest. Also the study duration was only one month. Although this time period has been reported to be sufficient to observe changes in blood lipids and lipoproteins [52], longer-term studies are required to determine the prolonged effects on other health outcomes such as body weight. Further, there was no control group, which meant we were unable to examine the effects of consuming nuts per se. We were limited to the comparison of the effects of consuming nuts between 2 different ethnic groups. Lastly, both groups were relatively young and healthy, limiting the extrapolation of the study results.

5. CONCLUSIONS

In conclusion, there were no significant differences in CVD risk factors between Māori and Europeans with the regular consumption of nuts. Body weight was not affected by the addition of nuts and diet quality improved in both groups. Importantly both 'liking' and 'desire to consume' nuts remained stable over the intervention period in both groups indicating that the guideline to regularly consume 30 g of nuts is achievable and sustainable in both ethnic groups. Lastly, given the relatively good health status of the populations studied here, it is important to repeat this study in a group more representative of the general Māori and European populations.

6. ACKNOWLEDGEMENTS

We would like to thank the participants for their commitment and enthusiasm in participating in this study.

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