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Effect of individualised dietary advice for weight loss supplemented with walnuts on blood pressure: the HealthTrack study

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Abstract

Background/objectives: In addition to weight-loss, healthy dietary patterns and lower sodium intakes can help reduce blood pressure (BP), but individualised dietary advice may be necessary to achieve these effects. This study aimed to examine the impact of individualised dietary advice on BP in the intensive phase of a weight-loss trial. Subjects/methods: Secondary analysis of baseline and 3-month data from the HealthTrack randomised controlled trial (n = 211). Participants were randomly assigned to one of three dietary advice groups: general advice (control), individualised advice (intervention group, I), or intervention group supplemented with 30 g walnuts/day (IW). Resting BP and 24-h urine sodium and potassium were measured. Dietary intake was evaluated through diet history interviews. Results: Unadjusted SBP reduced significantly in all groups (IW and I groups $P < 0.001$; control group $P = 0.002$) and DBP in IW and I groups ($P < 0.001$). Compared to controls, the reductions in BP were 3-4 mmHg greater in the I and IW groups, but this only reached significance for DBP in the I group (−3.3 mmHg; $P = 0.041$). After controlling for age, sex, medication, weight-loss, physical activity and smoking, only the IW group showed a significant association between SBP reduction and increased urinary potassium ($\beta = -0.101$, $P = 0.044$), decreased sodium:potassium ratio ($\beta = 2.446$, $P = 0.037$) and increased consumption of seed and nut products and dishes ($\beta = -0.108$, $P = 0.034$). Conclusions: Dietary patterns with distinctive foods and lower sodium:potassium ratios may enhance the effects of weight-loss on BP. The patterns were best achieved with individualised dietary advice and food supplements.

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Effect of individualised dietary advice for weight loss supplemented with walnuts on blood pressure: The HealthTrack study[1-4]

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Running title: Dietary advice for weight loss and blood pressure

[4]Abbreviations used: BP, blood pressure; BMI, body mass index; C, control (usual care); DASH, Dietary Approaches to Stop Hypertension; DBP, diastolic blood pressure; I, interdisciplinary intervention with individualised dietary advice; IW, interdisciplinary intervention with individualised dietary advice plus a supplement of 30 grams of walnuts per day; Na:K, sodium-to-potassium ratio; SBP, systolic blood pressure.

Abstract

Background/Objective: In addition to weight-loss, healthy dietary patterns and lower sodium intakes can help reduce blood pressure (BP), but individualised dietary advice may be necessary to achieve these effects. This study aimed to examine the impact of individualised dietary advice on BP in the intensive phase of a weight-loss trial.

Subjects/Methods: Secondary analysis of baseline and 3-months data from the HealthTrack randomized controlled trial (n=211). Participants were randomly assigned to one of 3 dietary advice groups; general advice (control), individualised advice (intervention group, I), or intervention group supplemented with 30 grams walnuts/day (IW). Resting BP and 24-h urine sodium and potassium were measured. Dietary intake was evaluated through diet history interviews.

Results: Unadjusted SBP reduced significantly in all groups (IW and I groups $P<0.001$; control group $P=0.002$) and DBP in IW and I groups ($P<0.001$). Compared to controls, the reductions in BP were 3-4 mmHg greater in the I and IW groups, but this only reached significance for DBP in the I group (-3.3 mmHg; $P=0.041$). After controlling for age, sex, medication, weight-loss, physical activity and smoking, only the IW group showed a significant association between SBP reduction and increased urinary potassium (β=-0.101, $P=0.044$), decreased sodium:potassium ratio (β=2.446, $P=0.037$) and increased consumption of *seed and nut products and dishes* (β=-0.108, $P=0.034$).

Conclusions: Dietary patterns with distinctive foods and lower sodium:potassium ratios may enhance the effects of weight-loss on BP. The patterns were best achieved with individualised dietary advice and food supplements.

Keywords: blood pressure, dietary patterns, obese, potassium, sodium, walnuts, seafood

INTRODUCTION

Hypertension or high blood pressure (BP) is a major risk factor for cardiovascular disease and the leading risk factor for total burden of disease and mortality worldwide.[1] Lowering systolic BP (SBP) by 10 mmHg or diastolic BP (DBP) by 5 mmHg through the use of BP lowering medication has been shown to reduce the incidence of coronary heart disease events and stroke by 25% and 30% respectively.[2]

Different lifestyle approaches have been recommended to lower BP. These include weight loss, regular physical activity, reducing dietary sodium intake and consuming a healthy diet.[3] Previously, dietary trials for BP-lowering have primarily focused on interventions that result in reductions in sodium intake, either with or without a concomitant increase in potassium intake. A systematic review of these trials shows that reducing dietary salt to 4.4 g/day (1716 mg sodium/day) leads to an estimated reduction of 5.0 mmHg and 3.0 mmHg in SBP and DBP, respectively, in hypertensive subjects and 2.0 mmHg and 1.0 mmHg, respectively, in normotensive subjects.[4] On the other hand, a meta-regression has shown an increase in potassium intake by 44 mmol/day (1716 mg/day) to be associated with a reduction of 2.4 mmHg and 1.6 mmHg in SBP and DBP, respectively.[5] However, the urinary sodium-to-potassium (Na:K) ratio may be more strongly associated with BP than urinary sodium or potassium alone,[6] and may be more indicative of total diet.

Given that weight loss itself helps to reduce BP,[7] adding knowledge of healthful food patterns to that of energy restriction may be beneficial in managing obesity and its related disorders such as hypertension. The relationship between obesity and hypertension is well established.[8] Patients with higher body mass index (BMI) have an increased risk of hospitalisations due to a wide range of cardiovascular diseases in which hypertension may also be implicated.[9] As a result, weight loss is recommended as a strategy to lower BP in overweight and obese

individuals.[3] An average of 5 kg weight loss resulted in BP reduction of 4.4 mmHg and 3.6 mmHg in SBP and DBP respectively in a meta-analysis of 25 randomized controlled trials.[7]

While weight loss is dependent on total food intake, investigations into the effects of single foods on BP have been conducted through randomized clinical trials and observational studies. These studies have focused on fruit and vegetables, meat, nuts, dairy foods, tea, and coffee.[10-15] Research that focuses on individual nutrients or single foods may not consider the complexity of the interdependence between nutrients and foods and their relationship with disease outcomes.[16] In nutritional epidemiology, research on dietary patterns may present a broader view of the impact of nutrient and food intakes and enable a better understanding of the association between diet and chronic disease risk.[17] Dietary patterns associated with BP include the Dietary Approaches to Stop Hypertension (DASH) diet,[18] the Mediterranean diet[19] and the Nordic diet.[20] Given that improved dietary choices is a goal of dietary advice in practice, the aim of this study was to examine the impact of individualised dietary advice, on BP during a weight loss trial.

SUBJECTS AND METHODS

The current study is a secondary analysis using baseline and 3 month data from the 12-month HealthTrack randomized controlled trial, commencing in May 2014 and investigating whether a novel lifestyle intervention is more effective than usual care in achieving weight loss in overweight/obese adults. Participants were randomized to one of three groups: intervention [(I) (interdisciplinary intervention with individualised dietary advice], intervention + walnut [(IW) (interdisciplinary intervention with individualised dietary advice plus a supplement of 30 grams of walnuts per day], or control [(C) (usual care]. Randomisation was performed by an investigator unrelated to the study using computer generated randomisation sequence. Participants were blinded to their randomised group. Dietary advice in both intervention groups

was provided in an individualised manner according to the targeted requirements and usual food habits of the participants. A number of food choices were prescribed from the food groups defined in the Australian Guide to Healthy Eating.[21] This Guide was also used for the controls but advice was given in a general manner. In the IW group, walnut supplementation was integrated into diets so as not to provide extra energy but to increase the specificity of the intervention to consume healthy food. The control group received general advice on food choices that enabled them to adjust their usual food patterns to the dietary guidelines.[21] The HealthTrack study was registered with the Australian and New Zealand Clinical Trial Registry (ANZCTRN 12614000581662) and was approved by the University of Wollongong/Illawarra Shoalhaven Local Health District Human Research Ethics Committee (HE13/189) including the current analysis. All participants provided their informed written consent before participating in the study. For the analysis reported here, the outcomes of interest were SBP and DBP.

Study context: The HealthTrack Trial

The HealthTrack study was conducted in the Illawarra, a major coastal region 70 km south of Sydney, Australia, with a detailed study protocol and primary results reported elsewhere.[22,23] In brief, adults aged between 25 and 54 years were recruited via advertisements in local media (Figure 1). Participants were included if they had a BMI of 25-40 kg/m^2 and were permanent residents of the Illawarra region. Participants were excluded if they did not have a good command of English language, had a serious medical condition that could limit their participation, immunodeficiency, reported regular alcohol intake of more than 50 g of alcohol per day, illegal use of drugs, or other major impediments to taking part in some components of the study.

SBP and DBP were measured in the supine position using an automatic BP monitor (OMRON BP-203RPE III, OMRON Healthcare Co. Ltd, Kyoto, Japan) and using appropriately sized BP cuffs for obese participants. Participants rested for 5 minutes after which a test BP reading was conducted. After 10 seconds, a confirmatory reading was recorded. All BP measurements were performed by trained health practitioners using standard techniques.

For estimation of dietary sodium and potassium intake, urinary sodium and potassium excretion were used as biomarkers since they are considered the gold standard.[24] It has also been shown that individuals with higher BMI usually under-report dietary sodium and over-report dietary potassium intake.[25] Participants were instructed to collect 24-h urine in the provided standard plastic containers. One 24-h urine collection was made at baseline and at 3 months. After voiding the initial urine sample of the day, participants were requested to record the time and then collect all further urine samples for the subsequent 24 hours, ending at about the same time the following day. The collected sample was then taken to Southern IML Pathology whereby total urine volume was determined, and subsequently stored at 2-8 degrees centigrade. Indirect ion-specific electrodes were used to determine sodium and potassium concentrations whilst the creatinine concentration was determined using the Jaffe reaction colorimetric method.[26] Samples were considered to be incomplete if their total volume was less than 500 mL (n = 1 at baseline, n = 1 at 3 months) and/or creatinine concentration levels were below 5.0 mmol/d (n = 1 at baseline) and therefore excluded from the present analysis.[27]

Dietary intake was assessed through self-reported diet history interviews conducted by Accredited Practising Dietitians. Participants described their usual diet including types and amounts of food and drinks consumed using a validated protocol.[28] Dietary data was entered into the FoodWorks nutrient analysis software program (Xyris software, FoodWorks. 2012: Brisbane, Australia). Dietary data was originally analysed using AUSNUT 2007 (ref. 29), which was the most recent survey-specific food composition database available when the study

142 began. Due to the subsequent release of AUSNUT 2011-2013 (ref. 30), dietary data was
143 categorized as per the food groups in AUSNUT 2011-2013. In order to convert AUSNUT 2007
144 foods to AUSNUT 2011-2013 equivalents, a matching file was created to using a systematic
145 process which has been reported elsewhere.[31] Specifically, intakes of the AUSNUT 2011-13
146 major food groups *seed and nut products and dishes*, *fruit products and dishes*, and *seafood*
147 *products and dishes* were determined. These food groups were selected as they were
148 significantly associated with BP in a previous baseline analysis in this sample.[32]

149 Physical activity was assessed through the International Physical Activity Questionnaire via the
150 questionnaire's short questions.[33] Trained health practitioners conducted anthropometric
151 measurements. Weight and percent body fat via bioelectrical impedance were measured on
152 digital scales [Tanita scales, UM0703581(1), Tanita Corporation, Tokyo, Japan] with subjects
153 wearing light indoor clothing and no shoes. Weight was recorded to the nearest 0.1 kg while
154 percent body fat was recorded to the nearest 0.1%. Height was measured and recorded to the
155 closest millimetre in accordance with established anthropometric protocols[34] using a wall-
156 mounted stadiometer. The widest part of hip and narrowest waist circumference were measured
157 to the nearest centimetre according to standard protocols.[34] BMI was computed as weight (kg)
158 divided by the height (m) squared.

159 **Statistical analysis**

160 Power calculations to determine the sample size were conducted using SAS PROC POWER
161 whereby 120 participants per group were considered adequate, in order to detect a minimum of
162 2.7 kg weight loss difference between groups which was the primary outcome. In this
163 secondary analysis, baseline characteristics were presented as means and standard deviation for
164 normally distributed data and median and interquartile range for data that was not normally
165 distributed. To assess differences between study groups at baseline, one-way analysis of
166 variance was conducted for normally distributed data while Kruskal-Wallis H test was

conducted for data that was not normally distributed. A chi square test was performed to compare difference in the proportion of participants with hypertension (participants were categorised as hypertensive if BP was ≥140/90 mmHg and/or taking antihypertensives) between study groups. To determine between-intervention differences in the change in weight, BP and urinary excretion, the one-way analysis of variance was used. To determine the difference between baseline and 3 months in each study group in weight, BP and urinary excretion, paired-samples T-test was used while the Wilcoxon signed-rank test was used to assess differences in the intake of key food groups (*seed and nut products and dishes*, *fruit products and dishes*, and *seafood products and dishes)*. The one-way analysis of variance or Kruskal-Wallis H test was used to determine the difference between groups at each time point, and significant results were explored via post-hoc Tukey, Games-Howell test or Mann Whitney U tests with Bonferroni adjustment. We also repeated these analyses after excluding participants who were taking diuretics at baseline and/ or 3 months, as diuretics have been shown to increase sodium and potassium excretion.[35] Multiple linear regression was performed to assess the association between change in BP from baseline and (1) change in urinary excretion and (2) consumption of key food groups, while controlling for age, sex, BP medication, weight loss, change in physical activity, and smoking. All analyses were performed in accordance with an as-treated analysis approach. Statistical analysis was performed using the Statistical Package for the Social Sciences (IBM Corp., SPSS for Windows Version 21, Armonk, New York, USA). Significance level was considered at *P* value <0.05.

RESULTS

Baseline characteristics

Participants (n=377) were randomized to one of the 3 groups; intervention + walnut (IW), intervention (I) or control (C). For this secondary analysis, complete BP, urinary excretion data and dietary intake data at baseline and 3 months was available from 211 participants (60 men and 151 women). Table 1 shows the baseline characteristics of the 3 groups.

Change from baseline to 3 months

Weight reduced significantly in all the three groups from baseline to 3 months (P <0.001 in all groups). Unadjusted for weight loss, SBP reduced significantly in all groups *(IW, I:* $P < 0.001$; C: $P = 0.002$) but DBP was only significantly reduced in the IW and I groups ($P < 0.001$) (Figure 2 and Table 2). Compared to controls, the reductions were greater in the IW group (SBP -3.7 mmHg, $P = 0.06$; DBP -2.8 mmHg, $P = 0.057$) and the I group (SBP -3.7 mmHg, $P = 0.095$; DBP -3.3 mmHg, $P = 0.041$). From a biomarker perspective, compared to the I group, the IW group showed greater reductions in urinary sodium ($P = 0.007$) and urinary Na:K ratio ($P = 0.012$), and the C group showed greater reductions in urinary sodium ($P = 0.018$) (Table 3). From a food perspective, the IW group consumed greater amounts of *seed and nut products and dishes* compared to the I group and C group at 3 months ($P < 0.001$ and = 0.024 respectively) and increased their intakes of these foods more ($P < 0.001$ and < 0.001 respectively) across the intervention period. Both the IW and I groups also increased their intakes of *fruit products and dishes* during this time ($P < 0.001$ and= 0.005 respectively). Results were similar when participants on diuretics were excluded from the analysis (data not shown).

Using multiple linear regression and controlling for age, sex, BP medication, weight loss, change in physical activity and smoking, only the IW group showed a significant association between the reduction in SBP and the increase in urinary potassium (β=-0.101, 95% CI:-0.199,-0.003; P=0.044) and decrease in urinary Na:K ratio (β=2.446, 95% CI:0.152,4.740;

214 *P*=0.037) (Table 4). The control group did show an association between reduced urinary
215 sodium and reduced DBP (*P*=0.028). From a food perspective, the IW group also showed a
216 significant association between reduction in SBP and an increase in the consumption of *seed*
217 *and nut products and dishes*, and between a reduction in DBP and increased intake of *seafood*
218 *products and dishes*. The results did not change after excluding participants who were taking
219 diuretics at baseline and 3 months (data not shown).

220 **DISCUSSION**

221 This secondary analysis of data from a weight loss trial provided further insights into the
222 impact of changes in dietary patterns, foods and nutrients on BP. The setting which tested
223 individualised versus general dietary advice enabled this to occur. Dietary patterns,[18] key
224 foods such as nuts[36] and dietary levels of nutrients such as sodium[4] and potassium[5] can all
225 affect BP, but these effects are also inter-related.[37] The present analysis showed that
226 individualised dietary advice, strengthened by a daily supplement of a heathy food, 30 g
227 walnuts, resulted in greater decrease in urinary Na:K ratio, a parameter associated with lower
228 BP.[6] After adjusting for weight loss, we found the decrease in Na:K ratio and concomitant
229 increase in intakes of the "nuts and seeds" and "seafood" food categories were significantly
230 associated with BP reduction, confirming the effect of diet composition.

231 The significantly greater reduction in Na:K ratio in the IW group was indicative of the dietary
232 pattern achieved. Diets with a lower Na:K ratio have been negatively associated with
233 hypertension in epidemiological studies[38] and have been found to reduce BP in randomized
234 controlled trials.[39] Sodium and potassium play an interdependent role in affecting BP, whereby
235 consumption of excessive sodium and insufficient potassium cause the vascular smooth muscle
236 cell to contract and as a result lead to an increase in the peripheral vascular resistance which
237 increases BP.[40]

The results of the current study build on our earlier analysis that identified an inverse association between BP and a dietary pattern that was rich in "nuts, seeds, fruit and fish" and BP.[32] In addition, we found significant inverse associations between SBP and dietary patterns characterized by fruit and nuts, and between DBP and dietary patterns characterized by seafood in analyses of food-based dietary trials previously conducted.[41] Other randomized controlled trials show have reported beneficial effects of walnut consumption on BP. In a 2-year study investigating the effect of a Mediterranean-style diet on endothelial function and inflammation markers in 180 patients with metabolic syndrome, a Mediterranean-style diet that included consumption of 25-50 g of walnuts per day significantly reduced SBP by 3 mmHg and DBP by 2 mmHg compared to a control prudent diet.[42] Likewise, in the PREDIMED study, the group following a Mediterranean diet which contained a daily supplement of 30 g mixed nuts including 15 g of walnuts showed greater reductions in ambulatory SBP and DBP (-2.4 mmHg and -1.0 mmHg respectively) after one year compared to the control diet.[43] In a recent meta-analysis of 21 randomized controlled trials, total nut consumption was shown to lower SBP by 1.29 mmHg in participants without type 2 diabetes.[36] Nuts contain high amounts of mono- and polyunsaturated fats, magnesium, potassium and fibre and are low in sodium and saturated fats and thus may elicit a BP lowering response.[44] Consumption of nuts may also be associated with improved diet quality[45] which in turn may lead to adoption of healthier dietary patterns.

In this study, we also found the IW group showed an association between increased seafood consumption and decreased DBP. The effect of fish consumption on BP has been assessed in previous studies. For example, moderate consumption of fatty fish (150 g salmon, three times per week) led to greater reductions in DBP in an 8 week weight-loss study compared to lean fish, fish oil capsules or placebo capsules.[46] While various studies have shown a BP lowering effect through supplementation with omega-3 polyunsaturated fatty acids,[47] conclusive evidence on the effect of dietary fish intake on BP is lacking. This is possibly due to other

263 factors that may attenuate the protective effects such as the method of preparation,
264 consumption of salted fish or presence of other contaminants such as mercury and pesticides.[48]

265 Compared to individual foods, however, dietary pattern analysis may better demonstrate diet-
266 BP relationships since foods are not consumed in isolation but as part of a total diet. In
267 addition, the concept of food synergy proposes that investigation of patterns of food
268 consumption may be more informative than focussing on individual nutrients or single foods.[49]
269 Our study has demonstrated that under weight-loss conditions, a dietary pattern with an
270 increase in nuts, seeds and seafood was associated with reductions in BP. Further
271 investigations are warranted on the effect of change in dietary patterns on change in BP
272 especially in different cultural contexts and cuisines.

273 One of the limitations of this analysis is that as a secondary analysis of a randomized controlled
274 study testing the effects of forms of intervention on weight loss, there is a likelihood the
275 analysis would be underpowered, particularly in relation to the analysis of changes in dietary
276 patterns which carry a high degree of variability. However, as under-reporting of dietary
277 sodium and over-reporting of dietary potassium occurs especially in individuals with higher
278 BMI,[25] a strength of the study was the assessment of sodium and potassium intake by the gold
279 standard of 24-h urine excretion,[24] with completeness of urine samples being determined by the
280 use of urinary creatinine concentrations. Despite this, it is acknowledged that repeated 24-h
281 urinary collections would have provided greater accuracy due to the well-known large day-to-
282 day intra-individual variability of sodium and potassium intake.[50]

283 Our analysis observed significant reductions in SBP that were associated with increased intake
284 of seeds and nuts and reduced Na:K excretion, while reductions in DBP were associated with
285 increased intake of seafood. Identification of a dietary pattern that includes these foods and
286 leads to a low Na:K ratio could be helpful in the development of food based dietary

recommendations in clinical practice that not only address weight loss but also BP. In the context of this trial, the impact of individualised dietary advice (and the inclusion of a relevant food supplement) helped to achieve a healthy dietary pattern and expose effects.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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FIGURE LEGENDS

Figure 1

Participant flow in the HealthTrack study and available data for the current analysis. Adapted from Tapsell L.C., Lonergan M., Martin A., Batterham M.J., and Neale E.P., Interdisciplinary lifestyle intervention for weight management in a community population (HealthTrack study): study design and baseline sample characteristics. Contemporary Clinical Trials, 2015(45): p. 394-403.

Figure 2

Change in systolic and diastolic blood pressure in each group from baseline to 3 months and between intervention groups and control group. C, control (usual care); DBP, diastolic blood pressure; I, interdisciplinary intervention with individualised dietary advice; IW, interdisciplinary intervention with individualised dietary advice plus a supplement of 30 grams of walnuts per day; SBP, systolic blood pressure; asterisks (*) indicate significant change at $P < 0.05$; Error bars indicate standard error of the mean.

Table 1. Baseline characteristics of the 211 participants with complete data on blood pressure, urinary sodium and potassium and dietary intake in the HealthTrack study (n=211)[1]

Characteristic	**IW (n=82)**	**I (n=62)**	**C (n=67)**	**P value for group difference[2]**
Age, years	43.2 (8.7)	45.2 (7.1)	45.1 (7.2)	0.242
Height, m	1.7 (0.1)	1.7 (0.1)	1.7 (0.1)	0.397
Weight, kg	90.0 (14.6)	93.0 (16.1)	89.6 (15.4)	0.4
BMI, kg/m^2	32.0 (4.1)	32.6 (4.4)	32.2 (4.2)	0.784
Waist circumference, cm	102.4 (11.4)	104.7 (11.8)	103.7 (13.3)	0.57
Hypertensives, % (n)[3]	31.7 (26)	32.3 (20)	26.9 (18)	0.755
Dietary intake				
Median energy, kj/day (IQR)	8671 (7309-10350)	8618 (7701-10981)	9486 (8066-11438)	0.165
Median sodium, mg/day (IQR)	2453 (1974-3037)	2260 (1682-3099)	2521 (2003-3065)	0.452
Median potassium, mg/day (IQR)	3694 (3027-4211)	3519 (3044-4452)	3849 (3191-4674)	0.123
Median magnesium, mg/day (IQR)	423 (329-542)	427 (331-522)	449 (349-570)	0.214
Median calcium, mg/day (IQR)	894 (663-1134)	985 (713-1234)	951 (731-1233)	0.334
Urinary excretion[4]				
Volume, mL/day	2114 (962)	2048 (874)	2018 (838)	0.799
Creatinine, mmol/day	13.6 (4.4)	14.2 (4.1)	13.8 (4.7)	0.758
Sodium, mmol/day	149.7 (54.6)	138.2 (62.5)	151.0 (61.7)	0.448
Median sodium, mmol/day (IQR)	137 (108-191)	128 (97-170)	145 (99-181)	0.391
Potassium, mmol/day	75.5 (27.8)	77.9 (21.3)	84.5 (38.0)	0.276
Median potassium, mmol/day (IQR)	72 (54-89)	77 (63-91)	75 (59-98)	0.319
Sodium-to-potassium ratio	2.1 (0.99)[a]	1.8 (0.57)[b]	2.0 (0.85)[ab]	0.024
Median sodium-to-potassium ratio (IQR)	1.9 (1.4-2.7)	1.8 (1.3-2.1)	1.9 (1.4-2.1)	0.206

[1]Values are expressed as means (standard deviation) unless otherwise stated; [2]Group comparisons were made using analysis of variance for normally distributed data; [3]Group comparisons were made using Chi square test; [4]Group comparisons were made using Kruskal-Wallis H test for data that was

not normally distributed; C, control (usual care); I, interdisciplinary intervention with individualised dietary advice; IQR, interquartile range; IW, interdisciplinary intervention with individualised dietary advice plus a supplement of 30 grams of walnuts per day.

Table 2. Change in weight and blood pressure from baseline to 3 months in the HealthTrack study (n=211)[1]

		IW (n=82)	I (n=62)	C (n=67)	P value for group difference	IW vs. C (95% CI)	P value	I vs. C (95% CI)	P value
Weight (Kg)	Baseline	90.0 ± 14.6	93.0 ± 16.1	89.6 ± 15.4	0.394				
	3 months	87.2 ± 14.2	90.0 ± 16.1	88.2 ± 15.4	0.54				
	Change (95% CI)	-2.8 (-3.6 to -2.0)[a]	-2.9 (-3.8 to -2.1)[a]	-1.4 (-1.9 to -0.9)[b]	0.007	-1.4 (-2.5 to -0.2)	0.021	-1.5 (-2.8 to -0.3)	0.013
	P value for difference between baseline and 3m	<0.001	<0.001	<0.001					
Blood pressure	Baseline	127.5 ± 16.6	127.5 ± 18.6	123.0 ± 13.0					
SBP (mmHg)	3 months	120.5 ± 13.3	120.5 ± 15.6	119.7 ± 12.5					
	Change (95% CI)	-7.0 (-9.5 to -4.6)	-7.0 (-9.8 to -4.2)	-3.3 (-5.4 to -1.2)	0.057	-3.7 (-7.5 to 0.1)	0.06	-3.7 (-7.9 to 0.5)	0.095
	P value for difference between baseline and 3m	<0.001	<0.001	0.002					
	Baseline	74.2 ± 10.3	75.0 ± 12.5	72.6 ± 9.4					
DBP (mmHg)	3 months	69.8 ± 9.3	70.1 ± 11.3	71.0 ± 9.0					

	Change (95% CI)	-4.4 (-6.0 to -2.7)[ab]	-4.9 (-7.0 to -2.8)[b]	-1.6 (-3.3 to 0.2)[a]	0.027	-2.8 (-5.7 to 0.1)	0.057	-3.3 (-6.6 to -0.1)	0.041
	P value for difference between baseline and 3m	<0.001	<0.001	0.076					

1Values are mean ± standard deviation unless otherwise stated; a,b,cGroups with different superscripts were significantly different after Bonferroni adjustment; change in blood pressure unadjusted for weight loss; C, control (usual care); DBP, diastolic blood pressure; I, interdisciplinary intervention with individualised dietary advice; IW, interdisciplinary intervention with individualised dietary advice plus a supplement of 30 grams of walnuts per day; SBP, systolic blood pressure.

Table 3. Change in 24-h urinary excretion and key food groups from baseline to 3 months in the HealthTrack study (n=211)[1]

		IW (n=82)	I (n=62)	C (n=67)	P value for group difference
Urinary excretion					
Urinary sodium (mmol/d)	Baseline	149.7 (54.6)	138.2 (62.5)	151.0 (61.7)	0.448
	3 months	118.9 (55.1)	138.3 (56.7)	125.0 (62.3)	0.135
	Change	-30.8 (62.2)[a]	0.1 (69.6)[b]	-26.0 (80.8)[ab]	0.026
	P value for difference between baseline and 3m	<0.001	0.991	0.011	
Urinary potassium (mmol/d)	Baseline	75.5 (27.8)	77.9 (21.3)	84.5 (38.0)	0.276
	3 months	72.6 (29.3)	77.6 (24.9)	72.2 (22.8)	0.416
	Change	-2.95 (26.5)[ab]	-0.26 (21.9)[a]	-12.3 (35.7)[b]	0.042
	P value for difference between baseline and 3m	0.316	0.926	0.006	
Urinary Na:K ratio (mmol/mmol)	Baseline	2.13 (0.99)[a]	1.77 (0.57)[b]	1.96 (0.85)[ab]	0.024
	3 months	1.79 (0.79)	1.91 (0.84)	1.80 (0.78)	0.654
	Change	-0.34 (1.06)[a]	0.14 (0.80)[b]	-0.16 (1.06)[ab]	0.02
	P value for difference between baseline and 3m	0.006	0.187	0.217	
Food groups					

Seed and nut products and dishes (g/d), median (IQR)	Baseline	13.4 (5.4-34.4)	16.2 (6.4-30.6)	18.2 (7.1-37.5)	0.56
	3 months	30.0 (27.4-37.3)[a]	10.4 (4.2-19.1)[b]	20.4 (6.9-41.2)[c]	<0.001
	Change	20.4 (4.9 to 30)[a]	-1.5 (-13.5 to 5.1)[b]	-1.8 (-18.5 to 11.6)[bc]	<0.001
	P value for difference between baseline and 3m	<0.001	0.008	0.766	
Fruit products and dishes (g/d), median (IQR)	Baseline	113.1 (57.7-224.7)	151.4 (81.0-258.8)	140.8 (69.9-231.6)	0.276
	3 months	212.3 (146.7-270.9)[ab]	241.9 (149.6-301.4)[a]	160.9 (109.9-262.7)[b]	0.022
	Change	62.5 (-10.8 to 169.1)	79.2 (-37.6 to 168.9)	37.0 (-51.6 to 107.2)	0.073
	P value for difference between baseline and 3m	<0.001	0.005	0.096	
Seafood products and dishes (g/d), median (IQR)	Baseline	35.0 (19.8-58.3)	35.4 (14.9-60.6)	32.9 (20.0-67.1)	0.957
	3 months	35.1 (20.3-64.3)	45.4 (21.1-67.5)	40.1 (20.4-57.1)	0.404
	Change	7.8 (-11.0 to 20.1)	2.9 (-15.8 to 29.6)	0.0 (-15.9 to 16.8)	0.641
	P value for difference between baseline and 3m	0.224	0.31	0.716	

[1]Values are mean (standard deviation) unless otherwise stated; [a,b,c]Groups with different superscripts were significantly different after Bonferroni adjustment; C, control (usual care); I, interdisciplinary intervention with individualised dietary advice; IW, interdisciplinary intervention with individualised dietary advice plus a supplement of 30 grams of walnuts per day; Na:K. sodium-to-potassium ratio.

Table 4. Linear regression for association between change in blood pressure and change in urinary markers and key food groups in the HealthTrack study (n=211)[1]

	IW (n=82)		I (n=62)		C (n=67)	
	B ± SE	P value	B ± SE	P value	B ± SE	P value
Change in SBP						
Change in urinary Na (mmol/d)	0.009 ± 0.021	0.687	0.010 ± 0.022	0.649	0.019 ± 0.013	0.154
Change in urinary K (mmol/d)	-0.101 ± 0.050	0.044	0.057 ± 0.074	0.445	0.022 ± 0.031	0.471
Change in Na:K ratio	2.446 ± 1.171	0.037	-1.107 ± 1.976	0.575	0.442 ± 1.041	0.671
Change in consumption of seed and nut products and dishes (g/d)	-0.108 ± 0.051	0.034	-0.002 ± 0.061	0.975	-0.011 ± 0.021	0.608
Change in consumption of fruit products and dishes (g/d)	-0.002 ± 0.010	0.867	-0.007 ± 0.010	0.451	0.002 ± 0.006	0.785
Change in consumption of seafood products and dishes (g/d)	-0.072 ± 0.041	0.083	-0.056 ± 0.032	0.077	-0.011 ± 0.030	0.72
Change in DBP						
Change in urinary Na (mmol/d)	0.007 ± 0.015	0.644	0.005 ± 0.017	0.751	0.024 ± 0.011	0.028
Change in urinary K (mmol/d)	-0.056 ± 0.034	0.103	0.070 ± 0.056	0.213	0.010 ± 0.025	0.697
Change in Na:K ratio	1.500 ± 0.808	0.063	-1.141 ± 1.497	0.446	0.856 ± 0.851	0.315
Change in seed and nut products and dishes (g/d)	-0.046 ± 0.035	0.195	0.003 ± 0.047	0.946	-0.014 ± 0.017	0.925
Change in fruit products and dishes (g/d)	-0.004 ± 0.007	0.59	-0.003 ± 0.008	0.653	0.001 ± 0.005	0.672
Change in seafood products and dishes (g/d)	-0.063 ± 0.028	0.024	0.030 ± 0.025	0.231	-0.0002 ± 0.024	0.994

[1]Controlling for age, sex, BP medication, weight loss, change in physical activity, smoking; C, control (usual care); DBP, diastolic blood pressure; I, interdisciplinary intervention with individualised dietary advice; IW, interdisciplinary intervention with individualised dietary advice plus a supplement of 30 grams of walnuts per day; K, potassium; Na, sodium; Na:K. sodium-to-potassium ratio; SBP, systolic blood pressure.

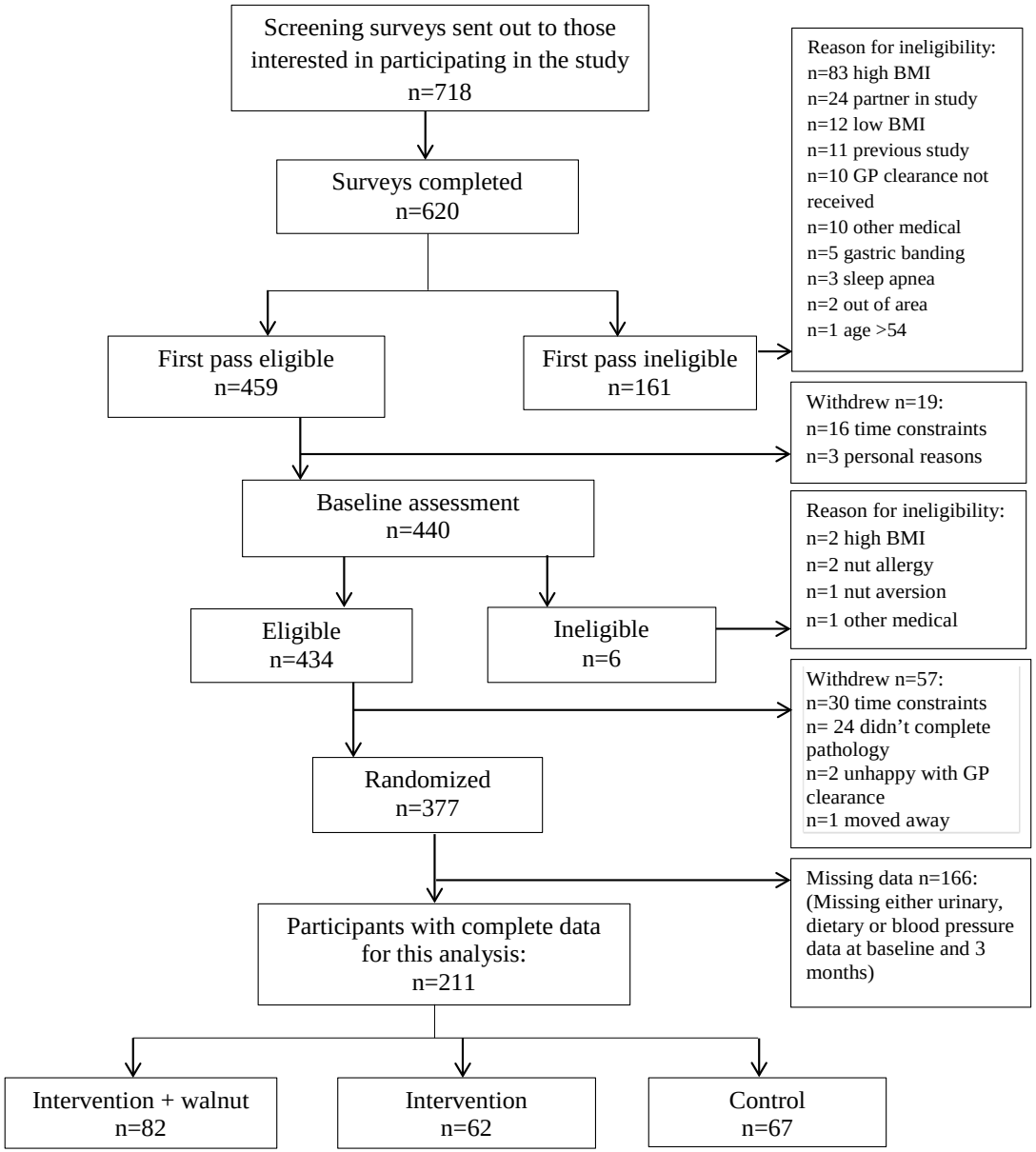
Screening surveys sent out to those interested in participating in the study n=718
Surveys completed n=620
First pass eligible n=459
First pass ineligible n=161
Reason for ineligibility:
n=83 high BMI
n=24 partner in study
n=12 low BMI
n=11 previous study
n=10 GP clearance not received
n=10 other medical
n=5 gastric banding
n=3 sleep apnea
n=2 out of area
n=1 age >54
Withdrew n=19:
n=16 time constraints
n=3 personal reasons
Baseline assessment n=440
Eligible n=434
Ineligible n=6
Reason for ineligibility:
n=2 high BMI
n=2 nut allergy
n=1 nut aversion
n=1 other medical
Withdrew n=57:
n=30 time constraints
n= 24 didn't complete pathology
n=2 unhappy with GP clearance
n=1 moved away
Randomized n=377
Missing data n=166:
(Missing either urinary, dietary or blood pressure data at baseline and 3 months)
Participants with complete data for this analysis: n=211
Intervention + walnut n=82
Intervention n=62
Control n=67

Figure 1