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Associations between dietary patterns and blood pressure in a clinical sample of overweight adults

Rhoda Ndanuko
University of Wollongong, rnn954@uowmail.edu.au

Linda C. Tapsell
University of Wollongong, ltapsell@uow.edu.au

Karen E. Charlton
University of Wollongong, karenc@uow.edu.au

Elizabeth Neale
University of Wollongong, elizan@uow.edu.au

Marijka Batterham
University of Wollongong, marijka@uow.edu.au

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Abstract

Background Dietary pattern analysis provides important evidence revealing diet-disease relationships. It may be especially useful in areas less well researched, such as diet and hypertension in clinical populations. Objective The aim of this study was to identify the association between dietary patterns and blood pressure (BP) in a sample of overweight adults volunteering for a clinical trial for weight loss. Design This cross-sectional analysis used baseline data from the HealthTrack study, a 12-month randomized controlled trial. Dietary intake was evaluated with 4-day food records. Participants/setting Participants were 328 adults recruited from the Illawarra region of New South Wales, Australia, between May 2014 and April 2015. Main outcome measures Resting BP and 24-hour urine sodium and potassium were measured. Statistical analysis Dietary patterns were derived by principal component analysis from 21 food groups. Multiple regression analysis was performed to assess the association between the extracted dietary patterns and BP. Results The participants' mean age was 43.6±8.0 years, mean body mass index was 32.4±4.2, and mean systolic BP/diastolic BP was 124.9±14.5/73.3±9.9 mm Hg. Six major dietary patterns were identified: "nuts, seeds, fruit, and fish," "milk and meat," "breads, cereals, and snacks," "cereal-based products, fats, and oils," "alcohol, eggs, and legumes," and "savoury sauces, condiments, and meat." The "nuts, seeds, fruit, and fish" dietary pattern was significantly and inversely associated with systolic BP (F [7,320]=15.248; P<0.0005; adjusted R2=0.234 and diastolic BP (F [7,320]=17.351; P<0.0005; adjusted R2=0.259) and sodium-to-potassium ratio (F [7,320]=6.210; P<0.0005; adjusted R2=0.100). Conclusions A dietary pattern rich in nuts, seeds, fruit, and fish was inversely associated with blood pressure in this clinical sample. The findings suggest that current dietary guidelines are relevant to an overweight clinical population and support the value of dietary pattern analysis when exploring the diet-disease relationship.

Keywords

clinical, sample, dietary, overweight, patterns, pressure, adults, blood, associations, between

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Rhoda N Ndanuko, MSc, APD*, Linda C Tapsell, PhD, FDAA*, AM*, Karen E Charlton, PhD, APD*, RPHNutr.*, Elizabeth P Neale, PhD, APD*, Marijka J Batterham, PhD, AdvAPD*, AStat*

R. N. Ndanuko, PhD candidate, School of Medicine, University of Wollongong, Northfields Avenue, Wollongong NSW 2522, Australia. Tel: +61 424 093033. Email: rnn954@uowmail.edu.au

L. C. Tapsell, Professor, School of Medicine, University of Wollongong, Northfields Avenue, Wollongong NSW 2522, Australia. Tel: +61 2 4221 4844. Email: ltapsell@uow.edu.au

K. E. Charlton, Associate professor, School of Medicine, University of Wollongong, Northfields Avenue, Wollongong NSW 2522, Australia. Tel: +61 2 4221 4754. Email: karenc@uow.edu.au

E.P Neale, Research fellow, School of Medicine, University of Wollongong, Northfields Avenue, Wollongong NSW 2522, Australia. Tel: +61 2 4221 5961. Email: elizan@uow.edu.au

M. J. Batterham, Associate professor, Director, Statistical Consulting Centre, School of Mathematics and Applied Statistics, University of Wollongong, Northfields Avenue, Wollongong NSW 2522, Australia. Tel: +61 2 4221 8190. Email: Marijka@uow.edu.au

*Australian-certified

To whom correspondence should be addressed: Rhoda Ndanuko, School of Medicine, University of Wollongong, Northfields Avenue, Wollongong NSW 2522, Australia. Email: rnn954@uowmail.edu.au

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Abbreviations used: BP, blood pressure; BMI, body mass index; DASH, Dietary Approaches to Stop Hypertension; DBP, diastolic blood pressure; Na:K, sodium-to-potassium; PCA, principal component analysis; SBP, systolic blood pressure

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ABSTRACT

Background: Dietary pattern analysis provides important evidence revealing diet-disease relationships. It may be especially useful in areas less well researched such as diet and hypertension in clinical populations.

Objective: The aim of this study was to identify the association between dietary patterns and blood pressure (BP) in a sample of overweight adults volunteering for a clinical trial for weight loss.

Design: This cross-sectional analysis utilised baseline data from the HealthTrack study, a 12-month randomized controlled trial. Dietary intake was evaluated with 4-day food records.

Participants/ setting: Participants were 328 adults recruited from the Illawarra region of New South Wales, Australia between May 2014 and April 2015.

Main outcome measures: Resting BP and 24-h urine sodium and potassium were measured.

Statistical analysis: Dietary patterns were derived by principal component analysis from twenty-one food groups. Multiple regression analysis was performed to assess the association between the extracted dietary patterns and BP.

Results: The participants' mean age was 43.6 ± 8.0 years, mean BMI was 32.4 ± 4.2 kg/m^2 and mean systolic BP (SBP)/diastolic BP (DBP) was 124.9 ± 14.5/73.3 ± 9.9 mmHg. Six major dietary patterns were identified: "nuts, seeds, fruit and fish", "milk and meat", "breads, cereals and snacks", "cereal based products, fats and oils", "alcohol, eggs and legumes" and "savoury sauces, condiments and meat" dietary pattern. The "nuts, seeds, fruit and fish"

dietary pattern was significantly and inversely associated with SBP (F (7,320) = 15.248 20, $P < 0.0005$; adjusted $R^2 = 0.234$), DBP (F (7,320) = 17.351, $P < 0.0005$; adjusted $R^2 = 0.259$) and sodium-to-potassium ratio (F (7,320) = 6.210, $P < 0.0005$; adjusted $R^2 = 0.100$).

Conclusions: A dietary pattern rich in nuts, seeds, fruit and fish was inversely associated with blood pressure in this clinical cohort. The findings suggest that current dietary guidelines are relevant to an obese clinical population and support the value of dietary pattern analysis when exploring the diet-disease relationship in the clinical setting.

INTRODUCTION

Hypertension or high blood pressure (BP), a major risk factor for developing cardiovascular disease, stroke and kidney disease [1], has been identified as the leading risk factor for mortality and is the first ranked risk factor for total burden of disease worldwide leading to an estimated 9.4 million deaths per year [2]. Currently, about one billion people are hypertensive and the prevalence is predicted to reach 29% (1.56 billion) by 2025 [3]. Reducing BP has been shown to reduce the risk of coronary heart disease, stroke, and major cardiovascular events [4] with an increase of 20 mmHg or 10 mmHg in systolic BP (SBP) and diastolic BP (DBP) respectively, being associated with doubling of the risk of stroke and cardiovascular disease [5].

Various lifestyle-based approaches have been recommended for reduction of high blood pressure in various groups within the community. These include weight loss strategies for those who are overweight or obese, engaging in regular physical activity, following a healthy eating plan such as the Dietary Approaches to Stop Hypertension (DASH) diet, and reducing dietary sodium intake [6]. Traditionally, epidemiological research has examined dietary risk factors for high BP through investigation of the effect of single nutrients such as sodium [7] and potassium [8]. In addition, the effect of individual foods on BP has been investigated in randomized controlled trials and observational studies but with conflicting results. Foods investigated include fruit and vegetables [9], dairy foods [10], eggs [11], nuts [12], pulses [13], meat [14], tea [15] and coffee [16].

Inconsistencies in the findings for single foods, and possible differences in population sub-groups suggest a need for more research to better understand diet-BP associations, particularly in at risk groups such as obese and overweight adults. Diets are complex with multiple nutrient interactions, making it difficult to isolate the role of individual foods or

nutrients in relation to specific health and disease outcomes [17]. Dietary pattern analysis has been recommended in nutritional epidemiology as an additional method to better understand relationships between diet and chronic diseases [18]. Various beneficial dietary patterns for BP regulation include the DASH diet [19], the Nordic diet [20] and the Mediterranean diet [21]. These dietary patterns are characterized by a diet that is high in fruit and vegetables, whole grains, legumes, seeds and nuts, fish and dairy and has a low consumption of meat and sweets and moderate alcohol intake. In dietary pattern analysis, two different approaches are commonly used to derive specific dietary patterns; a priori or hypothesis-oriented approaches, for example diet quality scores; and exploratory or posteriori methods that derive dietary patterns from the data at hand, such as principal component analysis (PCA), exploratory factor analysis, or cluster analysis [22]. Our team has previously demonstrated that the PCA method can reveal dietary patterns associated with BP in clinical cohorts participating in weight loss trials [23]. In these food based dietary trials we found significant associations between BP and dietary patterns, namely those characterised by fruit and nuts (inversely associated with SBP), seafood (inversely associated with DBP), or a yeast extract and seasonings (positively associated with both SBP and DBP). These results need to be confirmed by further studies in broader lifestyle interventions with at risk populations to add to the evidence base. The aim of the study reported here was to examine the association between dietary patterns and BP in a sample of overweight adults volunteering for a lifestyle intervention trial targeting weight loss. A secondary aim was to identify the association between dietary patterns and 24hr sodium and potassium excretion.

METHODS

The current study is an analysis of baseline data collected between May 2014 and April 2015 from the 12-month HealthTrack randomized controlled trial. The HealthTrack study (Australian and New Zealand Clinical Trial Registry: ANZCTRN 12614000581662) is an

interdisciplinary lifestyle intervention investigating whether a novel lifestyle intervention is more effective than usual care in achieving weight loss in overweight/obese adults. The Healthtrack study was approved by the University of Wollongong/ Illawarra Shoalhaven Local Health District Human Research Ethics Committee (HE13/189) and the approval was extended to include the current secondary analysis. SBP and DBP were the primary outcomes for this analysis. All participants gave their informed written consent before participation.

Study context: The HealthTrack study

The HealthTrack study is a randomized controlled trial conducted in the Illawarra region, south of Sydney, Australia. The detailed study protocol is described elsewhere [24]. In brief, the study recruited adults 25-54 years of age through advertisements in local newspapers (**Figure 1**). Inclusion criteria were people living in the Illawarra region with a body mass index (BMI) of 25-40 kg/m^2 and between 25-54 years of age. Participants were not excluded if they had chronic disease risk factors such as family history of coronary heart disease, elevated low-density lipoprotein cholesterol and low high-density lipoprotein cholesterol. Individuals who could not communicate in English, had severe medical conditions that limited their ability to participate in the study, immunodeficiency, had medical conditions that could limit survival to 1 year, reported excessive alcohol intakes (greater than 50 grams of alcohol per day) or illegal drug use, or had difficulties in participating in some parts of the study were excluded.

SBP and DBP were measured using automatic BP monitor (OMRON BP-203RPE III, OMRON Health Care Co. Ltd, Kyoto, Japan). A test BP reading was taken after participants had rested in the supine position for 5 minutes and a confirmatory reading was taken 10 seconds after the first. All BP measurements were performed by trained health practitioners.

Participants' collected 24-h urine for estimation of sodium and potassium excretion in standard plastic containers that were provided after receiving detailed instructions. They were instructed to discard the first urine of the day and collect the rest over the 24 hours. Urine samples were delivered to Southern IML pathology where the total volume of urine was measured and recorded and they were stored at 2-8 degrees Centigrade. Sodium and potassium concentrations were determined by indirect ion-specific electrodes while the Jaffe reaction colorimetric method was used to determine creatinine concentration [25]. Samples were classified as incomplete and excluded from the analyses if they had a total volume of less than 500 mL (n = 1) or creatinine concentrations levels less than 6.0 mmol/d in volumes less than 1000 mL (n = 1) [26].

A 4-day food record taken over four consecutive days (including one weekend day) was used to assess dietary intake. Participants were instructed by trained health practitioners to record all foods and drinks consumed including recipes and amounts. Quantities of food intakes were determined using common household measures such as cups and spoons that were provided. Information on dietary supplement use was not collected. The records were reviewed for completeness by nutrition trained personnel upon return and then entered into the Foodworks nutrient analysis software program (Xyris software, FoodWorks. 2012: Brisbane, Australia). Dietary data was originally analysed using the most recent survey-specific food composition database at the time of study commencement, AUSNUT2007 [27]. The recent release of AUSNUT2011-2013 [28] compelled dietary data to be categorized according to the AUSNUT2011-2013 food groups. A matching file was developed to convert the data from AUSNUT2007 foods to AUSNUT2011-2013, with details of this process reported elsewhere [29].

The International Physical Activity Questionnaire (IPAQ) was used to assess physical activity through the survey's short form questions [30]. Physical measurements were

conducted by trained health practitioners. Body weight was measured in light indoor clothing with no shoes on digital scales which incorporated body fat via bioelectrical impedance [Tanita scales, UM0703581(1), Tanita Corporation, Tokyo, Japan] and recorded to the closest 0.1 kg and 0.1% respectively. Height was measured without shoes rounded to the nearest millimetre using a wall-mounted stadiometer in accordance with the established anthropometric protocols [31]. Hip and waist circumference were measured in accordance with the reported acceptable protocols [31]. BMI was calculated as body weight (kg) divided by height (m) squared.

Statistical analysis

To derive dietary patterns, principal component analysis (PCA) was performed based on consumption of the 24 AUSNUT 2011-2013 major food groups (grams/day). The suitability of PCA was assessed prior to analysis. Sampling adequacy was supported by a Kaiser-Meyer-Olkin (KMO) measure of 0.55 and Bartlett's test of sphericity < 0.0005, indicating that the data was likely factorizable. Inspection of the Anti-image Matrices was performed in order to determine the food groups to retain for principal component analysis. To determine the number of components to retain, eigenvalues > 1.0 were considered along with examination of the Scree Plot [32]. To simplify the structure and improve interpretability, an orthogonal (varimax) rotation was applied. Calculation of the factor scores for each component was performed using the regression method. Food groups with positive loadings signify direct relationship with that pattern while those with negative loadings indicate an inverse relationship. Multiple regression analysis was performed to assess the association between the extracted dietary patterns and BP, controlling for age, sex, BMI, BP medication, energy intake and physical activity in the model. As alcohol intake was collected in the four day food records and included in the PCA as a food group, it was not included as a covariate in the analysis. Similarly due to the low number of smokers in the sample (4%), smoking was also

not included as a covariate. The difference in macronutrient and micronutrient intakes between individuals adhering or not adhering with specific dietary patterns was analysed using independent t-test. Chi square test was performed to determine the association between the dietary patterns and hypertension status. All statistical analyses were performed using the Statistical Package for the Social Sciences (Version 21, 2012, IBM Corp. New York, USA). Statistical significance was considered at $P < 0.05$.

RESULTS

Baseline characteristics

A total of 377 participants were randomized to the HealthTrack study. For the present analysis, data was included from 328 participants (89 men and 239 women) who had complete dietary intake, blood pressure and 24-h urine collections data (**Figure 1**). The main characteristics of the participants are presented in **Table 1**.

Dietary pattern analysis

Due to a lack of participants consuming foods from the AUSNUT2011-13 categories labelled *Infant formulae and foods, Reptiles, amphibia and insects,* and *Dietary supplements*, these food groups were excluded, leaving n = 21 AUSNUT2011-13 food groups categorized for this analysis **(Table 2)**.

Six principal components (dietary patterns) were derived, explaining 46% of the total variance **(Table 3)**. Food groups with factor loadings of more than 0.4 were considered as significant contributors to the dietary pattern. The "nuts, seeds, fruit and fish" dietary pattern was characterized by the consumption of seeds/nuts, fruit, fish and seafood products, and confectionery (including cereal/nut/fruit/seed bars); "milk and meat" dietary pattern by consumption of non-alcoholic beverages, milk products and dishes, and meat, poultry and

game products and dishes; “breads, cereals and snacks”, dietary pattern by intake of cereal based products and dishes, confectionery and snack foods; “cereal based products, fats and oils” dietary pattern by intake of cereals and cereal products, fats and oils; “alcohol, eggs and legumes” dietary pattern by consumption of alcoholic beverages, eggs products and dishes, and legumes; and “savoury sauces, condiments and meat” dietary pattern by intake of savoury sauces and condiments and meat.

After adjusting for age, sex, BMI, hypertension medication, physical activity and energy intake, multiple linear regression found the “nuts, seeds, fruit and fish” dietary pattern was significantly and inversely associated with SBP ($F(7,320) = 15.248$, $p < 0.0005$; adjusted $R^2 = 0.234$), DBP ($F(7,320) = 17.351$, $p < 0.0005$; adjusted $R^2 = 0.259$) and sodium-to-potassium ratio ($F(7,320) = 6.210$, $P < 0.0005$; adjusted $R^2 = 0.100$). In addition, the “alcohol, eggs and legumes” and “savoury sauces, condiments and meat” dietary patterns were significantly and positively associated with sodium excretion while the, “milk and meat”, and “breads, cereals and snacks” dietary patterns were significantly and positively associated with potassium excretion. The “savoury sauces, condiments and meat” dietary pattern was significantly and positively associated with urinary Na:K ratio **(Table 4).**

Mean energy intake between participants whose diet aligned and those not aligned with “milk and meat”, “breads, cereals and snacks”, “cereal based products, fats and oils”, “alcohol, eggs and legumes” and “savoury sauces, condiments and meat” dietary patterns were significantly different ($P<0.05$) **(Table 5)**. There was a significant difference in percentage protein intake between participants that aligned to the “milk and meat”, “breads, cereals and snacks”, “cereal based products, fats and oils” and “savoury sauces, condiments and meat” dietary patterns and those not aligned to the specific dietary patterns. Dietary sodium intake was not significantly different in participants aligned with “nuts, seeds, fruit and fish” dietary pattern compared to those not aligned with this pattern. Dietary potassium between participants

whose diets aligned and those not aligned to all the dietary patterns was significantly different (P<0.05). There was no association between hypertension status and whether participants were aligned or not aligned with a dietary pattern in all patterns identified (P>0.05) (data not shown).

DISCUSSION

Findings from this study reveal dietary patterns associated with BP in a defined clinical cohort. In this study, a dietary pattern characterised by a high intake of nuts and seeds, fruit, and fish was inversely associated with both SBP and DBP. (This pattern also included confectionery items but as that also meant muesli bars and snack bars, some of which contain seeds and nuts, the inclusion was not considered noteworthy). This combination of foods provides nutrients and food components that have been shown to be protective for blood pressure such as potassium [8], magnesium [33], polyphenols [34], and long chain omega-3 fatty acids [35]. The pattern is consistent with a previous analysis from a different clinical cohort that found dietary patterns characterised by fruit and nuts or by seafood were inversely associated with SBP and DBP, respectively [23]. The larger sample size in the study reported here (n=328 vs n=118) may account for the stronger ability to cluster all these foods and to show associations with both SBP and DBP. In addition, the present study included younger participants (mean age = 43.6 vs 45.1 years) that had higher BMI (32.4 vs 31.2 kg/m^2) compared to the previous cohort and also did not exclude participants with diabetes and chronic disease risk factors such as elevated LDL and low HDL cholesterol.

The association between dietary patterns and blood pressure has been investigated in large population-based cohort studies in different countries. In middle-aged Chinese men, a dietary pattern characterized by fruits and milk was inversely associated with SBP and DBP ($P <$ 0.001) [36]. In the Netherlands, a “cosmopolitan” dietary pattern that was high in vegetables

and vegetable oil, pasta, rice, fish, chicken and wine was significantly associated with lower SBP while a "traditional" dietary pattern that was higher in intake of red meat, coffee, potatoes, beer and high saturated added fat and low in fruit, tea, breakfast cereals and low-fat dairy was associated with higher SBP in adults aged 20-65 years [37]. Likewise, in Japan, a high intake of the "vegetable" pattern in women was significantly associated with lower SBP and DBP [38]. There is however a paucity of data on the association between dietary patterns and blood pressure in clinical populations.

The dietary patterns inversely associated with BP emphasise plant based foods. Plant-based diets that include consumption of fruit, vegetables, nuts, and whole grains have been associated with lower risk of cardiovascular disease [39]. In the Framingham Study, an inverse association was observed between fruit and vegetable intake and development of stoke in middle-aged men after 20 years of follow-up [40]. Likewise, consumption of nuts was significantly inversely associated with hypertension (RR: 0.66; 95% CI: 0.44, 1.00; P = 0.049) in a recent meta-analysis of four prospective studies [12]. Dietary patterns such as the DASH diet [19], the Mediterranean diet [21] and the Nordic diet [41] have been shown to reduce BP. In our previous research, a meta-analysis of 17 randomized controlled trials showed that a dietary pattern that was rich in fruits, vegetables, wholegrains, legumes, nuts, seeds, dairy and fish and low in processed foods and red meat reduced SBP and DBP by 4.06 mmHg and 2.30 mmHg, respectively [42]. In the current study, a diet that was high in nuts, seeds, fruit and fish was associated with lower BP and therefore our findings are consistent with previous research.

In the analysis reported here, there was no significant difference between the reported dietary sodium intakes in participants who aligned and those not aligned with the "nuts, seeds, fruit and fish" dietary pattern which was significantly associated with BP. However, the "nuts, seeds, fruit and fish" and the "savoury sauces, condiments and meat" dietary patterns were

associated with the urinary Na:K ratio. Previous studies have reported a positive correlation between Na:K ratio and high BP [43] with the ratio showing a stronger association with BP compared to sodium or potassium alone [44]. Many BP-lowering intervention studies focus on reduction of dietary sodium, with or without an increase in potassium intake [45] [46]. This approach may not be useful for translation of dietary advice into practice, where consideration of the whole of diet within the context of the population cuisine appears to be more important.

There are a number of potential synergistic mechanisms at play that could explain our findings. BP regulation is mediated through the effect on various mechanisms in the endothelial system that increase vasodilation such as production of nitric oxide, endothelium-derived hyperpolarizing factors and prostaglandins [47]. A high sodium intake has been shown to impair endothelial function [48] while increased potassium intake enhances endothelial function [49]. In addition, other dietary constituents and diets have also been found to improve endothelial function such as polyunsaturated fats [50], polyphenols [51], de-alcoholized red wine [52] and the Mediterranean diet [53]. Vegetables are a rich source of nitric oxide [54] and ingestion of dietary nitrate load has been shown to reduce BP in acute studies [55]. This highlights that BP regulation may be achieved via a combination of various dietary constituents present in different foods.

A major strength of our study is the use of 24-hour urinary sodium and potassium excretion which is considered as the "gold standard" [56] to assess dietary sodium and potassium intake, given that under-reporting of energy intake has been shown to occur in overweight and obese participants [57]. This is therefore a novel approach in dietary patterns research as it allows for the evaluation of the relationship between dietary patterns and urinary sodium, potassium and Na:K ratio.

There are limitations to this study. This was a secondary analysis of data from a randomized controlled trial that was designed to answer a different research question from the one addressed in this study. The subjective nature of the PCA method to extract dietary components also needs to be considered. Some subjective but crucial decisions include the number of factors to extract and description of the components for each of the dietary patterns identified. However, the use of eigenvalues and examination of the scree plots guided determination of the best number of components to extract. The food grouping classifications used were done a priori by Australian Bureau of Statistics and Food Standards Australia and New Zealand to group similar foods together and to examine trends in food consumption and not necessarily to investigate food-health relationships. However, these groupings have been designed to classify similar foods together in order to reflect the current food supply in Australia, thus warranting their use in this study. Information on the use of dietary supplements was not collected in this study and this could be a potential study limitation. The use of discretionary salt was included in the 4-day food records although it has been shown to be poorly reported [56].

The clinical sample of obese trial volunteers is also a limitation regarding generalizability. In terms of potential bias, about a quarter of the participants were already hypertensive and may have made dietary changes as a result of receiving previous dietary advice from a health professional [58]. In addition our study participants were predominantly female (73%). However, this is likely to reflect the greater proportion of women in the community that would be expected to seek primary care services particularly those aged between 20 and 44 years [59].

The use of office blood pressure is another potential source of bias. Ambulatory blood pressure has been shown to eliminate “white coat hypertension” and has increased precision over office BP [60]. Repeated measurements of ambulatory blood pressure provide an even

more accurate indication of usual BP than a single 24hr measurement [61]. However, automated office BP measurement is recommended for use in primary care settings as it has been shown to be comparable with awake ambulatory BP [62], and was thus deemed appropriate in this research context.

CONCLUSIONS

This analysis demonstrated that for participants in a weight loss clinical trial, consumption of a dietary pattern rich in nuts, seeds, fruit and fish was inversely associated with BP and with urinary Na:K ratio. Other dietary patterns shown to be associated with either urinary sodium or potassium excretion or Na:K ratio were not predictive of BP. In clinical weight loss settings, these findings could be integrated with other well-studied dietary patterns that have been shown to reduce BP such as the DASH diet, the Nordic diet and the Mediterranean diet for BP regulation. The findings also align with current dietary guidelines and highlight the importance of considering the whole dietary pattern when exploring the diet-disease relationship.

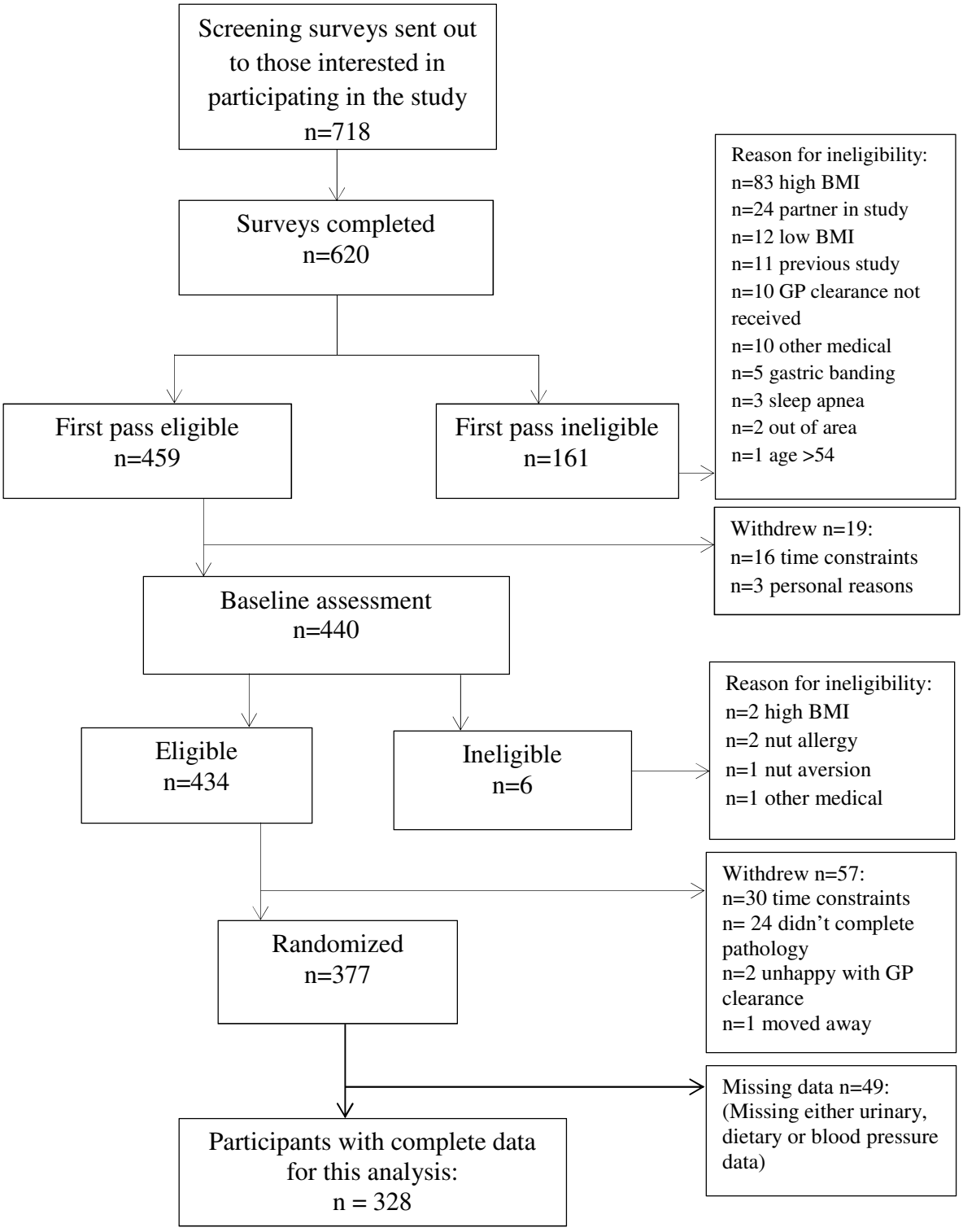

Figure 1

Flowchart of the Australian HealthTrack study recruitment and available baseline data for the present analysis. Adapted with permission from Tapsell LC (2015) *Interdisciplinary lifestyle intervention for weight management in a community population (HealthTrack study): study design and baseline sample characteristics. Contemp Clin Trials.45:394-403. © (2015) Elsevier.*

TABLE 1

Baseline characteristics of the 328 Australian adults participating in the HealthTrack study [a]

Characteristic	**Mean (SD)**
Male/ female, % (n)	27/73 (89/239)
Age, years	43.6 (8.0)
Height, m	1.7 (0.1)
Weight, kg	91.6 (15.1)
BMI, kg/m^2	32.4 (4.2)
Waist circumference, cm	103.4 (11.8)
Blood pressure	
Systolic, mmHg	125 (15)
Diastolic, mmHg	73 (10)
Hypertensives, % (n) [b]	26 (85)
Urinary excretion	
Volume, ml/day	2029 (879)
Creatinine, mg/day	1574 (498)
Median sodium, mEq/day, (IQR)[c]	139.0 (99.0-180.0)
Median potassium, mEq/day, (IQR)[c]	74.0 (57.0-91.0)
Median sodium-to-potassium molar ratio, (IQR)[c]	1.9 (1.5-2.4)
Median salt equivalent, g/day (IQR)[c]	8.2 (5.9-10.6)
Dietary intake	
Median energy, kcal/day, (IQR)[c]	2088 (1745-2500)
Median sodium, mg/day, (IQR)[c]	2682 (2084-3439)
Median potassium, mg/day, (IQR)[c]	3124 (2680-3825)
Medium calcium, mg/day, (IQR)[c]	915 (695-1139)
Medium magnesium, mg/day, (IQR)[c]	370 (304-473)

[a]Data are presented as mean (standard deviation), unless otherwise stated; [b]Participants were categorised as hypertensive if blood pressure was ≥140/90 mmHg and/or taking antihypertensives; [c]IQR, Interquartile range.

TABLE 2

AUSNUT2011-13 major food groups and example foods used in the Principal Component Analysis in the Australian HealthTrack study[a]

Major food group	Example food items
Alcoholic beverages	Beers, wines, spirits, cocktails and liqueurs
Cereal and cereal products	Bread, rice, noodles, pasta and breakfast cereals
Cereal based products and dishes	Sweet and savoury biscuits, cakes, sweet and savoury pastry, pizza, sandwiches and burgers
Confectionery and cereal/nut/fruit/seed bars	Chocolate, muesli bars, fruit bars, lollies, chewing gum
Dairy & meat substitutes	Soy beverages, almond milk, tofu, quorn and tofu stirfry
Dietary supplements	Vitamins and mineral supplements, fish oil supplements, fibre supplements
Egg products & dishes	Eggs, omelette, soufflé and frittata
Fats & Oils	Butter, margarine and oils
Fruit products and dishes	Apples, pears, berries, oranges, peaches, bananas, banana split, melons, dried fruit, apple crumble
Infant formulae and foods	Toddler formula, rusks, infant cereals and fruit, infant custards and fruit juices
Legumes and pulse products and dishes	Lentils, soy beans, chickpeas, kidney beans, falafel and dhal
Meat, poultry, game product and dishes	Beef, chicken, lamb, pork, veal, kangaroo, ham, dried meats, sausages, casseroles and curries
Milk products and dishes	Milk, yoghurt, cream, cheese, ice cream, dairy desserts, and cheesecake
Miscellaneous	Yeast, salt, intense sweeteners, herbs, stock, essences, gelatine and spreadable yeast extract
Non-alcoholic beverages	Coffee, tea, fruit juice, cordial, soft drink, water and electrolyte drinks
Reptiles, amphibia and insects	Crocodile, turtle, goanna
Savoury sauces and condiments	Tomato sauce, chutney, salad dressings, mayonnaise, vinegar and dips
Seafood products and dishes	Fish, prawns, canned tuna, fish with pasta or rice
Seed and nut products & dishes	Peanuts, walnuts, almonds, peanut butter, pumpkin seeds, coconut milk
Snack foods	Potato crisps, popcorn, corn chips, rice crisps and pretzels
Soup	Canned and homemade soup, dried soup mix
Special dietary foods	Liquid and powdered meal replacements, protein drinks and powders, oral supplement powder and beverages
Sugar products and dishes	Sugar, honey, jam, icing sugar, apple sauce and meringue
Vegetable products and dishes	Potatoes, carrots, beans, tomato, lettuce, cucumber, corn, salads, potato bake

[a]Adapted from: http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/4364.0.55.007Appendix22011-12; Food groups labelled Infant formulae and foods, Reptiles, amphibia and insects, and Dietary supplements were excluded from analysis due to a lack of participants consuming foods from these categories.

TABLE 3

Factor loading matrix for the dietary patterns identified by factor analysis among the Australian HealthTrack study participants (n = 328)[a]

Food group	Dietary pattern					
	Nuts, seeds, fruit and fish	**Milk and meat**	**Breads, cereals and snacks**	**Cereal based products, fats and oils**	**Alcohol, eggs and legumes**	**Savoury sauces and condiments and meat**
Seeds and nut products and dishes	**0.626**	-0.096	-0.053	-0.071	0.024	0.115
Fruit products and dishes	**0.574**	0.146	-0.316	0.117	-0.133	-0.215
Confectionery and cereal/nut/fruit/seed bars	**0.524**	0.062	**0.458**	0.084	-0.064	-0.112
Fish and seafood products and dishes	**0.427**	0.013	0.030	-0.047	0.346	0.138
Non-alcoholic beverages	0.166	**0.693**	-0.013	-0.055	0.155	-0.023
Milk products and dishes (milk, yoghurt, cheese, custard)	0.089	**0.575**	-0.021	0.294	-0.160	-0.159
Dairy and meat substitutes	0.388	**-0.540**	-0.002	0.021	0.072	-0.165
Meat, poultry and game products and dishes	-0.161	**0.482**	-0.121	-0.121	0.145	**0.400**
Snack foods	0.181	0.065	**0.613**	-0.079	-0.050	0.254
Cereal and cereal products (bread, rice, pasta, breakfast cereals)	-0.162	-0.124	**0.612**	0.061	0.134	-0.088
Vegetables products and dishes	0.164	0.064	**-0.548**	0.033	0.364	0.288
Sugar products and dishes	-0.117	0.249	0.262	0.221	0.059	-0.056
Cereal based products and dishes (biscuits, cakes, pastries)	0.047	-0.064	-0.043	**0.669**	-0.040	0.220
Fats and oils	-0.071	0.065	0.100	**0.609**	0.249	0.023
Special dietary foods	-0.010	-0.061	0.008	**-0.535**	0.167	0.043
Alcoholic beverages	-0.090	0.047	0.074	-0.106	**0.673**	0.201
Egg products and dishes	0.040	0.043	-0.033	0.020	**0.584**	-0.097

Legume and pulse products and dishes	0.104	-0.151	-0.143	0.313	**0.438**	-0.364
Savoury sauces and condiments	0.079	-0.049	-0.046	0.262	0.030	**0.784**
Variance explained (%)	9.46	8.69	7.99	7.21	6.71	5.97

[a]Factor loadings represent the magnitude and direction of association with dietary patterns and can range from -1.0 to 1.0. Factor loadings are interpreted similarly to the correlation coefficients. Bold font indicates factor loadings > ± 0.4 that were considered significant for inclusion of a food group in the respective dietary pattern. Two food groups (Miscellaneous and soup) were excluded from analysis due to low Kaiser-Meyer-Olkin measure (< 0.45) after inspection of the Anti-image Matrices.

TABLE 4

Regression coefficients (confidence intervals) showing associations between the six dietary patterns with blood pressure, urinary sodium, urinary potassium and sodium-to-potassium ratio among participants of the Australian HealthTrack study (n=328)[a]

	Nuts, seeds, fruit and fish	**Milk and meat**	**Breads, cereals and snacks**	**Cereal based products, fats and oils**	**Alcohol, eggs and legumes**	**Savoury sauces, condiments and meat**
SBP[b]	-0.005 (-0.010, -0.000)*	-0.001(-0.005, 0.004)	-0.003 (-0.008, 0.002)	0.003 (-0.002, 0.008)	0.005 (0.000, 0.010)	0.003 (-0.002, 0.008)
DBP[c]	-0.007 (-0.013, -0.001)*	-0.003 (-0.009, 0.002)	0.001 (-0.005, 0.007)	0.006 (0.000, 0.012)	0.004 (-0.002, 0.010)	0.003 (-0.003, 0.009)
Urinary sodium	-4.001 (-10.543, 2.540)	1.541 (-4.767, 7.850)	-4.652 (-11.418, 2.14)	-0.438 (-7.175, 6.300)	9.575 (3.161, 15.989)**	9.865 (3.485, 16.245)**
Urinary Potassium	2.165 (-1.169,5.499)	3.589 (0.390, 6.789)*	-4.960 (-8.377, -1.544)**	0.297 (-3.137, 3.732)	3.269 (-0.031, 6.570)	-0.903 (-4.199, 2.393)
Sodium-to-potassium ratio	-0.128 (-0.215, -	-0.076 (-0.161,	0.057 (-0.035,	0.014 (-0.077,	0.014 (-0.074,	0.123 (0.036,

	0.040)**	0.010)	0.149)	0.106)	0.103)	0.209)**

[a]Model adjusted for age, sex, BMI, antihypertensive medication, energy intake and physical activity; [b]SBP, systolic blood pressure; [c]DBP, diastolic blood pressure; *P<0.05, **P<0.01.

TABLE 5

Reported macronutrient and micronutrient intakes per day showing alignment and non-alignment with each of the six dietary patterns among participants of the Australian HealthTrack study (n=328)[a]

	Nuts, seeds, fruit and fish		**Milk and meat**		**Breads, cereals and snacks**		**Cereal based products, fats and oils**		**Alcohol, eggs and legumes**		**Savoury sauces, condiments and meat**	
	Aligned (n=160)	Not aligned (n=168)	Aligned (n=209)	Not aligned (n=119)	Aligned (n=166)	Not aligned (n=162)	Aligned (n=173)	Not aligned (n=155)	Aligned (n=153)	Not aligned (n=175)	Aligned (n=181)	Not aligned (n=147)
Macro Nutrients												
Energy, kcal	2236 (608)	2100 (582)	2224 (618)	2065 (547)*	2299 (661)	2030 (490)***	2328 (597)	1985 (546)***	2303 (640)	2047 (531)***	2267 (635)	2042 (523)***
Protein, g	105.4 (27.9)	103.2 (32.7)	108.6 (28.6)	96.7 (32.1)**	102.6 (30.1)	106.0 (30.6)	107.3 (30.0)	100.8 (30.6)	111.7 (31.4)	97.8 (27.9)***	112.3 (31.8)	94.4 (25.4)***
Total fat, g	89.7 (30.2)	82.5 (30.2)*	88.1(31.5)	82.3 (28.0)	93.0 (32.9)	78.9 (25.7)***	94.3 (30.3)	76.8 (27.7)***	92.3 (32.6)	80.5 (27.2)***	91.1 (33.0)	79.7 (25.5)***
Saturated fat, g	33.9 (12.8)	34.6 (14.9)	35.5 (14.5)	32.1 (12.6)	38.2 (15.1)	30.2 (11.3)***	38.0 (14.5)	30.1 (12.0)***	36.4 (15.0)	32.4 (12.6)*	35.2 (14.6)	33.1 912.9)
Polyunsaturated fat, g	15.1 (6.2)	11.4 (4.3)***	13.3 (5.6)	13.1 (5.7)	13.7 (5.7)	12.7 (5.3)	14.3 (5.6)	12.0 (5.4)***	14.2 (5.9)	12.3 (5.3)**	14.2 (6.1)	12.0 (4.8)***
Monounsatura	34.2	30.6	33.0	31.2	34.4	30.2	35.2	29.2	34.9	30.1	35.1	28.9

ted fat, g	(13.0)	(11.4)**	(12.6)	(11.7)	(12.9)	(11.3)**	(12.6)	(11.3)***	(13.2)	(11.0)***	(13.6)	(9.5)***
Cholesterol, mg	309.5 (117.2)	331.4 (142.6)	335.6 (122.8)	294.6 (141.3)**	318.5 (125.0)	323.0 (137.5)	331.4 (131.6)	308.9 (130.0)	372.5 (140.9)	275.5 (102.7)***	339.3 (135.5)	297.9 (122.2)**
Carbohydrate, g	230.1 (73.6)	212.9 (63.8)*	227.0 (73.8)	211.3 (59.1)*	242.2 (75.1)	199.8 (55.0)***	241.2 (70.7)	199.0 (60.3)***	222.1 (76.9)	220.5 (61.8)	223.7 (70.3)	218.3 (67.9)
Sugars, g	105.9 (41.9)	92.8 (39.5)**	106.9 (43.8)	85.8 (32.1)***	107.0 (45.5)	91.2 (34.5)***	106.3 (43.3)	91.3 (37.2)**	94.8 (42.0)	103.1 (40.1)	96.7 (39.8)	102.4 (42.7)
Starch, g	121.0 (44.8)	117.0 (36.3)	117.3 (41.1)	121.9 (39.9)	131.9 (42.2)	105.7 (34.4)***	131.9 (39.1)	104.5 (37.6)***	123.3 (45.1)	115.2 (36.1)	123.5 (41.3)	113.3 (39.3)**
Alcohol, g	6.1 (11.0)	8.5 (13.0)	7.1 (11.7)	7.7 (12.7)	7.1 (11.1)	7.6 (13.0)	6.4 (11.8)	8.4 (12.3)	13.5 (14.6)	1.9 (4.8)***	8.9 (13.2)	5.4 (10.2)**
Dietary fibre, g	27.4 (8.8)	21.8 (7.4)***	24.4 (8.0)	24.7 (9.6)	23.2 (8.5)	25.9 (8.6)**	26.7 (8.6)	22.1 (7.9)***	25.7 (8.4)	23.5 (8.6)*	25.3 (8.5)	23.5 (8.6)
Micronutrients												
Thiamin, mg	1.80 (0.67)	1.69 (0.88)	1.83 (0.83)	1.61 (0.69)*	1.77 (0.82)	1.72 (0.76)	1.94 (0.87)	1.53 (0.62)***	1.74 (0.75)	1.75 (0.82)	1.79 (0.80)	1.70 (0.77)
Riboflavin, mg	2.54 (0.90)	2.40 (1.28)	2.65 (1.19)	2.15 (0.89)**	2.54 (1.15)	2.40 (1.07)	2.68 (1.13)	2.23 (1.04)***	2.38 (1.01)	2.55 (1.20)	2.53 (1.19)	2.40 (1.01)
Vitamin C, mg	110.01 (63.15	88.84 (61.19)**	100.45 (57.53)	96.91 (71.70)	84.83 (55.05)	113.86 (67.20)***	99.76 (59.65)	98.51 (66.64)	105.97 (52.59	93.22 (70.40)	100.60 (62.33	97.41 (63.88)

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Vitamin D, µg	3.65 (1.92)	3.14 (1.67)*	3.65 (1.86)	2.93 (1.64)***	3.39 (1.83)	3.40 (1.80)	3.59 (1.77)	3.17 (1.83)*	3.72 (1.86)	3.10 (1.72)**	3.50 (1.94)	3.25 (1.63)
Vitamin E, mg	11.07 (4.31)	8.47 (3.26)***	9.79 (3.90)	9.66 (4.23)	9.62 (3.86)	9.86 (4.18)	10.52 (4.33)	8.87 (3.46)***	10.45 (3.83)	9.11 (4.09)**	10.51 (4.45)	8.79 (3.17)***
Total folate, µg	406.6 (154.1)	366.2 (212.8)	399.6 (194.9)	361.9 (171.4)	378.6 (188.8)	393.4 (186.0)	430.0 (196.6)	336.7 (163.4)***	385.7 (168.6)	386.1 (202.7)	379.2 (190.0)	394.2 (184.2)
Total Vitamin A equivalents, µg	1008. 0 (487.2)	923.2 (461.7)	981.2 (446.3)	935.4 (523.6)	877.5 (442.3)	1053.8 (492.9)**	1058. 7 (493.1)	859.5 (433.0)***	1049. 2 (503.0)	890.6 (438.2)**	992.9 (498.8)	929.7 (444.3)
Retinol, µg	326.7 (161.4)	374.6 (195.7)*	369.3 (183.6)	319.4 (172.7)*	388.2 (200.4)	313.3 (150.3)***	404.8 (192.4)	291.3 (146.3)***	375.6 (186.9)	329.9 (173.6)*	351.5 (179.3)	350.8 (183.8)
Beta-carotene equivalents, µg	4085 (2846)	3291(2357)**	3670 (2405)	3694 (3004)	2935 (2140)	4441 (2870)***	3922 (2728)	3407 (2505)	4040 (2695)	3363 (2545)*	3848 (2719)	3471 (2519)
Sodium, mg	2799 (1129)	2926 (1077)	2953 (1166)	2709 (968)*	3052 (1090)	2671 (1086)**	3073 (1178)	2631 (964)***	3057 (1201)	2696 (982)**	3126 (1202)	2542 (869)***
Potassium, mg	3509 (913)	3064 (875)***	3398 (904)	3077 (915)**	3112 (868)	3454 (941)**	3415 (857)	3132 (966)**	3470 (906)	3116 (902)**	3456 (939)	3067 (850)***
Calcium, mg	986 (385)	908 (316)*	1001 (367)	848 (304)***	966 (362)	925 (343)	1007 (329)	878 (367)**	938 (331)	953 (371)	955 (377)	934 (322)
Magnesium, mg	437 (136)	354 (108)***	405 (129)	375 (125)*	385 (128)	404 (128)	415 (122)	371 (132)**	418 (133)	374 (120)**	420 (133)	363 (115)***

Phosphorus, mg	1763 (424)	1627 (443)**	1763 (433)	1572 (424)***	1689 (453)	1698 (424)	1768 (408)	1610 (457)**	1765 (450)	1631 (420)**	1780 (454)	1587 (396)***
Iron, mg	13.41 (3.75)	11.77 (3.50)***	12.70 (3.51)	12.33 (4.06)	12.24 (3.82)	12.90 (3.58)	13.20 (3.66)	11.86 (3.66)**	13.18 (3.69)	12.04 (3.66)**	13.12 (3.74)	11.89 (3.57)**
Zinc, mg	13.40 (4.19)	12.74 (4.49)	13.67 (4.18)	11.97 (4.45)**	12.65 (4.04)	13.48 (4.62)	13.33 (4.03)	12.75 (4.68)	13.86 (4.52)	12.36 (4.09)**	13.89 (4.578)	12.03 (3.82)***
Iodine, µg	127.60 (43.89)	129.01 (54.14)	138.55 (49.66)	110.38 (43.47)***	131.56 (49.91)	125.02 (48.68)	137.46 (49.84)	118.14 (46.86)***	130.72 (48.92)	126.23 (49.74)	131.18 (51.96)	124.81 (45.83)
% Energy												
Percent of total energy from protein, %	19.5 (3.8)	20.2 (4.3)	20.3(4.1)	19.1 (4.1)*	18.3 (3.1)	21.4 (4.4)***	18.9 (3.3)	21.0 (4.6)***	20.0 (3.9)	19.7 (4.3)	20.4 (3.6)	19.2 (4.6)*
Percent of total energy from fat, %	35.2 (5.2)	34.2 (5.3)	34.6 (5.3)	34.8 (5.2)	35.4 (4.9)	34.0 (5.6)*	35.6 (5.0)	33.7 (5.4)**	35.1 (5.2)	34.4 (5.3)	35.1 (5.6)	34.2 (4.8)
Percent of total energy from carbohydrate, %	41.8 (6.3)	41.5 (7.5)	41.4 (6.5)	42.1 (7.7)	43.0 (6.3)	40.3 (7.3)***	42.2 (6.3)	41.1 (7.6)	39.2 (6.9)	43.9 (6.3)***	40.3 (7.1)	43.3(6.4)***

[a]Data presented as mean (standard deviation); *P<0.05, **P<0.01, ***P<0.001; P values represent significant differences between participants who aligned or did not align with a specific dietary pattern.

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Conflict of Interest Disclosure

No authors report a conflict of interest

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