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Baseline dietary patterns are a significant consideration in correcting dietary exposure for weight loss

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Abstract

Background/objectives: Dietary pattern studies are traditionally the domain of epidemiological research. From a clinical perspective, there is a need to explore the effects of changing food and dietary patterns of individuals. The aim was to identify patterns of food choice in the context of a clinical weight loss trial. Cluster analysis based on reported serves of food groups revealed dietary patterns informative for the clinical setting.

Subjects/Methods: Cluster analysis was conducted using diet history data from two clinical trials at baseline, and outcomes at 3 months were reviewed based on these clusters (n=231). The cluster solution was analysed using defined food groups in serves and with respect to clinical parameters and requirements for selected nutrients.

Results: Two distinct dietary patterns were identified from the reported baseline dietary intakes. Subjects in Cluster 1 reported food patterns characterised by higher intakes of low-fat dairy and unsaturated oils and margarine and were generally more closely aligned to food choices encouraged in national dietary guidelines. Subjects in Cluster 2 reported a dietary pattern characterised by non-core foods and drinks, higher- and medium-fat dairy foods, fatty meats and alcohol. At 3 months, Cluster 2 subjects reported greater reductions in energy intake (−5317 kJ; $P<0.001$) and greater weight loss (−5.6 kg; $P<0.05$) compared with Cluster 1.

Conclusions: Overweight subjects with reported dietary patterns similar to dietary guidelines at baseline may have more difficulty in reducing energy intake than those with poor dietary patterns. Correcting exposure to non-core foods and drinks was key to successful weight loss.

Keywords

exposure, weight, significant, correcting, dietary, consideration, patterns, baseline, loss

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Keywords: Cluster analysis; dietary pattern; weight reduction; health outcome assessment; dietetic practice; food

Introduction

Dietary advice for weight loss is given in terms of foods or meals, therefore in the clinical setting, review of dietary patterns may be most informative. Dietary pattern analysis is conceptually complex [1], and whole-of-diet approaches have now been used in a variety of countries to study a range of diseases [2-7] but studies applied specifically to dietary interventions are limited [8, 9]. Togo et al 2007 [10] defined dietary patterns as 'the distribution (by frequency and/or amount) of foods in the habitual diet' (as distinct from meal patterns). Knowing which foods or patterns in the habitual diet need to change to achieve clinically relevant outcomes is an important adjunct for all dietary therapy.

In clinical practice and research, high quality dietary data is required in the initial dietary assessment. Typically, the diet history interview and 7-day food record have interchangeably served as 'gold standards'[11-14]. While both provide records of foods consumed, the diet history 'tells the story' of foods and meals *usually* consumed over a defined time period of a week or a month [15], and captures this within the narrative of the consultation performed by a skilled professional [16]. In the clinical setting, the interviewer-administered diet history method may be more precise than a self-administered food record as it allows for quantification of more individual items and greater flexibility to probe for less frequently consumed foods that may be important for behaviour change. As a method of dietary data collection it is less affected by education level as it is not reliant on written instruction, and the method of questioning maintains respondent interest and helps build rapport [12]. The narrative, including portion size and food frequency, can then be distilled manually (in a typical practice setting) or using computer analysis, with data analysed in terms of nutrients, foods or food groups. This output can be utilised to help correct dietary exposure and inform tailored advice to facilitate dietary change [17].

In dietary pattern research, the percent energy contribution from the food subgroups can be used for cluster analysis but if consumption of a single macronutrient happens to be high, other values are depressed [18]. Using foods for analysis lends itself to exploration of dietary patterns and may be more sensitive in discerning contributions of food groups, particularly foods associated with positive (eg low

energy vegetables) or negative health outcomes (eg high saturated fat foods). Bailey et al [18] found more consistent results with a focus on food in serves, which mimics approaches in the practice setting and allows easy translation of research to practice.

Cluster analysis can be used to segment and identify dietary patterns within the study population independently of their associations with outcomes [19]. Cluster analysis is data driven, however the food groupings, used to organise the data, are the result of a systematic, hypothesis driven approach. This statistical method lends itself well to the concept of healthy diets, such that one would expect positive (and negative) dietary patterns to cluster together [20]. When applied to population samples, cluster analysis 'groups people who share similar frequency patterns for consumption of foods' [21], such that an individual can only belong to one cluster, for example, 'Prudent' or 'Western' diet patterns[22]. The specific food choices of successful dieters, even those selected prior to a dietary intervention may reveal dietary patterns that are informative for clinical practice.

This study applied cluster analysis to explore dietary patterns at baseline from participants in weight-loss dietary interventions. The aim of the study was to identify patterns of food choice in the context of a clinical weight loss trial.

Methods

Participant diet history records from two registered clinical weight loss trials (ACTRN 12608000425392 and 12610000784011) were analysed. The trials utilised were 12 month randomised controlled dietary trials in healthy overweight adults drawn from the local area using newspaper advertisements. Participants in both trials were blinded to the intervention and education was based on a similar approach to kilojoule restriction for weight reduction. Each had a control and intervention group and exclusion criteria as described in Table 1. For each clinical trial, diet history data reflective of a weekly pattern of intake was collected at baseline and 3 months by accredited practising dieticians. Participants had completed an estimated 4-day food record prior to interview which assisted with recall of types and amounts of foods

consumed. A checklist of the frequency of consumption of specific foods was also used for items that may have been omitted from the history. All food records were analysed using a computerised food and nutrient database, Foodworks™ Professional (Xyris, Brisbane, Australia, Version 6, 2009).

In many studies of dietary patterns and disease, little justification is provided for the food groups utilised [23] with food groupings predicated by the tool or method used to collect the data. Our work defined and tested the food groups specific to the clinical setting in advance, using a sub-set of dietary data [24]. In defining the food groups, the number of categories was broadened from the usual five core food groups and were based on (i) their biological characteristics to define categories of food (eg. fruit, or nuts and seeds)[25], or (ii) by their means of production (eg. alcohol)[25], or (iii) by their nutrient composition including energy density (eg. milk and milk alternatives), or (iv) by their culinary use, and (v) the evidence base for relationships between food consumption patterns and health outcomes specifically with interest to weight management. This resulted in seventeen groups including wholegrains, non-wholegrain cereal foods, starchy vegetables, free vegetables, fruit, higher fat, medium fat and low fat milk and milk alternatives, lean and fatty meat, eggs, legumes, fish, nuts and seeds, unsaturated oils and margarine were used for the cluster analysis. Non-core energy dense foods and drinks were categorised separately to alcohol. Table 2 outlines the scope of foods included in each of the 17 groups. The dietary data collected at baseline and three months were tabulated by food group and a ready reckoner (RR)[26, 27] was used to calculate the serves of each food group consumed. In the clinical trial protocol, baseline and 3-month anthropometry and fasting biochemistry were measured.

In order to explore the diverse nature of the non-core foods and drinks category, six additional groups were created for use in subsequent analysis of the non-core food and drinks category specifically in relation to consumption pattern by gender. These groups included juice (100% juice, juice drinks), soft drink (all types, including cordial), sweet treats (chocolate, chocolate bars, sweet biscuits, cake, ice cream), savoury treats (savoury biscuits, dips, crisps), takeaway food items (commercial hamburgers and foods, takeaway meals, fried foods like fish and chips) and other foods/ ingredients (sugar, butter, spreads, sauces). All non-core

foods and drinks were based on 600kJ as per the Australian Guide to Healthy Eating (AGHE)[28], so the weight of the drinks would not influence the number of serves for the non-core foods and drinks category.

An independent samples t-test (IBM SPSS Statistics, version 19.0.0 IBM Corporation Armonk NY), was used to determine any significant differences between the two trial datasets in terms of age of participants, BMI and reported percent of macronutrients consumed, and a Chi-square test for gender differences (categorical variables) between the baseline data sets and between clusters. In the dietary pattern analysis, a two-step clustering procedure was used to allow the food group serve data to drive the clustering rather than setting a predefined number of clusters. In the two-step procedure, pre-clusters are formed and then re-clustered using a hierarchical process. A number of alternative cluster solutions were tested to ensure that the natural group structure of the data was adequately defined. The clusters were established with baseline data and were compared alongside changes at three months in serves of food, anthropometric data, biochemical data and selected nutrient data from Foodworks™ using independent samples t-test between the clusters and paired t-tests for within-cluster changes. All data were checked for normality using Shapiro-Wilks and median and interquartile ranges (IQR 25th-75th percentile) were presented where appropriate.

Results

Subjects

Combining two clinical trial data bases allowed for analysis of data from 231 participants. Baseline data from each trial are provided in Table 1. Independent t-tests revealed no baseline differences between the two sets of trial data in terms of age of participants or percent fat or carbohydrate intake yet there was a significant difference in the percent protein (*P* 0.006) and the reported energy intake (*P* 0.006). At baseline the reported macronutrients were within the accepted macronutrient distribution range (AMDR)[29] with the exception of carbohydrate for Study 1, which was lower than the suggested target of 45-65% E. The baseline BMI was significantly different (*P* 0.002) as the entry criteria differed for each study, though there

was no difference between trials in the weight lost by 3mo (*P* 0.639). Chi square analysis found no difference in gender between the two groups.

Cluster analysis

All foods reported from the diet history records were able to be categorised using the outlined 17 food groups. Two distinct dietary patterns were identified at baseline. Cluster 1 (n =193; 83.5%) represented subjects consuming a significantly greater number of portions of low fat dairy foods (*P* 0.001) and unsaturated oils and margarine (*P* 0.012). This cluster also represented a lower mean energy intake at baseline compared to Cluster 2 (*P*<0.0001). Cluster 2 (n =38; 16.5%) represented subjects reporting consumption of a significantly greater number of portions of non-core foods and drinks (*P*<0.0001), fatty meat (*P* 0.031), higher fat dairy foods (*P* 0.003) and medium fat dairy foods (*P*<0.0001), alcohol (*P* 0.003), non-wholegrain cereal foods (*P*<0.0001) and wholegrains (*P* 0.002). Based on these differences, Cluster 1 were referred to as the low-fat dairy pattern and Cluster 2 as the high-non-core food choices pattern as these were dominant groups in the clustering process. These results are presented in Table 3.

At 3 months, there were no differences in any food groups between the two clusters. Between baseline and 3 months both clusters reported decreased consumption of non-wholegrain cereal foods, higher fat dairy foods, fatty meat, alcohol and non-core foods and drinks and these within-group changes were significant. Both clusters significantly increased consumption of legumes and low-fat dairy. Cluster 1 significantly increased fruit, free vegetables and decreased lean meat, eggs, nuts and seeds, and unsaturated oils and margarine. Cluster 2 significantly decreased medium-fat dairy which includes full cream milk. The changes reported in dietary intake between time points resulted in significant differences between the clusters and these are detailed in Table 3.

Non-core foods and drinks category were separated into juice, soft drink, sweet treats, savoury treats, takeaway food items and other foods/ ingredients, shown in Table 3. Cluster 2 subjects consumed significantly more soft drink/cordial (*P* 0.039), sweet treats (*P* 0.001), takeaway foods (*P* <0.0001) and other non-core foods/ ingredients (*P* <0.0001) at baseline compared with Cluster 1 subjects. By 3 months, there

was no significant difference in non-core foods and drinks between groups. However within-clusters, all non-core foods and drinks were significantly reduced with the exception of juice and soft drink for Cluster 2.

There was a gender difference between clusters, with proportionally more men in Cluster 2 (P <0.0001), however there were commonalities between sexes within each cluster with regard to serves from the food groups. Males in each cluster report consuming significantly more alcohol (Cluster 1 P 0.032; Cluster 2 P 0.005) and females reported consuming significantly more unsaturated fat (Cluster 1 P 0.008; Cluster 2 P 0.034). Males reported more meat consumption than females; males consumed more lean meat and poultry (P 0.041) in Cluster 1, and more fatty meat (P 0.005) and fish and seafood (P 0.04) in Cluster 2. Compared with females, males also consumed more non-wholegrain cereal choices (P 0.021) in Cluster 1 but not in Cluster 2.

At baseline, Cluster 2 participants were heavier (P<0.001), had a higher BMI (P 0.046), and a larger waist measurement (P 0.005) than Cluster 1 subjects (Table 4). Cluster 1 subjects had a higher mean percent body fat (P<0.001) and a higher HDL-cholesterol level (P 0.011). There were no other significant differences in clinical parameters between the clusters at baseline. By three months, Cluster 2 subjects had lost more weight (-5.64kg; P 0.037) than Cluster 1 (-4.4kg). Cluster 2 had made greater changes in terms of energy intake (-5317kJ; P<0.001) in comparison to those in Cluster 1 (-2500kJ) (Table 4). Both clusters had significant reductions in total cholesterol and there were significant within-group changes in LDL-cholesterol, HDL-cholesterol, Glucose and Insulin for Cluster 1.

In order to assess the nutrient adequacy of the dietary patterns, nutrient values were compared to Australian Nutrient Reference Values[29]. The median (percent) macronutrient intake of Cluster 1 at baseline reflected the AMDR, however for Cluster 2 the total fat was just above the range (35.7%) and the carbohydrate was lower than the suggested target (40.7%). By 3 months, both clusters were more aligned

with the AMDR although carbohydrate remained lower in Cluster 2. Reported intakes of iron and calcium were within estimated average requirements (EARs) and mean dietary fibre met the adequate intake (AI) of 25g defined for females at baseline and 3 months for both clusters.

Discussion

This research found that participants with poor dietary patterns at entry to the weight-loss interventions achieved better results than those with established healthier dietary patterns. Subjects who reportedly consumed larger amounts of non-core foods, higher fat and medium fat dairy foods and alcohol at baseline (Cluster 2) were able to alter their dietary pattern more successfully to achieve an energy deficit. Cluster 2 subjects reduced energy (-5317kJ; $P<0.001$) and lost more weight (-5.64kg; $P<0.05$) over three months compared with Cluster 1. At baseline, subjects in Cluster 1 reported consuming higher amounts of low fat dairy and unsaturated oils and margarine and consumed amounts and types of each food group closer to national dietary guideline recommendations particularly for grains and cereals, milk and alternatives [30]. Over the study period, Cluster 1 subjects achieved a weight loss of -4.37kg, the result of a reduction in some higher energy food groups, though these subjects possibly found it more difficult to substantially alter energy intake. Cluster 1 and 2 subjects were successful in losing weight, but Cluster 2 subjects, made greater changes to their diet composition. Cluster 2 dietary patterns may be clinically meaningful, representing participants with dichotomous, “all-or-nothing” thinking [31] in relation to food choices, particularly relevant to attempts for reduced energy intakes. This behavioural approach to food decision making is known to be an unproductive method of long term weight control, and counselling is useful in building strategies to alter this habitual behaviour [32]. The use of cluster analysis proved useful in differentiating between subjects with respect to dietary patterns observed in the context of a weight loss intervention, and is an approach known to relate to health indicators [33-35] and behaviours [8].

Over the 3-month timeframe participants in both clusters increased consumption of vegetables and consumed adequate amounts of low-fat dairy foods while reducing non-core foods and drinks and alcohol. However, targeting non-core foods and drinks and limiting selection from this food group and making

188 appropriate substitutions appeared key to the greater weight loss achieved by Cluster 2 subjects. All non-
189 core food and drink categories were significantly reduced within Cluster 1, however for participants in
190 Cluster 2, reduced consumption of foods categorised as sweet treats and takeaway foods decreased the
191 baseline non-core food and drink consumption by half. A dietary intervention strategy focussing on
192 reducing the variety of non-core foods consumed was recently proposed and examined in a randomised
193 controlled trial in which the intervention strategy specifically targeted non-core foods on the basis that
194 they are non-nutrient, high energy choices [36, 37]. While participants achieved success in terms of compliance
195 with the diet prescription, there was no difference in percentage weight lost after 18 months as the overall
196 energy intake was not adequately reduced. The authors suggested that more than one energy-dense food
197 category needed to be targeted to achieve desired outcomes. In our study, Cluster 2 subjects reduced
198 intake of all problematic food groups that characterised the cluster at baseline. It has been reported [38] that
199 foods such as meat (processed and unprocessed), potatoes, potato chips and sugar-sweetened beverages
200 can be strongly associated with weight gain. Cluster 2 subjects reported consuming more of all of these
201 foods at baseline and by 3 months reduced lean and fatty meats by over 2 serves, and all non-core foods
202 and drinks by 5.75 serves or over 3400kJ.
203
204 It has been known for some time that Australians tend to consume large quantities of non-core foods, up to
205 36% of energy [39] and in this study, 31% (including alcohol), exceeding the maximum recommended limit of
206 20% for healthy individuals and the serves suggested in the AGHE [30]. Non-core foods and drinks can
207 displace nutrient rich core foods in the diet and influence the overall nutritional profile of the diet. The
208 focus in weight loss needs to be around creatively substituting non-core foods and beverages with core
209 foods that positively influence diet quality and the nutritional profile of the diet. Due to the known
210 excessive consumption of non-core foods, practice and research based diet prescriptions need to prescribe
211 specific types and amounts of non-core foods and beverages, such that they are a recognised part of the
212 total energy prescription. This may be important in tailoring advice and maintaining compliance in those
213 wishing to reduce their weight.
214

As a check of diet quality, Wirfalt and Jeffery [33] suggest checking nutrient intakes in relation to food energy between the clusters since a reduction in energy does not guarantee that nutrient density is high. This was an important confirmatory step in our study, since nutrient analysis alongside food based analysis is complementary and valuable for checking the adequacy of the reported diet. For example, there was a decrease in the number of serves of unsaturated oils and margarine (Cluster 1) by 3 months. This was not intended, although the change was easily noted via the food-level analysis, and highlights the importance of providing very specific education around food sources of preferred fats in the dietary advice setting. It is also possible that due to the dietary assessment methods, participants may have adjusted their reporting as they became familiar with portion sizes and the requirements of the diet history process. Self-reporting is known to be prone to systematic bias affected by factors such as age, gender, social desirability and approval [40]. Clinical data supports the dietary changes made by participants, particularly reductions in total Cholesterol.

There are limitations to cluster analysis techniques. Cluster methods may involve a degree of investigator subjectivity and this can influence the evaluation of the results, the naming of the cluster and the conclusions made. While we note the limitations of the cluster sizes, the analysis defined only these groups and these may define significant differences relevant in clinical practice. Kant, citing Jacobson and Stanton suggests that 'researchers should discard factors or clusters with due care because the obtuse factor/cluster may be the one that leads to recognition of new knowledge'[41]. In the two-step clustering used, we allowed the data to drive the groupings formed and clusters were named according to the most dominant food groups, therefore the choice was less subjective. In previous studies, there has been a tendency to simplify the naming of clusters for example, 'More healthy' and 'Less healthy' [42, 43] although a range of names have been used [41]. Importantly, dietary patterns are not dichotomous and permanent, and on balance, quantitative naming of clusters as has been used is preferred [43]. Few studies have investigated dietary change using dietary pattern approaches. Reedy et al, defined five clusters relating to fruit and vegetable consumption[8]. Importantly, this paper reinforces the value of dietary pattern research in moving away from a single theoretical model of what defines "health protective" behaviour. Madlensky et al define

three clusters also based on dietary change and found that even those in the cluster with the poorest dietary quality at baseline made major changes [9].

It is known to be difficult to compare dietary pattern results across studies, since the patterns reflect the actual practices within the population under study and as such, provide useful information for *that* population [44]. However, our study provides support for targeting non-core foods and drinks, and it is likely that within a comparable overweight population, there may be some consistency, making these findings 'reasonably reproducible' [45] since specific foods can cluster, while the overall pattern may differ [46]. The results of this study provide useful information about the scope of dietary change under supervised conditions and this method of analysis can be applied to other therapeutic areas of dietetics. It would also be valuable to assess dietary patterns in an intervention context over longer periods of time, greater than 3 months.

Conclusion

Cluster analysis to derive dietary patterns from diet history data provides useful insights into the diets of overweight study participants and the changes that are made at food group level within the context of a dietary trial. Overweight subjects with dietary patterns that are similar to dietary guidelines at baseline may have more difficulty in reducing energy intake than those with poor dietary patterns. Correcting exposure to non-core foods and drinks was key to successful weight loss. Adequately quantifying discretionary food items at baseline and ensuring advice is given specifically regarding these foods within the diet prescription, may give participants greater awareness of appropriate food choices, serve size and assist with compliance. The study highlights the importance of overall diet quality in the context of weight loss, and gives specific insight for targeting non-core foods and drinks.

The authors declare no conflicts of interest.

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434 Table 1. Baseline characteristics (Median and IQR) of clinical trial participants

	Study 1 (n=118)	*Study 2 (n=113)*	*P value*
Males	31	28	0.795
Females	87	85	
Age (mean ±SD)	45±8.4yrs	49.8±9.4yrs	<0.0001
Weight (kg)	88.1 (79.2-97.9)	83.4 (76.6-91.4)	0.007
BMI (kg/m^2)	30.7 (28.5-34.4)	29.9 (27.8-31.9)	0.002
Percent Body fat	40.3 (34.4-45.0)	39.2 (35.4-43.0)	0.417
Waist (cm)	104.0 (97.9-111.0)	97.8 (91-103.5)	<0.0001
Weight lost by 3mo (kg)	n=87 -4.7±3.1	n=107 -4.5±3.0	0.639
Total Cholesterol (mmol/L)	5.2 (4.5-5.9)	5.3 (4.6-5.9)	0.608
Triglycerides (mmol/L)	1.3 (1.0-1.9)	1.13 (0.8-1.6)	0.015
HDL (mmol/L)	1.4 (1.2-1.7)	1.4 (1.2-1.6)	0.316
Chol:HDL (mmol/L)	3.5 (2.9-4.4)	3.7 (3.0-4.6)	<0.0001
LDL (mmol/L)	3.2 (2.5-3.7)	3.2 (2.6-3.8)	<0.0001
Glucose (mmol/L)	5.0 (4.6-5.3)	5.3 (4.9-5.6)	<0.0001
Insulin (mU/L)	10.3 (8.0-14.2)	10.9 (7.9-14.6)	0.934
Energy (kJ)	9404.2 (7603.4-11069.6)	8404.3 (7296.1-9886.5)	0.006
% Protein	18.2 (16.1-20.3)	19.5 (17.9-21.1)	0.006
% Carbohydrate	41.9 (37.5-46.9)	43.0 (38.4-47.2)	0.155
% Fat	33.6 (30.0-38.9)	32.4 (28.8-35.8)	0.423

Inclusion criteria	18-60yo and BMI 25-≤37kg/m2	18-65yo and BMI 25-35kgm2.
Common exclusion criteria	Major illnesses, Type 1 and Type 2 diabetes mellitus, thyroid abnormalities, pregnancy/lactation, recent acute or chronic disease, medications that may affect body weight, unstable body weight, food allergies or avoidance of major food groups.	
Other exclusion criteria	Low density lipoprotein > 6 mmol/L, and an inability to take fish oil supplements	Heavy alcohol intake, fluctuating or strenuous exercise > 1hr/day, dietary avoidance (including extreme vegetarianism) or dislike of vegetables.
Diet prescription	Energy deficit (-2MJ) based on core food groups excluding non-core foods and drinks and alcohol.	
Control diet(s) (referencing national dietary guidelines)	Low calorie + placebo supplement (olive oil)	Low calorie with 5 serves of vegetables (75g/serve)
Intervention diet(s) (referencing national dietary guidelines)	Low calorie including fish (180g/day); Low calorie including fish oil supplements (EPA+DHA)	Low calorie with 10 serves of vegetables (75g/serve)
Education level	64% Tertiary education	85% Tertiary education
Smoking status	7/118 smokers	2/113 smokers
Physical activity	Habitual physical activity assessed by questionnaire*at Baseline and 12months	

435 Interquartile range (IQR); ***Baecke et al 1982** [47] ; Independent samples t-test, 95% CI; Chi Square for categorical variables (gender); Acceptable
436 Macronutrient Distribution Range (AMDR) Protein 15-25%, Fat 20-35%, Carbohydrate 45-65%[29].

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439 Table 2. Scope of foods included in each food group.

	Category	*Scope of food items*
1.	Wholegrain foods	Wholemeal or wholegrain breads or crispbreads, wholegrain English muffins, dark 'seedy' breads, wholegrain breakfast cereals, wholegrain pasta, brown rice, polenta, barley, puffed whole grains, bulgar, couscous, popcorn and oatmeal. Added brans- wheatgerm, oat, psyllium.
2.	Non-wholegrain cereal foods	White bread including fibre enriched, Turkish bread, White flour tortillas and other flat bread, white flour English muffins and crumpets; Refined breakfast cereals, white rice, noodles and pasta.
3.	Fruit	Fresh, canned, dried, frozen fruit.
4.	Free vegetables	All vegetables except potato, sweet potato, corn, pumpkin, parsnip.
5.	Starchy vegetables	Potato, sweet potato, corn, pumpkin, parsnip; no added fat in cooking.
6.	Legumes	Split peas, cannellini beans, borlotti beans, lentils (all types), chick peas, kidney beans, broad beans, butter beans, baked beans in tomato sauce (navy beans), bean mixes.
7.	Low fat dairy foods: <3.5% fat	All fat reduced or skim bovine milks and yoghurts (including soy-based).
8.	Medium fat dairy foods: 3.5-10% fat	Regular full cream milks and regular fat yoghurts (including soy based). Cottage cheese, ricotta, evaporated milk, condensed milk and custard were placed in a group depending on their fat composition*.
9.	Higher fat dairy foods: >10% fat	Soft and hard cheese*.
10.	Lean Meat & poultry	Red meat- beef, lamb, pork, veal, venison, rabbit, kangaroo, goat; Poultry- chicken, turkey or duck; Cut noted to assist in classification into lean or fatty cut; skin or fat trimmed; low fat cooking method.
11.	Fatty meat	Fatty cuts of meat, processed meat, luncheon meat, crumbed and fried meat; poultry skin intact.
12.	Fish & seafood	Fresh, tinned, smoked fish and seafood; not fried.
13.	Eggs	Eggs, all types; in cooking or as part of the meal.
14.	Nuts (& seeds)	Tree nuts and peanuts; seeds and seed mixtures (each 30g).
15.	Unsaturated oils & margarine	Monounsaturated and Polyunsaturated oils and margarines; olives and avocado.
16.	Alcohol	All alcoholic beverages (each 400kJ)
17.	Non-Core foods & drinks	Including foods and drinks of low nutrient density and food sources of saturated fat (butter, cream), added sugar, soft drink/cordial, juice, fruit drinks, snack foods, takeaway including commercial hamburgers, fried foods, sauces, spreads (each 600kJ)

440 * *Baghurst et al 2011* [48]

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Table 3. Core and Non-core food and drinks consumed at baseline, 3 months and change between and within Cluster 1 and 2.

	Baseline					*3 Months*					*Change*		
	Amount consumed by Cluster 1 (n=193)		*Amount consumed by Cluster 2 (n=38)*			*Amount consumed by Cluster 1 (n=165)*		*Amount consumed by Cluster 2 (n=30)*			*Change by Cluster 1 (n=165)*	*Change by Cluster 2 (n=30)*	
Food Group	*Median (IQR)*	*Mean Serves*	*Median (IQR)*	*Mean Serves*	*P value*	*Median (IQR)*	*Mean Serves*	*Median (IQR)*	*Mean Serves*	*P value*	*Mean Serves*	*Mean Serves*	*P value*
Wholegrain foods	78 g/d (48-117)	2.87	102 g/d (31-162)	4.23	0.077	77 g/d (48-100)	2.68	113 g/d (92-158)	4.24	0.001	-0.19	0.36	0.488
Non-wholegrain cereal foods	90 g/d (53-142)	3.34	158 g/d (71-202)	5.20	0.001	50 g/d (24-85)	2.08	73 g/d (35-174)	3.30	0.042	-1.24**	-1.86*	0.202
Fruit	165 g/d (96-256)	1.24	152 g/d (73-299)	1.49	0.286	223 g/d (158-279)	1.46	228 g/d (154-314)	1.70	0.218	0.21*	0.34	0.658
Free vegetables	214 g/d (145-317)	3.15	194 g/d (132-349)	3.33	0.627	372 g/d (266-469)	5.00	289 g/d (228-348)	4.10	0.014	1.81**	0.72	0.013
Starchy vegetables	53 g/d (27-85)	0.87	54 g/d (11-131)	1.03	0.382	61 g/d (35-91)	0.93	41 g/d (27-68)	0.80	0.375	0.05	-0.30	0.071
Legumes	0 g/d (0-27)	0.25	0 g/d (0-14)	0.14	0.052	26 g/d (2.8-59)	0.52	13 g/d (0-36)	0.35	0.155	0.27**	0.27*	0.982
Low fat dairy foods: <3.5% fat	252 g/d (115-468)	2.08	51 g/d (0-276)	1.01	0.001	365 g/d (238-510)	2.55	325 g/d (210-619)	2.51	0.878	0.46*	1.33*	0.021
Medium fat dairy foods: 3.5-10% fat	0 g/d (0-56)	0.27	373 g/d (0-693)	2.98	<0.0001	0 g/d (0-3.3)	0.21	0 g/d (0-37)	0.40	0.355	-0.04	-2.37**	<0.0001
Higher fat dairy foods: >10% fat	14 g/d (5.7-23)	0.56	24 g/d (4.6-65)	1.25	0.003	3 g/d (0-8)	0.22	3 g/d (0-12)	0.26	0.655	-0.34**	-0.80**	0.018
Lean Meat & poultry	102 g/d (69-145)	3.91	117 g/d (77-175)	4.47	0.203	82 g/d (63-120)	3.19	99 g/d (60-158)	3.72	0.221	-0.60*	-0.46	0.815
Fatty meat	33 g/d (10-61)	1.37	36 g/d (11-79)	1.96	0.137	8 g/d (0-22)	0.51	8 g/d (0-38)	0.68	0.363	-0.81**	-1.25*	0.119
Fish & seafood	35 g/d (13-57)	1.37	33 g/d (14-70)	1.78	0.221	33 g/d (20-54)	1.39	44 g/d (24-64)	1.65	0.251	0.02	-0.23	0.440
Eggs	12 g/d (3.8-20)	0.50	20 g/d (6.6-25)	0.71	0.039	9 g/d (3.6-14)	0.33	11 g/d (6.3-16)	0.46	0.033	-0.18**	-0.24	0.611
Nuts (& seeds)	11 g/d (1.8-28)	0.65	21 g/d (3.8-56)	1.09	0.051	8 g/d (1-13)	0.30	13 g/d (3-29)	0.56	0.023	-0.34**	-0.59	0.381
Unsaturated oils & margarine	12 g/d (3.3-32)	4.63	7 g/d (0.9-20)	2.15	<0.0001	6 g/d (1.3-14)	1.91	5 g/d (0-13)	2.60	0.409	-2.81**	0.30	0.008
Alcohol	175 kJ/d (10-424)	0.75	389 kJ/d (33-1456)	1.96	0.003	103 kJ/d (0-284)	0.50	202 kJ/d (0-522)	0.92	0.114	-0.27*	-1.03*	0.005
Non-Core foods and drinks	1932 kJ/d (1195-2953)	3.65	3080 kJ/d (1780-5731)	6.73	<0.0001	572 kJ/d (226-958)	1.17	587 kJ/d (358-1047)	1.35	0.406	-2.44**	-4.78**	0.003
Juice	137 kJ/d (66-240)	0.10	132 kJ/d (79-388)	0.17	0.148	111kJ/d (56-155)	0.05	277 kJ/d (104-414)	0.09	0.365	-0.06*	-0.06	0.928

Soft Drink/cordial	54 kJ/d (4-328)	0.20	114 kJ/d (8-575)	0.42	0.037	8kJ/d (1-74)	0.04	2 kJ/d (1-9)	0.04	0.912	-0.17**	-0.30*	0.484
Sweet Treats	728 kJ/d (369-1460)	1.62	1008 kJ/d (577-2434)	2.54	0.030	117 kJ/d (10-288)	0.39	170 kJ/d (0-390)	0.43	0.768	-1.23**	-2.00**	0.082
Savoury Treats	84 kJ/d (0-272)	0.35	159 kJ/d (0-456)	0.55	0.201	9 kJ/d (0-150)	0.17	0 kJ/d (0-102)	0.11	0.346	-0.19**	-0.46*	0.177
Takeaway Foods	284 kJ/d (60-632)	0.76	683 kJ/d (326-1716)	1.96	0.001	0 kJ/d (0-128)	0.19	87 kJ/d (0-265)	0.34	0.861	-0.06**	-1.03**	0.011
Other Non-Core items	299 kJ/d (136-519)	0.63	557 kJ/d (184-809)	1.11	0.018	141 kJ/d (60-253)	0.34	82 kJ/d (22-248)	0.28	0.849	-0.69**	-0.40**	0.386

Interquartile range (IQR); Grams (g) used to calculate serves per day for each core food group; Kilojoules (kJ) used for Alcohol and Non-Core Foods and Drinks; Kilojoules (kJ); Independent samples t-test, 95% CI; Paired T-test for within cluster differences at 3mo *P<0.05; **P<0.001

Table 4. Anthropometric, clinical and nutrient intake data at baseline, 3 months and changes within and between Cluster 1 and 2.

	Baseline			3 months			Change		
	Cluster 1 n=193 (83.5%)	Cluster 2 n=38 (16.5%)	*P* value	Cluster 1 n=165	Cluster 2 n=30	*P* value	Cluster 1 n=165	Cluster 2 n=30	*P* value
Weight (kg)	85.4±11.3	94.4±12.7	<0.001	80.9±11.2	88.1±12.4	0.002	-4.4**	-5.6**	0.037
BMI	30.5±3.2	31.6±3.2	0.046	28.8±3.0	29.3±2.9	0.417	-1.6**	-1.9**	0.156
Body fat (%)	39.6±6.5	35.4±6.7	<0.001	37.6±6.8	33.2±8.5	0.002	-1.9**	-2.1**	0.808
Waist (cm)	100.8±10.8	106.2±10.3	0.005	95.8±9.6	99.8±10.9	0.051	-5.2**	-6.0*	0.653
Cholesterol (mmol/L)	5.24±0.9	5.21±0.9	0.831	5.04±0.5	4.8±0.9	0.211	-0.3**	-0.3**	0.971
Triglycerides (mmol/L)	1.3±0.6	1.6±1.1	0.094	1.2±0.5	1.4±0.7	0.178	-0.2**	-0.2	0.802
HDL (mmol/L)	1.5±0.4	1.3±0.3	0.011	1.4±0.4	1.3±0.3	0.030	-0.1*	-0.1	0.481
Chol:HDL (mmol/L)	3.8±1.3	4.1±1.1	0.093	3.8±1.02	4.0±1.0	0.261	-0.1	-0.1	0.967
LDL (mmol/L)	3.2±0.9	3.1±0.8	0.768	3.1±0.76	2.9±0.82	0.387	-0.2*	-0.2	0.816
Glucose (mmol/L)	5.2±0.6	5.0±0.5	0.164	5.0±0.46	5.0±0.6	0.524	-0.3**	-0.1	0.425
Insulin (mU/L)	11.9±6.5	12.2±5.5	0.840	9.9±4.51	10.5±5.8	0.550	-2.3**	-1.5	0.445
Energy (kJ)	8659±1845	13464±4291	<0.0001	6130±1251	7599±1567	<0.0001	-2500**	-5317**	<0.001
Protein (g)	97±21.7	139±46.6	<0.0001	82±17.5	99±23.2	0.001	-14.6**	-34.7**	<0.001
Fat (g)	79±25.2	130±51.8	<0.0001	43±14.5	55±14.6	<0.0001	-35.6**	-67.0**	<0.001
Carbohydrate (g)	217±54.9	322±108.5	<0.0001	165±38.2	198±40.1	<0.0001	-51.2**	-113.6**	0.001
Dietary Fibre (g)	27±7.8	33±14.7	0.009	27±6.9	29±5.4	0.253	0.5	-3.3	0.050
Calcium (mg)	921±320.4	1499±670.0	<0.001	847±257.7	983±387.7	0.078	-61.1*	-468.3*	0.003
Iron (mg)	13±3.4	19±8.7	<0.001	11±3.03	13±3.01	0.010	-1.5**	-4.9*	0.050

Mean±SD; Independent samples t-test, 95% CI; Paired T-test for within cluster differences *P<0.05; ** P <0.001;