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# Older Australians can adhere to a traditional Mediterranean style diet over two weeks: a pilot dietary intervention study

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## Abstract

**Background:** Consumption of a Mediterranean diet (MedDiet) is associated with several significant health benefits, however most evidence comes from Mediterranean countries, where the diet may be more culturally acceptable. Whether older Australians can adhere to a traditional MedDiet is unknown. We aimed to test the feasibility of elderly Australians adhering to a MedDiet over two weeks.

**Methods:** Male ( $n = 4$ ) and female ( $n = 6$ ) omnivorous Australians aged  $\geq 65$  years living in metropolitan Adelaide were recruited and completed the study during June-July, 2013. Participants followed their habitual diet for one week (Habitual diet phase), then a MedDiet for two weeks (MedDiet phase). The intervention diet was rich in plant foods and extra virgin olive oil, moderate in dairy foods and seafood, and low in red meat and added sugars. Adherence to the MedDiet was measured through a semi-quantitative daily food checklist. Dietary intake was assessed by weighed food records (WFRs) and food frequency questionnaires (FFQ) during both phases to monitor dietary compliance and nutrient intake. A feasibility survey assessed barriers to following the diet. Height was measured at baseline; body mass at baseline, and at the end of each phase. Cohen's  $d$  effect sizes were calculated for differences between nutrient intakes during the Habitual diet and MedDiet phases. Means  $\pm$  SD are presented for continuous variables.

**Results:** Daily food checklists show adherence to the MedDiet was 87 %. Both WFRs and FFQs indicated that participants increased their intakes of total and monounsaturated fat, ratio of monounsaturated fat to saturated fat, fibre and vitamin C. Seven of 10 participants felt they could continue following the diet long term. Barriers to compliance included palatability of plain Greek yoghurt, limited red meat, limited variety within the diet and length of meal preparation.

**Conclusion:** This population of older Australians were able to follow a MedDiet over two weeks and most believed they could follow it longer-term. Minor adjustments to recommendations for dairy foods, poultry, small goods and discretionary foods would improve adherence. After modifications, the MedDiet will then be used in a larger, randomised controlled intervention trial.

**Trial registration:** Australia and New Zealand Clinical Trials Registry (ANZCTR): ACTRN12613000636752

**Keywords:** Mediterranean diet, Adherence, Elderly Australians, Semi-quantitative checklist, Feasibility survey

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## Background

The traditional Mediterranean dietary pattern is characterised by a high intake of legumes, wholegrain cereal products, nuts, vegetables, fruits, extra virgin olive oil, and seafood [1–3]. It is low in red meat and processed foods and contains moderate amounts of cheese, milk and yoghurt. Results from the European Prospective Investigation into Cancer and Nutrition (EPIC) found that amongst older participants aged >60 years at enrolment, closer adherence to a Mediterranean style plant-based diet was associated with lower risk of all-cause mortality [4]. In the Spanish cohorts, not only was mortality lower, the highest adherers to the Mediterranean diet (MedDiet) had a 40 % reduced risk of primary coronary heart disease compared to the lowest adherers (95 % confidence interval (CI): 0.47-0.77) [5, 6]. Similar relationships were observed for the Greek cohort [7]. Recently the *Prevención con Dieta Mediterránea* (PREDIMED) trial conducted in Spain found that after almost five years follow-up, following a MedDiet supplemented with either extra virgin olive oil or nuts lowered risk of all-cause mortality (multivariable adjusted hazard ratio (HR) 0.71, CI 0.56-0.90,  $P = 0.004$ ) and stroke (HR 0.61, CI 0.44-0.86,  $P = 0.005$ ) compared to the habitual Spanish diet [8].

The PREDIMED and EPIC studies were conducted in Europe. Estruch et al. [8] raise the possibility that the findings are limited by the fact that the study was conducted in a Mediterranean country with participants at high risk for cardiovascular disease. Observational evidence suggests healthy, non-European populations might benefit from the MedDiet in a similar way. Australian, Asian and North American populations adhering closely to the MedDiet have better health outcomes than those not adhering [9, 10]. However, there have been few interventions with a MedDiet in non-Mediterranean populations [11, 12]. Cultural, economic and geographic factors may limit how transposable the MedDiet is in non-Mediterranean populations, and gene-environment interactions may influence health outcomes. One Australian intervention study has been conducted in which a MedDiet was consumed by a sample of individuals with Type 2 Diabetes Mellitus for 12 weeks. Adherence was high (>70 %) due to the provision of pre-prepared meals [13]. Whether Australians living in the community could adapt dietary habits in the long-term to a Mediterranean style pattern is unknown.

In order to evaluate the cardiovascular and cognitive health benefits of following a traditional Mediterranean diet in a group of older Australians over six months (Mediterranean diet for cognitive and cardiovascular health in elderly adults (MedLey), Australian New Zealand Clinical Trials Registry number 12610000612011) [14], we piloted the feasibility of a MedDiet in a representative

population first. We aimed to firstly determine whether healthy, elderly Australians could follow a traditional MedDiet over two weeks; secondly to critically review the written resources used to educate participants about the MedDiet; and thirdly to determine whether there are major disparities between dietary assessment by food frequency questionnaire (FFQ) with weighed food record (WFR) for the same dietary period. The results informed formulation, administration and measurement of adherence to a MedDiet for Australians for use in the MedLey trial.

## Methods

### Participants

Volunteers who had participated in previous trials at the University of South Australia who had indicated a willingness to take part in future studies were contacted via post and invited to participate. Ten volunteers from Adelaide and surrounding area (South Australia, Australia) aged between 65 to 77 years agreed to participate. Exclusion criteria included age <65 years, currently undertaking a weight loss program, using appetite suppressants, or diagnosis of cognitive impairment (Alzheimer's disease or dementia). All participants provided written, informed consent at the first visit prior to commencement and the study was approved by the University of South Australia Human Research Ethics Committee, (#31163).

### Intervention

The intervention consisted of a week-long habitual diet (HabDiet) phase and a two week MedDiet phase. All visits occurred at the Sansom Institute for Health Research Clinical Trials Facility located within the University of South Australia, Adelaide, Australia. At visit one participants received instructions for the first phase and were asked to complete a validated FFQ based on their habitual intake over the previous 12 months [15]. The FFQ was supplemented with additional questions relating to soft drink, nuts, fish, and oil intake. Participants were instructed to consume their HabDiet for the following seven days, and to complete a four-day WFR during three consecutive week days and one weekend day. Volunteers then returned to the clinic and met with a dietitian for an hour-long education session on following a MedDiet and received written resources. The resources provided included a pictorial MedDiet pyramid [16], a seven-day sample menu, a guide for meal selection, suggestions for recipe modification and eating out, a recipe book, a list of serving sizes of major food groups and a table showing the recommended number of daily and weekly serves for fruit, vegetables, potatoes, olive oil, bread and cereal products, yoghurt, cheese, fish, legumes, nuts, poultry, red meat and red wine. Participants were

given two 400 g cans of chickpeas (Simplot Australia<sup>®</sup>), 2 kg of natural, low fat Greek yoghurt (Farmers Union, under Lion Drinks and Dairy<sup>®</sup>), two 750 ml bottles of extra virgin olive oil (Cobram Estate<sup>®</sup>) and 280-420 g of raw, unsalted Australian almonds (The Australian Almond Board) for the fortnight, totalling 30-35 % of their estimated energy requirements. The remaining 65-70 % of requirements was sourced by the participants. Small variations existed in the energy provision because participants received the same foods despite consuming different amounts of energy.

For the following 14 days participants followed the MedDiet, using a semi-quantitative checklist to monitor their adherence. The checklist required participants to record when one full serving of a food was consumed; if less than one serving was consumed, this was clearly indicated. There were 13 foods listed for which serving sizes had been determined (vegetables, fruits, olive oil, yoghurt, cheese, breads and cereals, potatoes, legumes, nuts, fish, poultry, red meat and red wine). The checklist was used to measure the primary outcome, adherence to the MedDiet. Participants completed a second WFR during this phase, then attended the clinic for their final visit, where they completed a second FFQ based only on the previous two weeks (MedDiet phase), and a Feasibility Survey to assess barriers they experienced adhering to the MedDiet. The Feasibility Survey included feedback questions on the resources given to inform the second aim. The WFRs and FFQs completed before commencement of the MedDiet were considered to represent the HabDiet, and those completed during and after the MedDiet phase were representative of a MedDiet. These dietary assessments were used to inform the third aim, to compare results from FFQs with the WFRs assessing the same period of dietary intake. Body mass was measured in kg to the nearest 0.1 kg using the TANITA Ultimate Scale 2000 (Tanita Corporation, Tokyo, Japan) at all three visits while the volunteer was in bare or stockinged feet and wearing light clothing. Height was measured in cm to the nearest 0.1 cm using a stadiometer in bare or stockinged feet at the first clinic visit. Two measures of both body mass and height were taken 30 s apart and averaged. These measures were used to calculate body mass index (BMI) in kg/m<sup>2</sup> at baseline, visit two and visit three. Participants were encouraged to maintain medications and normal physical activity during the study.

#### **Australianised Mediterranean diet**

The intervention diet was modelled on the results of a literature review designed to determine the nutritional content of a MedDiet [Davis et al. 2015, unpublished observations]. Briefly, the review aimed to define the diet by grams of key foods and nutrient content. The average

nutrient content of the MedDiet was determined based on eight observational and intervention studies (see Additional file 1). The intervention diet was modelled on this nutrient profile, and adapted to include Australian foods; wholegrain breakfast cereals, tinned products such as fish, legumes and vegetables and processed grain products such as low-fat savoury crackers. Differences between this and the results of the literature review were resolved using information on traditional MedDiets, such as from the Seven Countries Studies [2]. Two further adaptations of the diet were made to address differences in estimated energy requirements. The total energy provided by the diet was reduced from 9600 kJ to 8600 kJ and 7300 kJ, by making adjustments to recommended numbers of serves. Although total energy differed, nutrient content per 1000 kJ was maintained (within  $\pm 5$  %) to ensure similarity across the three energy levels. The recommended number of servings provided by each energy level is shown in Table 1. To determine which energy level to apply, the day selected as most representative of a typical day by the participant from the WFR collected during the HabDiet phase was entered into FoodWorks professional (version 7.0.3016, Xyris Software Australia). The energy level closest to the estimated intake calculated was then applied.

#### **Feasibility assessment**

All participants completed a survey designed to assess difficulties encountered in complying with the dietary requirements (the Feasibility Survey). This was administered at the conclusion of the 14-day intervention period. The Feasibility Survey comprised 37 questions divided into four sections, and was purposely designed for use in the present study (see Additional file 2). Section 1 assessed general and personal ease of adherence to the MedDiet, including questions relating to motivation, palatability, variety, volume of food, difference to normal diet, and any particular foods which were new, liked or disliked. Section 2 assessed how the diet interacted with lifestyle, including sourcing food and cost, issues with other household members, time taken to prepare meals, and any other interruptions to lifestyle. Section 3 assessed the usefulness of the recipe book. Section 4 assessed the usefulness of the written resources. Question 1 required participants to select their agreement with a series of statements, ranging from 1 (strong agreement) to 5 (strong disagreement). Otherwise questions consisted of open-ended written answers, yes/no answers or selecting an answer from a provided list.

#### **Statistical analysis**

Cohen's *d* analysis was performed to estimate the effect size of the change in BMI from baseline to visit 3 and differences in energy and nutrient intake between the

**Table 1** Recommended number of servings of key foods on the Mediterranean diet, by energy level

Food	Serving size	Energy level 1 (7300 kJ)	Energy level 2 (8600 kJ)	Energy level 3 (9600 kJ)
Olive oil	18 ml (1 Tb)	2/day	2-3/day	2-3/day
Fruit	150 g fresh 40 g dried	2/day	2-3/day	3/day
Vegetables	75 g raw or cooked	6/day	6/day	6/day
Potatoes	75 g (1 small)	≤1/day	≤1/day	≤1/day
Breads and cereals	35 g bread (1 slice) 75 g pasta (1/2 cup)	4/day	5/day	5-6/day
Yoghurt	150-200 g	1/day	1/day	1/day
Cheese	40 g	1/day	1/day	1/day
Red wine	100 ml	≤2/day	≤2/day	≤2/day
Fish	100-120 g cooked	3/week	3/week	3/week
Legumes	75 g	3/week	3/week	3/week
Nuts	35 g	4/week	5/week	6/week
Poultry	80-100 g cooked	3/week	3/week	3/week
Red meat	80-100 g cooked	≤1/week	≤1/week	≤1/week

HabDiet and MedDiet phases according to WFR and FFQ, and to estimate differences between WFR and FFQ reported intakes. In accordance with recommendations, a small effect size was considered  $\leq 0.1$ , medium as 0.1-0.3 and large  $\geq 0.5$  [17]. Dietary adherence was calculated from the semi-quantitative checklist. For each separate food group, the following formula was used to calculate weekly adherence as a percentage: (Total number of serves consumed/total number recommended)\*100. The totals for each food group were averaged to obtain overall weekly dietary adherence. Red wine was not included in the calculations because not all participants consumed alcohol and it was not a compulsory trial requirement. To calculate the dietary intake data from the FFQ supplement, the nutrients per 100 g provided by the nuts, oils, fish and soft drink were obtained from FoodWorks. According to frequency and serving size selected by the participants, nutrient intakes were then calculated for each individual and this data was added to the nutrient output provided by the Cancer Council Victoria based on the original FFQ. Continuous variables are presented as mean  $\pm$  standard deviation (SD).

## Results

Ten volunteers ( $n = 4$  males,  $n = 6$  females) were enrolled during May-June 2013 and completed the study between June and July 2013. Volunteers were elderly (mean age  $69 \pm 4$  years), and overweight (mean BMI  $28.8 \pm 3.3$  kg/m<sup>2</sup>). BMI did not change during the intervention period (mean  $28.8$  kg/m<sup>2</sup> pre and post intervention, Cohen's  $d$  0.00). Adherence to the MedDiet was  $87\% \pm 8$  after the removal of one outlier (adherence score  $>2$  SD from the mean). Data were missing for two participants who were not included in the calculation. Adherence was  $83.4 \pm 11.1$  in the first week, and  $89.8 \pm 8.1\%$  in the second week. Adherence by

food group is shown in Table 2. Yoghurt, vegetables, fruits and grains recommendations were best complied with, and cheese and poultry had the lowest compliance scores.

## Dietary intakes

Participants completed FFQs and WFRs during the HabDiet and the MedDiet phases. Compared with their habitual diet, most participants increased their servings in olive oil, fruits, vegetables, breads and cereals, cheese, yoghurt, nuts and legumes, and reduced servings of meat (Table 3). However, the two participants following energy level 3 did not increase their fruit or legume intakes and only marginally increased their olive oil intakes, indicating poorer compliance. The group following energy level 1 met recommendations for numbers of serves for olive oil, fruit, yoghurt, cheese, fish, legumes and meats. Those following energy level 2 met recommended intakes for olive oil, fruit, potatoes, yoghurt, cheese, fish, and meats. Those following energy level 3 met recommendations for yoghurt, nuts and meat only.

Additional files 3 and 4 provide data on nutrient intakes for WFR and FFQs, respectively. Both methods reported increases in total and monounsaturated fat, vitamins C and E, fibre and a decrease in saturated fat, cholesterol, sodium, iron, beta-carotene equivalents, and long chain omega-3 fatty acids. Generally, effect sizes were larger for the changes assessed by WFR. A comparison of the assessed change in nutrient intake by the two methods is shown in Table 4. In most instances, the WFRs more accurately showed typical changes expected on a MedDiet, including greater decreases in total protein, saturated fat, sodium and calcium, an increase in carbohydrate, and greater increases in vitamin C, fibre and the MUFA:SFA.

**Table 2** Per cent adherence to a Mediterranean diet measured by checklist, presented by food groups<sup>a</sup>

	EVOO <sup>b</sup>	Fruit	Veg <sup>c</sup>	B + C <sup>d</sup>	Yoghurt	Cheese	Fish	Legumes	Nuts	Poultry	Red meat
Average ± SD <sup>e</sup>	85.4 ± 23.5	93.5 ± 12.0	96.0 ± 6.3	91.2 ± 14.0	98.8 ± 3.1	68.4 ± 39.3	88.1 ± 8.1	81.9 ± 22.7	78.6 ± 32.8	72.6 ± 27.4	81.0 ± 21.4

<sup>a</sup> Total average with outlier = 82.3 %. Without outlier = 86.6 %. Outlier removed from data. Data is for seven participants with complete data from semi-quantitative checklist

<sup>b</sup> EVOO = extra virgin olive oil

<sup>c</sup> Veg = vegetables

<sup>d</sup> B + C = breads and cereals

<sup>e</sup> SD = standard deviation

### Feasibility survey

Section 1: ease of adherence to the MedDiet

Section 1 required participants to indicate their agreement with nine statements designed to determine the ease of following the MedDiet. Table 5 shows the average scores for each of the nine statements. Most participants agreed the diet offered variety, that it was easy to shop for the foods, the recipes were easy to make, and that the foods tasted good. Overall the participants felt it was easy to adhere to the diet. Half the participants avoided foods they disliked, including natural Greek yoghurt, almonds and olive oil. Two participants suggested removing the yoghurt from the menu would improve the palatability. Five participants desired changes including increased variety, more red meat and variety of meat, and greater inclusion of sweet foods. Participants did not have to try many new foods. Three of 10 tried new foods including feta cheese, legumes and natural yoghurt. Only the yoghurt was not enjoyed. Expensive items identified included cheese, fish, seafood and meats. Four participants suggested there was too much food

to consume, while six found they were comfortable with the amount of food. No one suggested the diet was very different or the same as their normal diet; 8/10 thought it was a little different. When asked if they had any other comments, one suggested there was limited variety and that they had to eat too frequently. Another suggested the MedDiet was quite different to the normal high protein focused Australian diet.

Section 2: the MedDiet and lifestyle

Most participants (7/10) found they did not have to eat differently to others in the household, mainly because they either lived alone or because all household members were in the study. Three participants did have to eat differently to others in the household; however only one thought that household members could not adjust. All participants agreed that following the diet did not interrupt their usual activities. Only one suggested that the frequency of eating had to be considered. One participant thought they could not follow the diet long-term due to the expense. Time taken to prepare meals was not considered a barrier to following the diet by 8/10 participants; two participants felt the meal preparation might affect their ability to

**Table 3** Average number of servings consumed during the Mediterranean diet phase, by energy level<sup>a</sup>

Food	Serving size	Habitual diet average (n = 10)	Energy level 1 (n = 4)	Energy level 2 (n = 3)	Energy level 3 (n = 2)
Olive oil	18 ml (1 Tb)	0.1	1.7	2.6	0.5
Fruit	150 g fresh 40 g dried	0.9	2.6	2.4	1.6
Vegetables	75 g raw or cooked	1.9	3.3	4.4	1.6
Potatoes	75 g (1 small)	0.8	1.3	0.4	0.9
Breads and cereals	35 g bread (1 slice) 75 g pasta (1/2 cup)	2.1	1.9	3.3	4.3
Yoghurt	150-200 g	0.8	1.2	2.0	1.2
Cheese	40 g	0.5	1.1	1.0	0.5
Red wine	100 ml	0.3	0.6	0.2	0.6
Servings per week					
Fish	150 g cooked	3.2	5.1	6.6	0.6
Legumes	75 g	1.3	3.1	2.1	0
Nuts	35 g	2.0	3.6	2.8	6.6
Meats (red and white)	80-100 g cooked	6.3	2.2	3.7	2.8

<sup>a</sup>Data is presented based on information from the 4-day weighed food records completed during the Mediterranean diet phase

**Table 4** Comparison of the change in nutrient intake calculated from 4-day WFRs and FFQs

	Mean change WFR <sup>a</sup>	Mean change FFQ <sup>b</sup>	Cohen's d effect size
Energy (kJ <sup>c</sup> )	137.3 ± 1709.2	964.4 ± 3413.3	0.32
kJ from protein (%)	-2.9 ± 4.7	-1.3 ± 2.3	0.44
kJ from total fat (%)	4.7 ± 7.9	7.0 ± 10.8	0.24
kJ from SFA <sup>d</sup> (%)	-2.5 ± 2.3	-1.4 ± 1.7	0.57
kJ from MUFA <sup>e</sup> (%)	6.2 ± 6.1	7.3 ± 8.2	0.16
kJ from PUFA <sup>f</sup> (%)	1.2 ± 1.5	0.9 ± 2.6	0.16
kJ from CHO <sup>g</sup> (%)	-0.3 ± 7.3	-3.9 ± 10.1	0.40
kJ from alcohol (%)	-2.0 ± 5.0	-1.8 ± 3.3	0.04
% fat as MUFA	11.5 ± 8.4	8.4 ± 7.5	0.39
% fat as PUFA	1.8 ± 5.3	-0.8 ± 3.7	0.58
% fat as SFA	-13.4 ± 7.0	-6.8 ± 6.1	1.00
MUFA:SFA	0.9 ± 0.4	0.8 ± 0.7	1.42
Cholesterol (mg)	-57.1 ± 93.5	-69.2 ± 104.0	0.12
Fibre (g)	3.2 ± 10.5	2.9 ± 8.2	0.04
Vitamin C (mg)	45.5 ± 75.2	11.9 ± 45.1	0.56
Vitamin E (mg)	5.7 ± 5.9	5.6 ± 10.0	0.01
Total folate (ug)	-3.1 ± 134.9	15.3 ± 89.4	0.16
Beta-carotene equivalents (ug)	-546.2 ± 3839.9	-97.1 ± 1506.3	0.17
Sodium (mg)	-481.3 ± 1281.7	-49.6 ± 697.2	0.44
Potassium (mg)	207.5 ± 711.1	355.1 ± 966.1	0.18
Calcium (mg)	-24.6 ± 179.8	185.4 ± 460.3	0.66
Iron (mg)	-1.4 ± 3.4	-0.6 ± 4.4	0.22
Long-chain omega-3 FAs <sup>h</sup> (mg)	-122.8 ± 238.7	-0.1 ± 0.3	1.03

<sup>a</sup>WFR Weighed food record<sup>b</sup>FFQ Food frequency questionnaire<sup>c</sup>kJ kilojoules<sup>d</sup>SFA saturated fatty acids<sup>e</sup>MUFA monounsaturated fatty acids<sup>f</sup>PUFA polyunsaturated fatty acids<sup>g</sup>CHO carbohydrates<sup>h</sup>FAs fatty acids**Table 5** Answers to question one, 'Ease of adherence to the Mediterranean Diet', from the Feasibility Survey

Response options <sup>a</sup>	Mean ± SD <sup>b</sup>
This diet was very different to my normal diet	2.6 ± 1.3
This diet offered a wide variety of food choices for meals and snacks	2.2 ± 1.1
This diet was expensive	2.5 ± 1.2
It was easy to find everything I needed to when shopping for this diet	1.4 ± 1.0
The recipes were easy to follow and make	1.9 ± 0.9
It took a long time to prepare foods	3.3 ± 1.3
Other household members were a barrier to adhering to the diet because they have different needs	4.0 ± 1.1
The foods tasted good	1.9 ± 1.2
Overall it was easy to adhere to this diet	2.2 ± 1.3

<sup>a</sup>Respondents could select the extent to which they agreed with the statement, ranging from 1 (strong agreement) to 5 (strong disagreement)<sup>b</sup>Responses of less than 2.5 indicate agreement with the statement

adhere. For lunch, all participants indicated it took less than 30 min, and 7/10 suggested less than 10 min to prepare. Seven participants indicated it took between 20 and 40 min to prepare their evening meal.

#### Section 3: the recipe book

Seven of 10 participants used the recipe book during the intervention phase. Participants were asked if the recipes in the book were adequate. One thought there should be more salad and dessert recipes, and two participants thought there should be more chicken and fish recipes. Most participants found the recipes easy to follow although one suggested they were mostly difficult and complex. No one felt any recipes should be removed. All who responded (8/10) felt they were able to modify their existing recipes based on the education given. One suggested adding more recipes and another suggested adding pork recipes.

#### Section 4: other written resources and food provision

All participants answered that the 7-day menu plan and the meal guide were useful. Most participants (6/10) felt the level of instruction and detail given was appropriate, with 4 preferring a less structured meal plan. Nine participants felt the explanation was easy to understand; one volunteer felt the serving sizes were difficult to grasp. Similarly, the checklist was well-received by 9/10 participants. One participant suggested it was unclear whether they needed to write down amounts of foods on the checklist or tick off foods as they consumed them. Suggestions to improve the checklist included adding milk, splitting vegetables into salad and cooked vegetables and adding pork. The foods provided included olive oil, yoghurt, almonds and chickpeas. Four participants suggested changes to the supply, including adding cheese, tinned tuna, sweet foods and pasta. Participants also suggested replacing or removing the nuts and yoghurt, and adding more foods. The only area where the majority of participants felt there was not enough information provided was eating out on the MedDiet. Other suggestions included adding a provision for eggs, and one participant suggested it would take more than two weeks to adjust to the diet.

## Discussion

In this pilot testing of an Australianised version of the MedDiet, older Australians were able to adhere to a Mediterranean style diet. Participants identified several barriers to consuming the diet including a dislike for natural Greek yoghurt, little meat and lack of variety. Appropriate changes to the diet and resources will be adopted for MedLey in response to this feedback, which could improve longer term adherence.

The adherence achieved and written feedback in this pilot study indicates that Australian's could adopt an

Australianised version of the MedDiet. It is well accepted that the more closely this dietary pattern is followed, the greater the benefit to longevity and risk of cardiovascular disease [18]. However few interventions outside of the Mediterranean basin have been conducted to confirm these benefits carry over to non-Mediterranean populations. Observational evidence suggests those more closely adhering have lower risk of stroke, CHD and death from CVD amongst female nurses in the US [9], and it appears to be associated with longevity in a Caucasian Australian population [10]. This preliminary evidence suggests introduction of a MedDiet in Western populations could impact on CVD mortality. Palatability and other practical aspects of adopting a new dietary pattern may affect long-term adherence, and hence health benefits. The MedDiet has been advocated as highly palatable, through the combination of olive oil, legumes, tomatoes and other vegetables and cheese as core ingredients, as well as environmentally friendly [1, 19]. Palatability as a factor impacting adherence has rarely been assessed in intervention studies. The present study showed that in a country with a Westernised dietary pattern most participants found the diet palatable, and that most foods were enjoyable. Itsiopoulos et al. [13] had good adherence to the MedDiet in their intervention in a city-dwelling Australian population, however did not assess aspects of palatability. In the PREDIMED study adherence was high, however again palatability was not assessed, and the population was Spanish where Mediterranean dietary practices were already in place [8]. Follow-up data from the Lyon Diet Heart trial showed participants had continued following the MedDiet pattern years after the intervention period had ceased, indicating the diet was palatable, although this was again in a Mediterranean population [20]. We also assessed other practical elements; the majority of participants found the MedDiet easy to follow, not excessively costly, satiating and believed they could follow it long term. A small amount of raw foods were provided to volunteers however they sourced and prepared the majority of foods, indicating free-living adults can access foods and follow Mediterranean recipes, which was confirmed by feedback from the Feasibility questionnaire.

The ability of participants to adhere was confirmed by objective measures of dietary intake and compliance. Participants substantially altered their nutrient intake in a two week period, mostly in accordance with the MedDiet. Energy level 3 was poorly complied with, which may be due to the larger requirements for servings, or due to random participant factors. Servings of key foods were mostly increased towards or meeting requirements, indicating whole diet change. There were some unexpected dietary changes; long chain omega-3

fatty acids and  $\beta$ -carotene intakes decreased according to both WFR and FFQ while on the MedDiet. This may be due to a lack of specification as to type of fish (oily vs non-oily) and type of vegetable (orange and green leafy vegetables), both specifications which should be included in MedLey. The checklist confirmed high adherence, and showed an improvement in adherence from the first to second weeks. Components of the diet, such as olive oil, fish, nuts and fruits and vegetables have been independently linked to health benefits, and the checklist designed for this study allowed calculation of adherence for these components, as well as an overall adherence score. Unlike checklist used in previous studies [8], our method has the advantage of crediting participants for consuming some, if not all, of a recommended food. Participants in the present study complied worst with the poultry and cheese recommendations, consuming too little of each. This could be addressed by reducing recommendations for these foods and replacing with other protein and dairy sources, such as smallgoods and milk.

Despite overall positivity regarding the diet, some unpalatable aspects included natural Greek yoghurt, lack of red meat and a sense of limited variety. In an Australian population, these complaints are perhaps expected. Limiting the discretionary foods is likely to have reduced the variety of foods volunteers were consuming. According to the Australian Bureau of Statistics, in 2011–12 discretionary foods provided up to 35 % of estimated energy requirements in the Australian population [21]. Nationally average daily meat, poultry and game products intake was 174.3 g/day for 51–70 year olds and 137.8 g/day for 71 years and over [22], whereas the intervention diet contained no more than 100 g/day. Intake of red meat and discretionary foods may be detrimental to health and displace foods such as grains and vegetables, thus a limit is an important aspect of the MedDiet to retain. In this pilot study there was no recommendation for small goods and the consumption of poultry was 3/week, which had the second lowest compliance score. Several strategies could address these complaints while retaining the nutritional profile of the MedDiet. Smallgoods could be introduced and poultry reduced, different varieties of yoghurt could be introduced and participants could be encouraged to experiment with different grains, legumes, vegetables and fruits, and recipes. Other feedback from volunteers will be considered for MedLey, including the provision of additional foods, removal of the structured meal plan, enhancements to the checklists and clarification of serving sizes, and additions to the recipe book.

There is merit to using both FFQs and WFRs to assess diet in trials. FFQs have the power to capture intake retrospectively, usually over 12 month period. The Cancer Council Victoria 74-item FFQ is validated for fruit and vegetable intake, and provides comparable data to other studies [23]. However FFQs have several important limitations, namely potential missing foods and possible misinterpretation of serving sizes or questions. WFRs are considered the gold standard for monitoring dietary intake, especially for within-study comparisons, but are limited to capturing a short length of time with high participant burden. In this pilot, changes in dietary intake were recorded by each method, and large differences were observed especially for total energy, intake of MUFA and SFA,  $\beta$ -carotene, sodium, vitamin C and calcium intake. It may be useful to include both methods in MedLey, to enable a more in-depth comparison.

There are limitations associated with the data reported here. This study only recruited participants from metropolitan Adelaide. There may be additional issues with following the diet in rural and remote areas, such as access to or cost of foods. As a pilot study the sample comprised only 10 participants – a greater sample would have provided more reliable feedback. Whether participants followed the diet alone or with other household members may have had an effect on palatability, which is unaccounted for in the analysis. The use of a two week period to assess ability to adhere might limit the generalizability of study results; adherence over a two week period may be easier to achieve than over a period of months or years. Conversely, adherence scores may have improved with longer duration; particularly if ongoing dietary counselling was provided and consumption patterns became habitual [24, 25]. Calculation of adherence may have been biased as not all foods were included. Smallgoods, pork, milk, and discretionary were not included in the calculation, although participants were advised to minimise intakes of these foods. The absence of certain foods in the MedDiet may be as crucial as the presence of health-promoting foods for its acclaimed health benefits. Calculation of additional nutrient intake from the FFQ supplementary may have inflated intakes, particularly of monounsaturated fat and protein from nuts, as the original FFQ includes an estimate of nut intake. There may also have been participant bias in answering questions pertaining to olive oil; intakes may have been underestimated pre-intervention and over-estimated post-intervention as it was a dietary focus. However there are no questions on specific nut, oil or soft drink intake in the original FFQ, and these are important to assess. Additional thought is required on how to incorporate information gathered on specific nut and oil use to avoid over-estimation.

## Conclusion

An adherence score of 87 % over two weeks is an indication that this population can follow this diet. This study used a detailed survey to gather feedback on a wide range of aspects of following the MedDiet, and used three measures of compliance (FFQs, WFRs and checklists), allowing in-depth analysis of both food and nutrient intakes. Change in nutrient intakes moved towards a Mediterranean dietary pattern. Most participants were able to adhere to the diet with good compliance to fruits, vegetables, breads and cereals, fish and yoghurt recommendations. Practical aspects of following the diet posed few barriers compared to palatability issues, which in themselves were few and potentially surmountable with slight modifications. Based on these results the diet is judged to be feasible in an Australian population, and with minor adjustments, adherence could be improved. Larger studies are required where palatability and other practical aspects of a MedDiet are assessed in non-Mediterranean countries to confirm these results.

## Additional files

**Additional file 1: Nutrient content of the Mediterranean diet according to the literature review [unpublished observations, Davis et al. 2015] and the nutrient content of the Australianised Mediterranean diet designed for the pilot study, according to the three energy levels.** (PDF 159 kb)

**Additional file 2: A copy of the Feasibility Questionnaire participants received at the conclusion of the study.** (PDF 236 kb)

**Additional file 3: Nutrient intakes of participants according to the 4-day weighed food records during the habitual phase and the Mediterranean diet phase.** (PDF 269 kb)

**Additional file 4: Nutrient intakes of participants according to the food frequency questionnaires during the habitual phase and the Mediterranean diet phase 8.** (PDF 269 kb)

## Abbreviations

MedDiet: Mediterranean diet; WFR: Weighed food record; FFQ: Food frequency questionnaire; EPIC: European Prospective Investigation into Cancer and Nutrition; PREDIMED: Prevención con Dieta Mediterránea; CI: Confidence interval; HR: Hazard ratio; MedLey: Mediterranean diet for cognitive and cardiovascular health in elderly adults; HabDiet: Habitual diet; BMI: Body mass index; SD: Standard deviation; SFA: Saturated fatty acids; MUFA: Monounsaturated fatty acids.

## Competing interests

The authors declare no competing interests.

## Authors' contributions

CD participated in study conception and design, dietary formulation, data collection, results analysis and drafted the manuscript. KM secured the funding with JB, CW and JH, participated in study design, dietary formulation, results analysis and helped draft the manuscript. JB participated in study design, dietary formulation and helped draft the manuscript. JH and CW participated in dietary formulation and manuscript revision. All authors read and approved the final manuscript.

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