# Assessment of Mediterranean Diet Scores in Older Adults

Caroline A. Shaw

Human Nutrition Research Centre

Institute of Cellular Medicine

In Fulfilment of the Requirements for the Degree
Doctor of Philosophy

March 2015

# Abstract

The United Kingdom is experiencing an ageing population. Currently one sixth of the UK's population is aged over 65 years and this is estimated to rise to one quarter by 2050. There is considerable inter-individual variation in human lifespan and much of this variation appears to be due to non-genetic factors, including lifestyle. Both observational and intervention studies indicate that adherence to a Mediterranean dietary pattern is associated with increased lifespan and reduced risk of age-related disease. The LiveWell Programme was established to develop and pilot lifestyle-based interventions (including promoting a Mediterranean diet) to enhance healthy ageing, which could be delivered to individuals in the retirement transition. The aim of this PhD was to test age-appropriate dietary assessment methods suitable for measuring change in adherence to a Mediterranean diet, as a consequence of lifestyle-based interventions.

Six different approaches for estimating Mediterranean diet scores (MDS) were applied to dietary data from the Mediterranean Diet in Northern Ireland (MEDDINI) intervention study. Based on the number of assumptions and modifications that were made to calculate the scores, the percentage change in diet between intervention groups and the coefficient of variation from baseline to follow up, the relative Mediterranean diet score (rMED) was identified as the most suitable score for testing the efficacy of intervention studies in a UK context.

The next stage of the work was to investigate the utility of INTAKE24, an online 24 hour recall, as a method for assessing the diet of retirement-age adults. INTAKE24 is a self-completed dietary assessment tool which was developed originally for use with young people. This was the first time that this tool was used with older people and so it was essential to undertake user-testing and estimation of relative validation. The system usability was rated as above average by the majority of users. Of the food items recorded in INTAKE24, 87% of the foods recorded during user-testing and 84% of the food items recorded during relative validation, either exactly or approximately matched foods recorded in a comparable interviewer-led 24 hour recall. No significant differences in nutrient intakes or adherence to the Mediterranean diet (assessed by the rMED) were found between the two dietary assessment methods for either the user-testing or the relative validation study.

In conclusion, INTAKE24 was well-received and assessed the diets of older adults well when compared with a conventional approach. However, further modifications of INTAKE24 (detailed within my thesis) would improve the usability and accuracy of the system for future studies involving older adults. In addition, the rMED method of scoring adherence to the Mediterranean dietary pattern is compatible with data collected using INTAKE24 and appears suitable for use in future dietary intervention studies with adults in the retirement transition.

# Acknowledgements

First and foremost, I would like to thank my supervisory team, Prof. John Mathers, Prof. Ashley Adamson and Dr. José Lara for their invaluable support, guidance, encouragement and belief in me throughout the past four and a half years that I have studied my MRes and Ph.D. I would also like to thank Prof. Chris Seal and Dr. Ruth Valentine for annually reviewing my progress and providing further support.

I am most grateful to the Lifelong Health and Wellbeing (LLHW) Cross-Council Programme Initiative and its funding partners (particularly the Medical Research Council) for funding my MRes and Ph.D. studentship via the LiveWell Programme, and for allowing me to further develop my skills as a researcher and to attend dissemination events.

I would also like to thank Prof. Jayne Woodside from Queen's University Belfast, for her collaboration and willingness to share her MEDDINI study data with me. Additionally, I am grateful to Prof. Woodside's colleague, Dr. Charlotte Neville, who organised the shipping of raw data to me. My thanks also go to Paul Adamson, who provided me with a database to calculate the nutrient output of the MEDDINI data.

I am very grateful of the generosity of Dr. Emma Foster, who allowed me to test INTAKE24 for the first time with an older age group. I also appreciated Jen Delve and Emma Simpson letting me attend some of their participant appointments, while carrying out their user-testing and relative validation studies of INTAKE24 with young people. This gave me an insight into how to conduct my own studies and to practise data collection techniques with their participants first. Furthermore, I would like to thank Prof. Patrick Olivier and Dr. Ivan Poliakov from the Digital Interaction Group at the Culture Lab, for their expertise in human-computer interactions and for setting up the surveys used in my INTAKE24 studies. I am also grateful to Dr. Peter James, who provided me with a power calculation to determine the sample size I needed for my relative validation study of INTAKE24.

I would also like to take this opportunity to thank all the participants who kindly took part in the MEDDINI study and in my two studies testing INTAKE24, without whom I would not be able to write this thesis. Thanks also go to Val Humphrey, who organised the room bookings for my INTAKE24 participant appointments, to Helen Sandford and Rebecca Smith, who advertised my INTAKE24 studies via VOICENorth and to Anne Richardson, who advertised my studies via the Elders Council. I would also like to thank Wendy Bal, Dr. Naomi Willis and Ammar Ashor, for providing me with a list of potential participants to recruit.

I am grateful to the authors of the six Mediterranean diet scores that were used to analyse the MEDDINI data in this thesis, who provided me with information about the foods included in their scores. These include: Prof. Miguel Martínez-González (MEDAS), Prof. Adalberta Alberti and Dr. Alessandro Menotti (MAI), Alexandra Bédard on behalf of Prof. Simone Lemieux (Mediterranean Score), Dr. Paul Jaques and Dr. Marcella Rumawas (MSDPS), Dr. Genevieve Buckland (rMED) and Prof. Demosthenes Panagiotakos (MedDietScore).

I would also like to thank the members of Prof. Mathers' research group whom I have got to know well over the last four years. I have made firm friends with Fiona Malcomson and Lynn Barron in particular, who started the MRes/ Ph.D. journey with me. Special thanks also go to Dr. Carlos Celis, who taught me how to conduct orthogonal contrast analysis, Idoia Ibero for checking my data entry of the MEDDINI FFQs and Caroline Wiuff for checking my calculations of the six Mediterranean diet scores.

Finally, I would like to express my sincere gratitude to those dearest to me: my boyfriend, Cameron Gee, who has been my rock, and my family who have always been my biggest supporters, both emotionally and financially. I am eternally indebted to my parents who provided me with the greatest education and start in life and I owe all of my achievements to them. For this reason, I would like to dedicate this thesis to my parents, Hilary and David Shaw.

# Contents

# List of Figures

# List of Tables

## List of Abbreviations

| | |
|---|---|
| A-CASI | Audio Computer-Assisted Self-Interviewing |
| aMED | Alternate Mediterranean Diet Index |
| AMPM | Automated Multiple-Pass Method |
| ANOVA | Analysis of Variance |
| APS | Average Portion Size |
| ARCD | Age-Related Cognitive Decline |
| ASA24 | Automated Self-Administered 24 hour Dietary Recall |
| BMD | Bone Mineral Density |
| BMR | Basal Metabolic Rate |
| CDA | Conventional Dietetic Advice |
| CHD | Coronary Heart Disease |
| CV | Coefficient of Variation |
| CVD | Cardiovascular Disease |
| DH | Diet History |
| DHQ | Diet History Questionnaire |
| EBIS | German abbreviation for Diet History, Consulting and Information System |
| EFCOVAL | European Food Consumption Validation |
| EFPQ | European Food Propensity Questionnaire |
| EI | Energy Intake |

| | |
|---|---|
| EPIC | European Prospective Investigation into Cancer and Nutrition |
| FBQ | Food Behaviour Questionnaire |
| FFQ | Food Frequency Questionnaire |
| FNDDS | Food and Nutrient Database for Dietary Studies |
| FSA | Food Standards Agency |
| HAP | Healthy Ageing Phenotype |
| HEI | Healthy Eating Index |
| IDEFICS | Identification and Prevention of Dietary- and Lifestyle- Induced Health Effects in Children and Infants Study |
| IMD | Index of Multiple Deprivation |
| IPSAS | Interactive Portion Size Assessment System |
| LIDNS | Low Income Diet and Nutrition Survey |
| MAI | Mediterranean Adequacy Index |
| MBIAT | Meal-Based Intake Assessment Tool |
| MD | Mediterranean Diet |
| MDBC | Mediterranean Diet using Behavioural Counselling |
| MDNC | Mediterranean Diet using Nutritional Counselling |
| MDP | Mediterranean Dietary Pattern |
| MDS | Mediterranean Diet Score |
| MEDDINI | Mediterranean Diet in Northern Ireland |
| Med-DQI | Mediterranean Diet Quality Index |
| MMDS | Modified Mediterranean Diet Score |
| MSDPS | Mediterranean-Style Dietary Pattern Score |

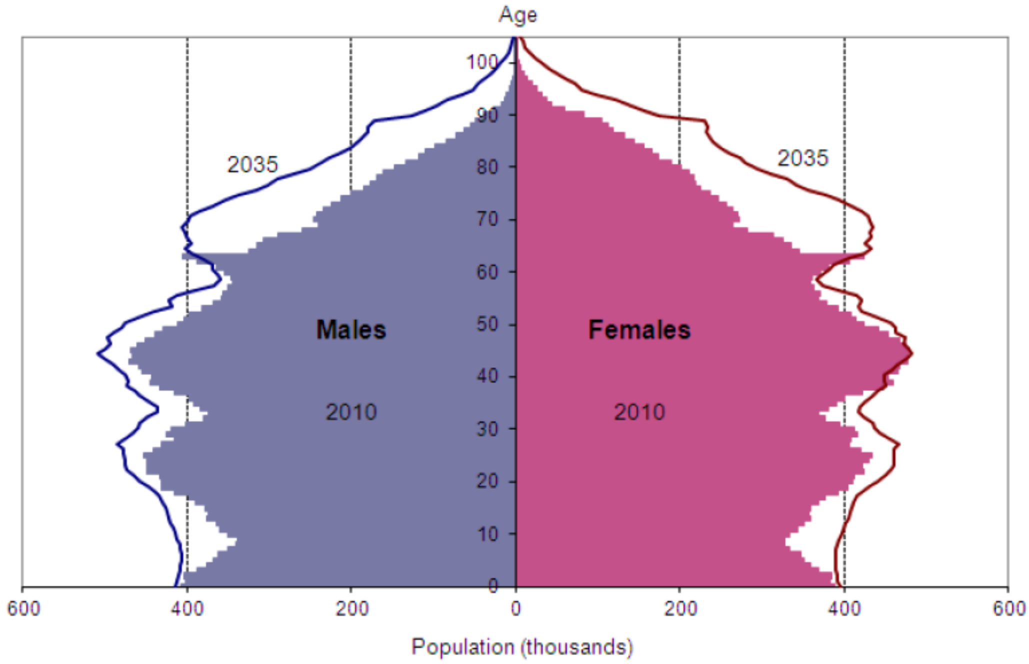
| | |
|---|---|
| MUFA | Monounsaturated Fatty Acid |
| NAFLD | Non-Alcoholic Fatty Liver Disease |
| NDNS | National Diet and Nutrition Survey |
| NHANES | National Health and Examination Survey |
| OR | Over-reporters of energy intake |
| PUFA | Polyunsaturated Fatty Acid |
| rMED | Relative Mediterranean Diet |
| ROS | Reactive Oxygen Species |
| RRR | Reduced Rank Regression |
| SACINA | Self-Administered Children and Infant Nutrition Assessment |
| SCRAN24 | Self Completed Recall and Analysis of Nutrition |
| SCS | Seven Countries Study |
| SD | Standard Deviation |
| SE | Standard Error |
| SFA | Saturated Fatty Acid |
| SNAP | Synchronised Nutrition and Activity Program |
| SUS | System Usability Scale |
| UK | United Kingdom |
| UR | Under-reporters of energy intake |
| USA | United States of America |
| USDA | United States Department of Agriculture |
| YANA-C | Young Adolescents’ Nutrition Assessment on Computer |

# Chapter 1 Introduction

## 1.1 The Ageing Population

### *1.1.1 Demography of ageing*

The United Kingdom is experiencing an ageing population: currently one sixth of the UK's population is aged over 65 years, but by 2050 this prevalence is estimated to rise to one quarter of the population (House of Commons Library Research, 2010). The fastest growing age group in the population is the over 85s, accounting for 1.4 million people in 2010, which is projected to more than double over the next 25 years (see Figure 1.1) (Office for National Statistics, 2011).




Source: Office for National Statistics (2011)

**Figure 1.1 Estimated and projected age structure of the UK population, mid-2010 and mid-2035**

This ageing population is not restricted to the United Kingdom. Although the proportion of older people is currently higher in more economically developed countries, over the next 50 years, the proportion of older adults is expected to grow at a faster rate in less economically developed countries (United Nations Department of Economic and Social Affairs Population Division, 2002). Whilst this ageing demography can be partly attributed to the post World War II "baby boomers" born between 1946-1964 now reaching the retirement transition, it is also due to reduced birth rates and linearly increasing longevity as a result of medical advances e.g. antibiotics and immunisations, improved living standards and lifestyle changes e.g. smoking cessation, which have consequently reduced the rate of mortality (Murphy and Di Cesare, 2012).

### *1.1.2 The importance of healthy ageing*

Healthy life expectancy (the number of years spent in good health) has not risen as fast as life expectancy, which has resulted in more years of chronic ill-health towards the end of life and proportionally greater demands on public health services (Stanner and Denny, 2009). The increasing rates of obesity and its comorbidities are some of the driving forces behind this. In 2010, the prevalence of overweight and obesity in adults aged 16 years and above reached an all-time high of 63%, with the highest levels recorded in the 65-74 year age group, at 77.5% (The NHS Information Centre for Health and Social Care, 2011). In the same year, the proportion of 65-74 year olds and people aged 75+ with hypertension (defined at a threshold of 140/90mmHg) was 64% and 79% respectively, and the levels of CVD and diabetes were highest in the 75+ year group, at 31% (CVD measured in 2006) and 14% (The NHS Information Centre for Health and Social Care, 2011).

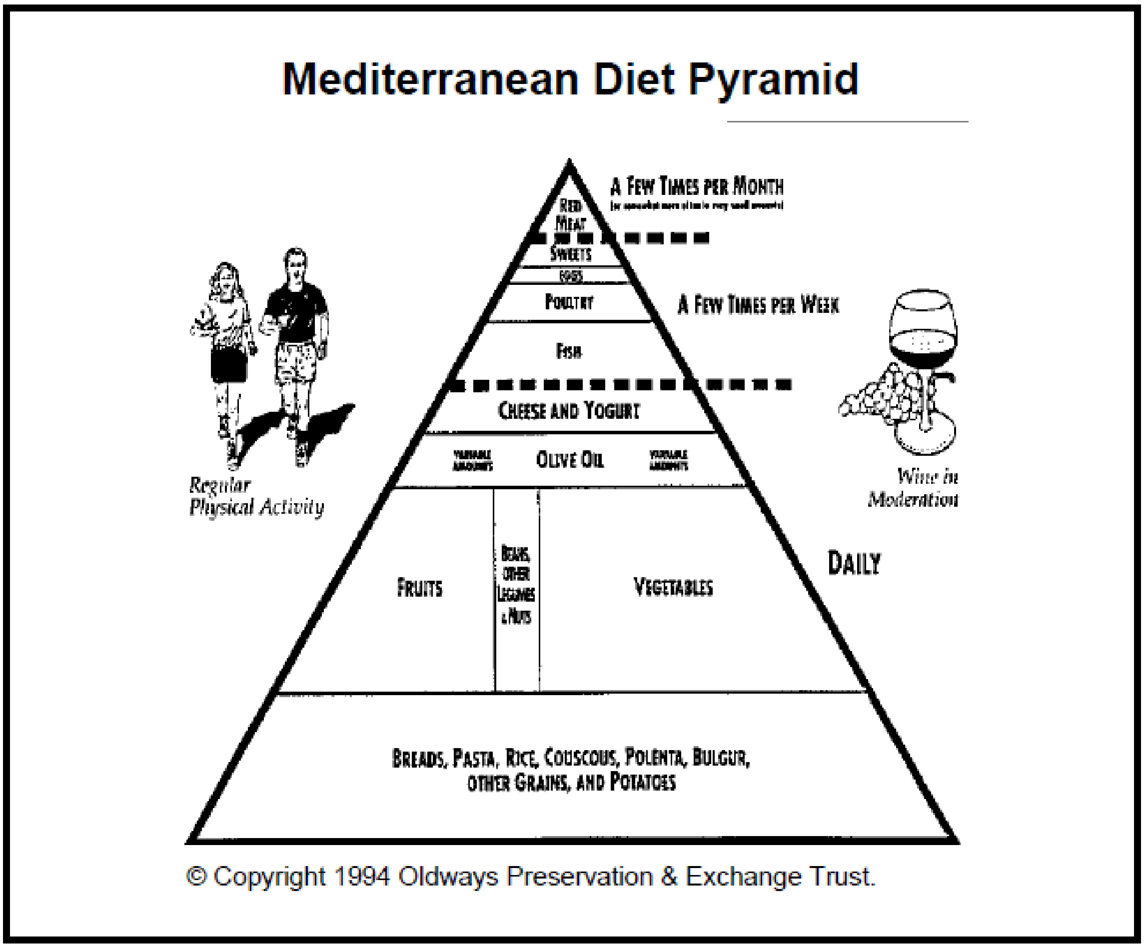
Currently, the average National Health Service spend for retired households is almost double the amount spent on non-retired households (House of Commons Library Research, 2010). Furthermore, using baseline data from the Newcastle 85+ Study, it has been predicted that the future need for 24-hour care for the elderly aged 80 years or over in England and Wales will increase by 82% between 2010 and 2030, with a demand for 630,000 care-home places by 2030 (Jagger *et al.*, 2011).

Ageing occurs from decreased biological functioning as a consequence of the lifelong accumulation of oxidative damage in cells and impaired repair mechanisms, which increases susceptibility to frailty and age-related disease. This process starts early in life and the accumulation and repair of such molecular damage is influenced by genetic factors (Kiefte-de Jong *et al.*, 2014). However, there is considerable inter-individual variation in human lifespan and much of this variation appears to be due to non-genetic factors, including lifestyle factors, such as smoking, diet and physical activity (Mathers, 2013). Successful health promotion interventions targeted to the older population are needed to prevent or delay the onset of non-communicable or chronic diseases, to improve health, autonomy and well-being of older people and reduce the need for long-term care. Dietary interventions are one of these mechanisms through which healthy life expectancy could be improved.

## 1.2 The Mediterranean diet

### *1.2.1 What is a Mediterranean diet?*

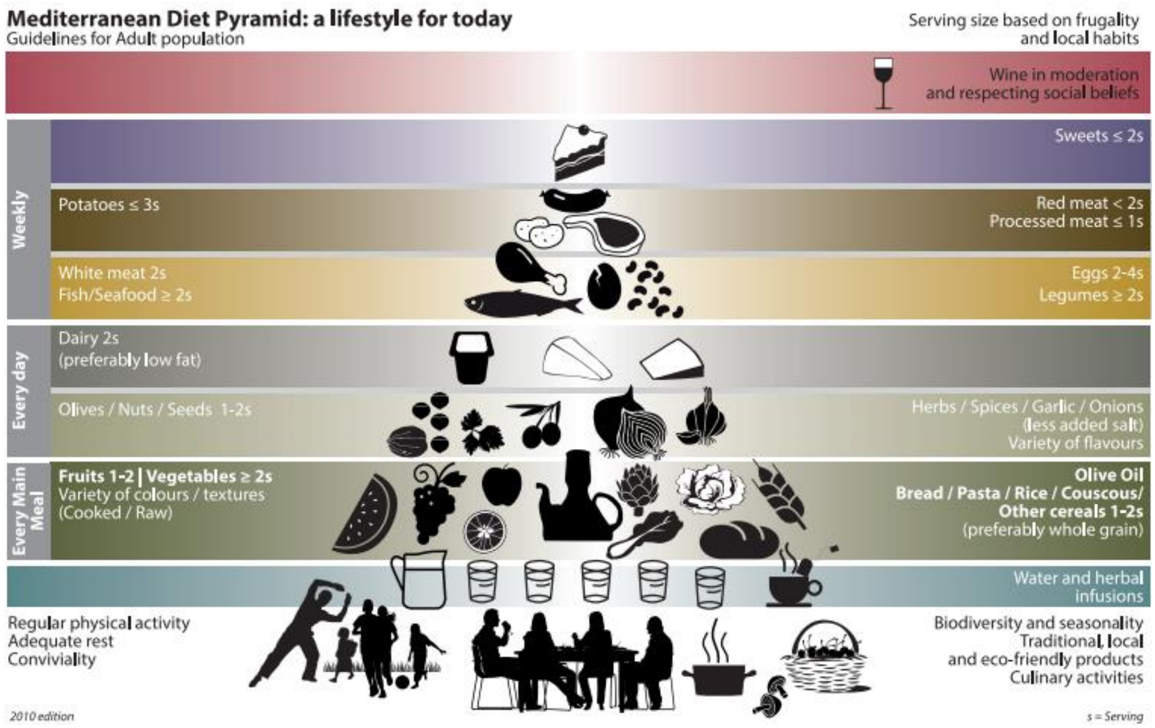
Adopting a Mediterranean dietary pattern could contribute to ageing healthily. The Mediterranean dietary pattern refers to the typical diets of populations living in the Mediterranean basin (particularly Crete, Greece and Southern Italy) during the early 1960s, as observed by Ancel Keys (Keys, 1980). The current Mediterranean diet (MD) guidelines were proposed and depicted as a pyramidal visual display during the International Conference on the Diets of the Mediterranean in 1993 (see Figure 1.2). Foods which should be the mainstay of the diet (eaten in the largest amounts) are situated at the bottom of the pyramid, whilst foods which should be eaten rarely or in moderation are placed at the top. Whilst the MD is somewhat heterogeneous between regions, the dietary components were defined as an abundance of plant-based foods (including fruit, vegetables, legumes, nuts, seeds and cereals), olive oil as the principle source of added fat, seasonal and locally-grown produce, minimal intakes of processed foods, low to moderate consumption of fish, poultry and dairy products (principally cheese and yoghurt), low amounts of red meats, up to 4 eggs a week, and low to moderate intakes of wine, usually consumed with meals. Regarding desserts, fresh fruit is consumed daily, or alternatively, those containing concentrated sugars, nuts or honey are consumed occasionally (Willett *et al.*, 1995).




Source: Willett *et al*. (1995)

**Figure 1.2 The original Mediterranean diet pyramid**

With accruing epidemiological evidence of the benefits of the MD on health, this pyramid has been revised several times. The most recent adaptation of the MD pyramid was created in 2010 and is a simplified graphical representation of the diet, which can be modified according to cultural differences in portion sizes and types of foods consumed between populations (see Figure 1.3). Brief guidelines were published in accordance with this diet pyramid, which elucidate what foods should be consumed and how often (Bach-Faig *et al.*, 2011). The main difference between the pyramids is that the 2010 version is more quantitative about the proportions and frequencies in which the different food groups should be eaten. This more recent adaptation has also highlighted that the MD is not simply a dietary pattern; it is a lifestyle behaviour which is centred on conviviality, cooking meals from scratch using local and seasonal produce, getting ample rest and engaging in regular physical activity.




Source: Bach-Faig *et al.* (2011)

**Figure 1.3 The Mediterranean diet pyramid today**

The Mediterranean diet differs from “Western” diets because the consumption of meat, dairy products, refined grains, saturated fat and sugar is much lower and consumption of fruit, vegetables, whole grains, legumes and olive oil is much higher. However, over the last few decades, the diets of people living in the Mediterranean region have become more Westernised as a consequence of globalisation and economic growth (Da Silva *et al.*, 2009). Furthermore, the Mediterranean diet itself has altered over the years from the traditional foods consumed in Crete in the 1960s, to foods which are not necessarily “Mediterranean” but which have similar nutritional compositions (Bere and Brug, 2010).

### *1.2.2 Mediterranean diet and longevity*

The Seven Countries Study was the first study to report that Cretan residents lived longer with lower incidence of major chronic disease, despite consuming diets containing high proportions of total dietary fat (Keys *et al.*, 1986). Since then, observational studies have supported this finding and have demonstrated that individuals who adhere to the Mediterranean diet have greater and healthier longevity (Trichopoulou *et al.*, 1995; Osler and Schroll, 1997; Trichopoulou *et al.*, 2003; Knoops *et al.*, 2004; Trichopoulou, 2005; Iestra *et al.*, 2006; Mitrou *et al.*, 2007; Buckland *et al.*, 2011; Tognon *et al.*, 2011; McNaughton *et al.*, 2012). For example, among Greek participants in the European Prospective Investigation into Cancer and Nutrition (EPIC) study, a two-point increase in a 10-point score measuring adherence to the MD was associated with 14% reduced overall mortality (Trichopoulou *et al.*, 2009).

This greater longevity has been attributed to the MD's role in preventing chronic diseases such as certain cancers, cardiovascular disease (CVD), type II diabetes and age-associated cognitive decline (Pérez-López *et al.*, 2009). Interestingly, adherence to a Mediterranean diet also reduced mortality in people who already had coronary heart disease (inclusion criteria were the presence of one or more of the following: diabetes mellitus, myocardial infarction with or without angina pectoris, angina pectoris without myocardial infarction and those taking medication for hypercholesterolemia and/or hypertension); a two-point increment in the same 10-point MD score was associated with a 27% lower mortality rate in Greek EPIC participants (Trichopoulou *et al.*, 2005). Furthermore, it has been suggested that the combined effects of the food groups contributing to the overall MD pattern are more influential than those from an individual component of the diet in increasing survival in older people (Trichopoulou *et al.*, 1995).

## 1.3 Mediterranean diet and prevention of disease

### *1.3.1 Cardiovascular disease and cerebrovascular disease*

Cardiovascular disease is the leading cause of death worldwide, accounting for more than 17 million deaths in 2008 (World Health Organisation, 2011). Although CVD can be attributed in part to non-modifiable risk factors such as age, its major risk factors include unhealthy diets, hypertension, smoking, obesity, high alcohol consumption, physical inactivity, hypercholesterolaemia and diabetes mellitus; all of which can be prevented by treatment or lifestyle modifications. Adherence to a MD pattern has been linked to this relationship. In a meta-analysis of prospective studies which investigated the association between adherence to the MD and health, a two-point increase in adherence to a 10-point MD score was associated with a 10% reduction from death and/or incidence of cardio- and cerebrovascular diseases (Sofi *et al.*, 2010a). The Lyon Diet Heart Study is the most important randomised secondary prevention trial for the prevention of a recurrent myocardial infarction through adherence to a Mediterranean diet. After a mean follow up of 46 months, a protective effect of the MD was observed, whereby the rate of cardiac death and nonfatal infarction in the experimental group was 1.24 per hundred patients per year, compared with a rate of 4.07 in the control group (De Lorgeril *et al.*, 1999). Furthermore, in the Prevención con Dieta Mediterránea (PREDIMED) intervention study, a MD supplemented with either virgin olive oil or nuts resulted in a 30% reduction in the risk of major cardiovascular events among individuals at high-risk (but who were initially free of CVD), after a median follow up of 4.8 years (Estruch *et al.*, 2013).

### *1.3.2 Type II diabetes mellitus*

The Mediterranean diet can have protective effects against the metabolic syndrome and Type II diabetes mellitus, despite the presence of a relatively high proportion of fat in the diet (total lipid intake can be approximately 40% of total energy intake in Greece) (Panagiotakos *et al.*, 2006b). An increase of two points in a 10-point scale measuring adherence to a Mediterranean diet was associated with a 35% relative reduction in the risk of developing Type II diabetes (Martinez-Gonzalez *et al.*, 2008). Mediterranean diets supplemented with either virgin olive oil or nuts were correlated with lower fasting glucose levels in people with Type II diabetes and/or coronary heart disease (CHD) risk factors, and lower fasting insulin concentrations and lower insulin resistance in people with CHD risk factors only (Estruch *et al.*, 2006). Additionally, a systematic review identified that Type II diabetic patients allocated to a MD in randomised control trials had better glycaemic control and reduced insulin resistance, than those following a control diet (Esposito *et al.*, 2010).

### ***1.3.3 Obesity***

Following a Mediterranean diet may prevent obesity, but this link may be tenuous, as there have been mixed results from several studies. In a French sample, higher adherence to the Mediterranean diet was associated with lower weight gain in men but not women over 13 years (Lassale *et al.*, 2012). In another prospective study, whilst adherence to the MD was negatively associated with abdominal fat gain over 10 years, there was no association with 10 year incidence of abdominal obesity. Moreover, in a cross-sectional study, Rossi *et al*. found no relationship between MD adherence and adiposity in a large Italian sample (Rossi *et al.*, 2008).

The correlation between the Mediterranean diet and obesity has been observed in children with more favourable results. In a European-wide study among primary school-aged children, a greater adherence to a food frequency-based Mediterranean diet score was inversely associated with overweight, obesity and body fat percentage (Tognon *et al.*, 2014). Interestingly, children with the highest MD scores lived in Sweden and those with the lowest scores lived in Cyprus, which suggests that children are no longer following the traditional diets of their region. In another study of 10-12 year old children, the relationship between obesity and Mediterranean diet was mediated by parental educational level: children with at least one parent with high educational status had greater adherence to the MD and were less likely to be overweight or obese (Antonogeorgos *et al.*, 2013). Similarly, amongst Sicilian adolescents, a greater adherence to the MD using the same KIDMED score as the aforementioned study (Serra-Majem *et al.*, 2004) was associated with higher socioeconomic class and physical activity levels, whereas lower MD adherence was associated with obesity (Grosso *et al.*, 2013).

### *1.3.4 Non-alcoholic fatty liver disease*

Non-alcoholic fatty liver disease (NAFLD) is the most common liver disorder in economically developed countries (Argo and Caldwell, 2009). It is characterised as the accumulation of fat in the liver (not due to excessive alcohol consumption) and is related to sedentary lifestyles, unhealthy diets, the metabolic syndrome and obesity (Trovato *et al.*, 2014). Whilst adherence to the Mediterranean diet may not be associated with a lower likelihood of having NAFLD, it has been associated with less severity of the disease with a higher MD adherence in an intervention study (Kontogianni *et al.*, 2013). This trend was found in another study and although the effects were gradual after a six-month intervention, they were, nonetheless, independent to other lifestyle factors (Trovato *et al.*, 2014). However, in order for these changes in disease severity to remain favourable, the lifestyle interventions must be maintained (Barrera and George, 2014).

### *1.3.5 Cancer*

As per CVD and Type II diabetes mellitus, environmental factors such as diet play a major role in the development of cancer. The incidence of overall cancer is lower in Mediterranean countries than in Western countries such as the UK, USA and Scandinavia, which is mostly attributable to the lower incidence of cancers known to be affected by dietary factors, including colorectal, breast, prostate and pancreatic cancers (Trichopoulou *et al.*, 2000). Differences in dietary patterns between Mediterranean and Western countries may be responsible for this trend. Adherence to the MD was associated with a 10% lower risk of mortality from cancer in elderly individuals (Knoops *et al.*, 2004), whilst a 12% reduction in incidence of all cancers was observed with a 2-point increase in a 10-point Mediterranean diet score (Benetou *et al.*, 2008). When studying the relationship between this dietary pattern and risk of developing certain cancers, just a one unit increase in adherence to an 18-point score resulted in a 5% reduced risk of gastric adenocarcinoma (Buckland *et al.*, 2010), conformity to the Mediterranean diet was associated with a lower breast cancer risk in postmenopausal women (Trichopoulou *et al.*, 2010) and high versus low adherence to a 10-point score was associated with a reduced risk of colorectal cancer in men (Reedy *et al.*, 2008). Furthermore, a one-point increase in the 75-point modified-MedDietScore was associated with a 16% lower likelihood of having colorectal cancer in people with three or more characteristics of the metabolic syndrome (Kontou *et al.*, 2012).

### *1.3.6 Cognitive decline*

Whilst brain ageing is extremely complex and its causes are poorly understood, age-related cognitive decline (ARCD) is a natural process of ageing, which includes the deterioration of executive functioning, processing speed and memory performance. Common pathological features are oxidative damage from endogenous and exogenous sources, the accumulation of protein aggregates (such as β-amyloid plaques and tau tangles in Alzheimer's disease and α-synuclein in Parkinson's disease) and selective neuronal loss (Cole *et al.*, 2010). Risk factors for cognitive decline and dementia are similar to those for CVD, including hypertension, diabetes, smoking, obesity and low physical activity, although no effective preventive interventions have delayed or prevented the onset of neurological diseases (Sofi *et al.*, 2010b). However, there have been some promising results when studying the relationship between the overall MD and cognitive decline risk. High adherence to a Mediterranean diet was associated with an inverse dose-response risk for Alzheimer's disease (Scarmeas *et al.*, 2006); mortality from Alzheimer's disease (Scarmeas *et al.*, 2007); and the risk of developing mild cognitive impairment and risk of its conversion to Alzheimer's disease (Scarmeas *et al.*, 2009). Additionally, in a meta-analysis of cohort studies, a two-point increase in adherence to a MD score was associated with a 13% reduction in the incidence of neurodegenerative diseases (Sofi *et al.*, 2010a).

### *1.3.7 Mood disorders*

In 2011, almost one in five people in the UK experienced anxiety or depression, with the highest levels in the 50-54 year age group and affecting women more than men (Office for National Statistics, 2013). There are also regional differences, with lower lifetime prevalence in Mediterranean countries than in Northern Europe (Kovess-Masfety *et al.*, 2007). In a longitudinal study measuring the MD and depressive symptoms in older adults, adherence to the MedDietScore was inversely associated with the risk of developing depressive symptoms. More precisely, the annual rate of developing depressive symptoms was almost 99% lower among participants with the greatest adherence to the MD, compared with those with the lowest adherence (Skarupski *et al.*, 2013). Of six patterns identified in the diets of women taking part in the Australian Longitudinal Study on Women's Health, only the MD was associated with lower prevalence of depressive symptoms at baseline and 3-year follow up (Rienks *et al.*, 2013). Furthermore, a meta-analysis identified a relationship between moderate and high adherence to the MD and a reduced risk of depression and cognitive impairment (Psaltopoulou *et al.*, 2013).

### *1.3.8 Osteoporosis*

Osteoporosis is characterised as the loss of bone mineral density (BMD) and bone strength, which results in an increased risk of fractures (Schuit *et al.*, 2004). As this bone disorder is age-related, the incidence of bone fractures is increasing with the ageing population. It was estimated that there could be 6.3 million fractures worldwide by 2050 (Cooper *et al.*, 1992). BMD can be modulated by environmental factors such as diet and, traditionally, interventions have focused primarily on increasing calcium and vitamin D intakes. More recently, the role of the whole diet on bone health has been explored. Despite the Mediterranean diet advocating relatively low intakes of dairy products, favourable effects on bone health have been observed. Within Europe, the incidence of osteoporosis in the Mediterranean area is much lower (Puel *et al.*, 2007). In the EPIC study, a greater adherence to the MD was associated with a reduced incidence of hip fractures, particularly among men (Benetou *et al.*, 2013). Additionally, adherence to the MD was associated with greater BMD in pre- and post-menopausal women (Rivas *et al.*, 2013).

Considering that peak bone mass occurs during our early 20's and that the amount laid down could be a predictor for fractures in later life, some studies have researched the role of diet and bone mineral status in adolescents. In a 28-day Mediterranean diet intervention study, calcium absorption and retention was significantly higher than compared with the participant's usual diets, as well as reduced urinary calcium excretion (Seiquer *et al.*, 2008). However, there was no correlation between bone mineral status and MD adherence in young Irish adults (although a "refined" diet was considered detrimental to bone health in males) (Whittle *et al.*, 2012). Meanwhile, a cohort study measured adherence to a MD and BMD in adolescents at age 13 and 17 years. Whilst there were no significant differences between BMD and tertiles of MD adherence at 17 years of age, there was a non-significant trend of increased BMD with greater MD adherence at age 13 years (Monjardino *et al.*, 2014).

## 1.4 Mediterranean diet scores

### *1.4.1 The use of dietary pattern analysis in nutritional epidemiology*

Traditionally, nutritional epidemiology assessed the effects of a single, or a few, foods or nutrients on health (Hu, 2002). However, this method is considered too reductionist, since food is mostly consumed in meals, which include a variety of foods with complex combinations of nutrients that are likely to work cumulatively and synergistically (Togo *et al.*, 2001). Therefore, studies using this approach are unable to detect small effects from single nutrients (Newby and Tucker, 2004). Over the last two decades, nutritional epidemiological studies have focused on analysing dietary patterns to investigate the effects of overall diet on health.

Dietary pattern analysis falls under two main approaches: *a priori* and *a posteriori.* The *a priori* dietary pattern approach is more theoretical, whereby foods are grouped together according to pre-defined indices of nutritional health, such as the Healthy Eating Index (Kennedy *et al.*, 1995) and the Mediterranean Diet Score (Trichopoulou *et al.*, 2003). Dietary indices are based on scientific knowledge or theory of favourable or adverse health effects from specific diets/ dietary constituents and usually represent nutritional guidelines and/ or specific dietary patterns which are considered healthy. The index components are quantified to calculate a ranking score and provide a measure of dietary quality in relation to habitual healthy dietary behaviours (Newby and Tucker, 2004).

The *a posteriori* technique uses multivariate techniques, including cluster analysis, factor analysis, principal components analysis (PCA) and reduced rank regression (RRR) to empirically derive patterns from dietary data *post hoc*. These techniques are exploratory and their interpretation is subjective. Factor analysis and PCA reduce the number of dietary variables based on inter-correlations with the original variables, to identify a number of independent linear combinations of foods or food groups which are frequently consumed together (Smith *et al.*, 2011). Whilst RRR is similar to factor analysis and PCA, it requires existing knowledge about variables associated with the specific disease(s) under investigation and is used to inform the dietary patterns produced (Hoffmann *et al.*, 2004). Cluster analysis reduces dietary data into a pre-specified number of patterns based on individual differences in mean intakes of each food or nutrient group. Each cluster is mutually exclusive, assigning each individual to only one (relatively) homogeneous cluster representing a dietary pattern (Kant, 2004). After these multivariate techniques have been applied to dietary data, statistical methods such as multiple regression analysis and univariate analysis are used to investigate associations between the dietary patterns and outcomes, such as health or disease status (Panagiotakos *et al.*, 2007b).

### ***1.4.2 The use of Mediterranean diet scores***

The Mediterranean Diet Score (MDS) was the first dietary score used to quantify adherence to the MD pattern and to investigate the relationship with health (Trichopoulou *et al.*, 1995). The MDS has eight food characteristics and, using the sex-specific median values for intake of each food group by the study population as cut-offs, one point is assigned to diets containing high consumption of the beneficial components of the score (i.e. MUFA: SFA, alcohol, legumes, cereals, fruit and vegetables) and for low consumption of the components considered less healthy (i.e. meat and meat products and dairy products). A direct variation of this score was developed by Osler and Schroll (1997).

Trichopoulou *et al*. have since developed two MDS which are variants of the original score. Recognising that fish consumption is associated with reduced coronary heart disease (Hu *et al.*, 2002), the first score was adapted to include fish as a beneficial component (Trichopoulou *et al.*, 2003), resulting in a score ranging from 0-9 points. This is the most widely used score to assess adherence to a Mediterranean diet. Two years later, a second MDS variant was created: the Modified Mediterranean Diet Score (Modified MDS) (Trichopoulou, 2005). Whilst the first two dietary scores were developed for use with the Greek population, this modified index was created for use in the nine European countries participating in the EPIC study. As the majority of these participating countries are not located in the Mediterranean basin, PUFAs were also included in the ratio of fatty acid consumption, as they are the principal sources of unsaturated added fat in Western diets and also play a protective role against CHD (Trichopoulou, 2005).

Nutrition epidemiologists have subsequently favoured utilising dietary indices to evaluate whether adherence to the Mediterranean dietary pattern lowers the risk of disease. Variants of Trichopoulou *et al.*'s 2003 version of the MDS have consequently been developed. These include the Modified Mediterranean Diet Score (MMDS) (Toledo *et al.*, 2010), the Mediterranean Dietary Pattern (MDP) score_1 (Sánchez-Villegas *et al.*, 2006), the alternate Mediterranean Diet Index (aMED) (Fung *et al.*, 2005), and the relative Mediterranean Diet (rMED) score (Buckland *et al.*, 2010), as well as Mediterranean diet scores composed by Muñoz *et al.* (2009), Issa *et al.* (2011) Cade *et al*. (2011) and Schröder *et al*. (2006). Tognon *et al.* (2011) have also produced a new score (refined modified MDS) based on Trichopoulou et al.'s Modified MDS (2005).

The above indices slightly differ from the traditional MDS by including modified food groups and/ or alternative scoring systems, e.g. Schröder *et al*. (2006) calculated their score according to tertile distribution of energy-adjusted food consumption, instead of sex-specific median values. Whilst these simple diet scores are easy to use even in large cohorts, their small range in scale might not be sensitive enough to detect small changes in diet over time and may fail to capture extreme food consumption behaviours (Panagiotakos *et al.*, 2006b). Another disadvantage of these simple indices is that the same weighting is given to all dietary components, regardless of the quantities in which they are usually consumed and the scientific evidence of their diet-disease relationships (Da Silva *et al.*, 2009).

Other unique scores have also been developed, which contain different food groups and/ or scoring systems to Trichopoulou *et al*.'s MDS and its derivations. The Mediterranean Adequacy Index (MAI) was first developed in 1999 to measure trends in food and nutrient intake from 1960-1991 of Italian participants taking part in the Seven Countries Study (SCS) (Alberti-Fidanza *et al.*, 1999). The index is computed using the percentage of total daily energy intake from food groups (although if this information is unavailable, the MAI can also be computed as g/ day per food group). The food groups in the MAI have been slightly modified more recently (Alberti *et al.*, 2009). Using the MAI, it has been found that over time, Italian people have progressively abandoned the traditional reference Italian-Mediterranean diet (Alberti-Fidanza *et al.*, 1999; Alberti-Fidanza and Fidanza, 2004). When compared with the MDS, the MAI was better at identifying dietary patterns of different populations in relation to CHD deaths (Alberti *et al.*, 2009).

A Mediterranean Diet Quality Index (Med-DQI) (Gerber *et al.*, 2000) was devised based on a Diet Quality Index (DQI) (Patterson *et al.*, 1994) and adapted to apply to a Mediterranean population. The DQI rates an individual's whole diet according to recommendations by the National Research Council and American Heart Association for prevention of chronic disease. Since the prevalence of CVD is traditionally lower in Mediterranean countries (despite total fat intake being similar to that of Northern European populations), a gradient of food consumption with increasing scores was introduced in the Med-DQI. Whilst the food group constituents were described in detail, it was not clear which of the seven food/ nutrient group gradient scores were constructed according to recommended consumption, or by dividing the sample's consumption into tertiles when recommendations did not exist. In addition, several components of the Mediterranean diet pyramids have not been incorporated into this index, suggesting that its ability to assess the overall dietary pattern might be questionable.

Goulet *et al*. (2003) developed a global Mediterranean diet score based on the components of the most recent version of the Mediterranean diet pyramid at that time. Each of the 11 components was scored between zero and four points, depending on consumption levels. This diet score was initially created to assess adherence to a Mediterranean diet intervention in a non-Mediterranean (Canadian) population, and from the results of this study, the index was sensitive enough to detect changes in diet over the three-month intervention period. Another advantage of this score is the level of detail provided for assigning points e.g. the foods contributing to the food groups are explained and recommended portion sizes are provided. However, unlike other MDS, this score does not include alcohol as a food group.

The MedDietScore is another dietary score based on the Mediterranean diet pyramid (Panagiotakos *et al.*, 2006b). It includes 11 food groups of the diet pyramid and uses monotonic functions (except for alcohol) to score the frequency of food group consumption between zero and five points. This score ranges from 0-55 points, with higher values signifying greater adherence to the Mediterranean diet. The authors claim that larger scale scores such as this one are more able to provide health predictions using continuous outcome variables (e.g. biological markers). Indeed, higher values of this score have been inversely associated with the risk of developing acute coronary syndromes (Panagiotakos *et al.*, 2006b), hypertension, diabetes, hypercholesterolaemia and obesity (Polychronopoulos *et al.*, 2005; Panagiotakos *et al.*, 2007a; Panagiotakos *et al.*, 2007c), and positively associated with total antioxidant capacity (Pitsavos *et al.*, 2005; Panagiotakos *et al.*, 2006b).

The allocation of points in MedDietScore has been modified more recently to take into account of the recommendations on the frequency with which the 11 components are eaten on a daily, weekly or monthly basis (Panagiotakos *et al.*, 2009). Firstly, five points are allocated to the potatoes food group if they are consumed 13-18 times per month, instead of more than 18 times per month, as specified in the original MedDietScore. Secondly, a weighting system has been devised which recognises that not all of the food groups contribute equally to the prevention or development of disease, to provide a scale ranging from 0-130 points. The authors hope that this modified score will have a higher accuracy and predictive ability of future health events.

FFQs are often employed in large-scale epidemiological studies to measure habitual diet. This is also true for the majority of studies which wish to measure an individual's adherence to the MD, alongside using a Mediterranean diet score. However, this process can be time consuming and therefore three shorter questionnaire-style dietary scores have been produced which fulfil the roles of both FFQs and Mediterranean dietary indices: the Mediterranean Diet Adherence Screener (MEDAS) (Estruch *et al.*, 2006) and two short Mediterranean diet questionnaires by Martínez-González *et al.* (Martínez-González *et al.*, 2004) and Mozaffarian *et al*. (Mozaffarian *et al.*, 2007).

The MEDAS tool was developed for use in the Prevención con Dieta Mediterránea (PREDIMED) study, a randomised controlled trial which included two Mediterranean diet interventions, one supplemented with virgin olive oil and the other with mixed nuts (Estruch *et al.*, 2006). MEDAS was validated as a rapid method of assessing compliance with the Mediterranean dietary interventions in the PREDIMED study (Schröder *et al.*, 2011). It consists of 14 items, each scoring zero or one, including 12 questions on food consumption frequency and two on habitual intake of foods considered characteristic of the Spanish Mediterranean diet. Martínez-González *et al.*'s short Mediterranean diet questionnaire (2004) assesses the frequency of consumption for nine food groups, each of which is split into two categories based on an observed dose-response relationship between overall score and myocardial infarction risk in a case-control study (Martínez-González *et al.*, 2002). The questionnaire by

Mozaffarian *et al*. (2007) includes questions on habitual intake of fruit, vegetables, fish, oils, butter, cheese, wine and coffee, with each item scored from zero to three points depending on the frequency of consumption.

In contrast with the MEDAS score, the other two short questionnaires do not provide guideline serving sizes, despite basing the scoring of questions on the frequency or amount consumed in a given period. Whilst these simple screener questionnaires may prove useful for assessment of dietary adherence, they do not necessarily follow the Mediterranean diet pyramid. For example, one point would be scored in the questionnaire by Martínez-González *et al.* (2004) if just one serving of vegetables is consumed per day, compared to the recommended intake of at least two servings to be consumed with every main meal by the most recent Mediterranean diet pyramid. Moreover, the questionnaire by Mozaffarian *et al*. (2007) did not include some food groups that are characteristic of the Mediterranean dietary pattern (such as grains, nuts and legumes) and included questions on some uncharacteristic food groups, such as coffee and butter. Furthermore, not enough information is provided on the questions, their possible answers and the allocation of points for others to be able to use the score.

Finally, the Mediterranean-Style Dietary Pattern Score (MSDPS) was created to overcome several disadvantages of other Mediterranean diet scores (Rumawas *et al.*, 2009). Firstly, traditional MD scores assign points according to sex-specific median levels of intakes. However, this system may not actually measure adherence to a Mediterranean diet (especially if utilised in non-Mediterranean populations) and may in fact reflect the dietary pattern of the study population. Instead the MSDPS is based upon adherence to recommended food intakes from a Mediterranean diet pyramid (Ministry of Health and Welfare Supreme Scientific Health Council of Greece, 1999) and has a continuous scale from 0-10 points, which removes the subjectivity of selecting what cut off points and food groups to include, which in turn minimises bias from misclassification of dietary exposure. The MSDPS also assigns a negative weighting to the overconsumption of foods which are less desirable from a MD perspective. Energy intake may become a confounder in results gained from diet scores which do not address this, as it is possible to achieve the recommended levels of the MD food groups purely by consuming greater amounts of food and therefore, more energy. In addition, as this diet score was created for use with an American population which may consume both Mediterranean and non-Mediterranean dietary constituents, this diet index negatively weights the proportion of energy intake derived from foods not considered part of the MD. As a consequence of including these factors, the MSDPS is the most complex to calculate out of all the aforementioned dietary indices.

In conclusion, whilst dietary indices can be used simply and easily in large populations to measure adherence to the Mediterranean dietary pattern, and this adherence has been associated with favourable health outcomes, these indices also raise some methodological concerns. For example, the majority of the MDS have been created for use in observational studies and are therefore not designed specifically (or since tested) to measure changes in diet in response to an intervention. In addition, dietary scores can be limited by the subjective choice of which of their foods are considered “Mediterranean” and those which are not (Da Silva *et al.*, 2009). As a result, coupled with their differing scoring techniques, dietary scores are not easily comparable with each other. An overview of all the MDS described in this section is included in Appendix A.

## 1.5 Approaches for dietary assessment

### *1.5.1 Traditional dietary assessment methods*

Traditional dietary assessment methods are pen and paper-based and rely on self-reporting using tools such as 24 hour recalls, food diaries, FFQs and diet histories. The food diary and 24 hour recall methods (including the Multiple-Pass Method, a more refined and in-depth five-step version of the standard 24 hour recall (Conway *et al.*, 2003), further described in Table 1.1), usually require trained interviewers to instruct participants on how to record their food consumption in sufficient detail for the interviewer to ascertain the types of food consumed, their preparation or cooking methods and portion sizes. To assess habitual diet, these methods need to be conducted over several days (which should be consecutive when using food diaries). Therefore, these methods pose a high investigator cost, there are problems of bias in that intake is often under-reported (especially among certain population groups), and, in the case of food diaries, data collection periods of more than a few days can incur high participant burden (Thompson and Subar, 2008).

Whilst FFQs are more practical and cost-effective for use in large epidemiological studies, they do not collect as much dietary intake information and may have greater measurement error. Since the frequency of food consumption is assessed on long retrospective periods (such as the previous 12 months), this can be a difficult cognitive task for some respondents. Diet histories are similar to FFQs in that they assess retrospectively long-term frequency of habitual food intake but, in addition, they also may attempt to ascertain other details such as portion size and intakes of specific food items, as opposed to broader food groups as utilised in FFQs. Diet histories share several limitations with FFQs: many participants find these subjective tasks difficult to recall and quantify usual portion size so that estimates of nutrient intakes are often higher than those by tools which measure short-term intakes (Thompson and Subar, 2008). Additionally, diet histories often require a high investigator burden.

Consequently, technological advances have been made which aim to improve the accuracy and speed of data collection and analysis and to reduce participant burden, misreporting of food intake and interviewer costs. Although technologies have been developed for use with smartphones, personal digital assistants and other electronic systems, only the use of computerised technology in nutritional epidemiology has been described in this chapter (see Section 1.5.2), to take into account of the project aims (see Section 1.6).

### *1.5.2 The use of computerised technology to assist with dietary assessment*

#### *1.5.2.1 Computerised food frequency questionnaires*

Food frequency questionnaires are the most commonly employed dietary assessment method in large-scale epidemiological studies. The advent of computerised self-administered FFQs has not only reduced the costs of printing and mailing the questionnaires to the study participants, but may also increase response rates and reflect more accurately actual intakes by reducing misreporting bias (Thompson *et al.*, 2010). DietAdvice is a web-based tool which is comprised of FFQ and diet history methodologies and was developed in Australia to record dietary intake of metabolic syndrome patients (Probst and Tapsell, 2007). Using this tool at home rather than in the primary healthcare setting was more common amongst overweight people and further encouraged accurate reporting by removing bias that may be present in face-to-face interviews (Probst and Tapsell, 2007).

Another self-administered web-based FFQ was developed to assess the diets of adolescents (Matthys *et al.*, 2007). This questionnaire asks three questions for each of the 69 food items: firstly if the food item is ever consumed, secondly the frequency of its consumption, ranging from one day/ month to everyday, and lastly, the portion size category. Estimated three-day food diaries were chosen as the reference method to validate the tool. Whilst the web-based tool has the advantages of reduced participant burden compared to other dietary assessment methods and reduced researcher time spent on interviews and data analysis, this FFQ is only appropriate for assessing population median intakes of water, fruit, bread, and fish/ eggs/ meat food groups and is not able to adequately determine absolute food intake.

The interviewer-administered meal-based intake assessment tool (MBIAT) was designed to assess habitual dietary intake of iron and zinc by meal rather than by foods, in order to aid participant recall, and applicable food lists are selected by the interviewer for the participants (Heath *et al.*, 2005). Participants are questioned about meals and snacks consumed during the previous month using a 630-item food list. Instead of the usual FFQ method of detailing a standard portion size, the MBIAT requires users to describe their own serving sizes using multiples and proportions of household measures, with the addition of three-dimensional food models to aid estimation. Relative validity of this tool was performed with weighed food diaries and it was found that the MBIAT is an appropriate tool to assess group dietary intakes of iron and zinc and their absorption modifiers (Heath *et al.*, 2005). However, using a meal-based system might not be the most useful method for people who have no particular eating pattern or those who "graze" food throughout the day. Additionally, the dependence of this dietary assessment method on interviewers implies that this would not be a suitable instrument for use in large studies.

A computer-assisted dietary interview was used in the Fukuoka Colorectal Cancer Study, which was administered before and after four seven-day food diaries (Uchida *et al.*, 2007). A total of 149 items were available to choose from in the computer-assisted tool, with a typical portion size of each food item displayed alongside. Similar to the MBIAT method, there was an option for participants to select their own usual portion sizes, with the options of 0.5, 1, 1.5 and 2 times the size of the item displayed. However, unlike the relative validity study of MBIAT, when dietary intake recorded by the computer-assisted interview was compared with the food diaries, mean daily energy and nutrient intakes were generally greater than those recorded by food diaries. Despite this, there were no significant differences in recorded dietary intake between the two dietary interviews performed one year apart (Uchida *et al.*, 2007).

Finally, the European Food Propensity Questionnaire (EFPQ) is self-administered and was made available in web-based and paper-based forms for a subset of participants from five cohort studies (Illner *et al.*, 2011). It assesses frequency of consumption of 166 food items over the previous year, with standard portion sizes pictorially displayed. In this study, diet was assessed over the long-term and short-term by combining the use of the EFPQ and three 24 hour recalls. In addition, users of the web-based system were encouraged to complete an evaluation questionnaire about their opinions of it. As might be expected, those who selected to use the web-based EFPQ were younger and more likely to have a university degree. However, a larger proportion of participants completed the EFPQ online than on paper, the online tool was generally rated highly and fewer participants requested help to complete the questionnaire online (Illner *et al.*, 2011). Nevertheless, this highlights the need for researchers to design computerised tools which are more accessible to the older generations and the less-educated.

#### *1.5.2.2 Computerised diet histories*

In one study by Landig *et al.* (Landig *et al.*, 1998), two German computerised diet history methods were compared and validated (unknowingly to the hospitalised participants) with weighed food diaries over eight days. One method was called the EBIS, a German abbreviation for “diet history, consulting and information system”. Here, a tree system is provided, starting with each meal and ending with individual foods. Interviewers are able to help guide the session by jumping to different parts of the diet history and ask questions. In the other method, the diet history (DH), a similar tree system is operated, but the programme is standardised and independent of the interviewer. Whilst there were no significant differences between the two programmes, they were not considered accurate enough to estimate food intake when compared to actual intake (Landig *et al.*, 1998). Since these programmes were tested on consecutive days after the eight-day weighed methods, their accuracy to detect actual food intake over the long term would be dubious.

An audio computer-assisted self-interviewing (A-CASI) diet history questionnaire (DHQ) was developed to measure dietary intake over the previous year in American Indian and Native people in Alaskan communities (Slattery *et al.*, 2008). With the assistance of tribal input, the questionnaire includes locally-available food items and questions are based on a tiered structure: firstly participants are asked whether they consume each of the 54 broad food groups 12 or more times per year. For positive responses, the broad food groups are expanded to examine which specific food items are consumed, then further questions are asked regarding typical consumption frequencies and portion sizes (with the aid of three portion size pictures). As the system is audio-assisted, participants chose whether to hear the questionnaire being read in English, Yupik, or Navajo languages. In a later validation study, dietary intake was measured prospectively using monthly 24-hour recalls over one year, with the DHQ administered at the beginning and end of the year (Murtaugh *et al.*, 2010). Whilst the DHQ was reliable when repeated after one month, it overestimated energy intake when compared to the 24 hour recalls, although for most food groups and nutrients, this seems to be compensated for when using a nutrient density approach (i.e. assessing nutrient intakes expressed as per 1000 kcals, rather than as gross intakes).

#### *1.5.2.3 Computerised food diaries*

The Young Children's Nutrition Assessment on the Web was developed for parents to record food consumption by their preschool children (Vereecken *et al.*, 2009). Parents were asked to record intake over three days, with each day divided into 24 potential eating occasions to reflect the hours of the day. Food items are arranged in a hierarchical tree, containing 25 broad food groups, which can be expanded up to seven levels to select specific foods from a list of approximately 800 items. For each item selected, one or more screens are shown to obtain the number of portions or portion size consumed, with options to add or subtract the amount shown. The system also included probes and prompts for forgotten foods and portion sizes, such as foods often eaten in combination with others. Whilst there is an option to select "items not found" for participants who cannot retrieve a food item, the system is not open-ended, so there are no options to record food items which are not included in the system.

When compared with pen and paper food diaries, the computerised tool produced similar dietary patterns (Vereecken *et al.*, 2009), although this comparison was not made within the same individuals.

Asian Assist is a self-administered tool which can be used as a food diary or a 24 hour recall and was designed to assess the diets of Chinese Americans (Hernández, 2001). The tool uses a dual language format and incorporates Chinese foods, with estimated portion size aided by pictures of containers commonly used for these foods. Similarly to the Young Children's Nutrition Assessment on the Web tool, Asian Assist does not allow for manually entering data and adopts a "point and click" style on pictures or text to select food items and portion sizes. Consumption of food items is also recorded to the nearest hour. Additionally, this programme records where food was consumed and provides a prompt for the use of condiments. Evaluation was conducted on Asian Assist by 24 hour recalls, and in a subset of user-testers, food diaries were completed on the day before using the tool, which were imputed by a researcher. No significant differences were found between the food diaries and the computerised 24 hour recalls for any of the food components and nutrients assessed (Hernández, 2001).

#### *1.5.2.4 Computerised 24 hour recalls*

If repeated several times throughout the course of a study, the 24 hour recall can precisely and cost-effectively represent habitual dietary intake, without altering participants' dietary intakes, and may actually out-perform the FFQ in accurately measuring food intake (Schatzkin *et al.*, 2003). Computerised versions can reduce investigator burden by immediately providing nutritional information, resulting in time-efficiency and reduced costs (especially if self-administered), which allow them to be feasible for large-scale studies.

One example of these systems is the Oxford Web-Q, a self-administered web-based 24 hour recall dietary questionnaire (Liu *et al.*, 2011). The participant is asked whether they ate any of the 21 food groups on the previous day, and if so, each food group is expanded to reveal individual food items. Standard units and portion sizes are provided, with the option for the participant to alter them to reflect the portion sizes they consumed. In order to gain complete records, the system does not allow participants to skip through unanswered questions. When the Oxford Web-Q was compared with an interviewer-administered 24 hour recall, it produced similar mean estimates of energy and nutrient intakes and took considerably less time to complete and calculate nutrient intakes (Liu *et al.*, 2011). However, this method is limited by its inability to probe for information on food preparation and cooking methods, food brands and its restrictive food list. Therefore, an accurate assessment of the whole diet is not possible when using this system.

DietDay, a self-administered web-based 24 hour recall, was developed for the Energetics study (Arab *et al.*, 2011). It contains 9,349 food items and over 7,000 food pictures, with portion sizes assessed using images of household measures. A wealth of dietary information is collected, including the time of day of food consumption, food preparation techniques and supplement use. Eight dietary recalls were completed by participants, which were compared with paper-based DHQs and validated using doubly labelled water as a biomarker of total energy expenditure. The validity of DietDay was found to be greater than that of the DHQ for white and black adults. Additionally, for energy estimation, two or three days of recall were considered adequate to characterise habitual diet (Arab *et al.*, 2011).

Doubly labelled water has also been used to validate the United States Department of Agriculture (USDA) Automated Multiple-Pass Method (AMPM) (Blanton *et al.*, 2006). Relative validity of nutrient intake was compared with 14-day estimated food diaries and performance was compared with the Block FFQ and the National Cancer Institute's DHQ. The AMPM is a five-step interviewer-administered recall, the details of which are described in Table 1.1. The multiple pass method is a standardised approach which is used to obtain more complete data and minimise bias from misreporting and from participants providing socially desirable responses (Fowles and Gentry, 2008). Portion sizes are estimated using The Food Model Booklet, which contains life-size drawings of household measures and standard portion sizes, for example a large wedge shape for triangular-shaped foods, such as pizza. The USDA Food and Nutrient Database for Dietary Studies (FNDDS) is used to convert portion sizes to grams and calculate the nutritional composition of each food item consumed. Mean total energy intake measured by the AMPM and food diaries were not significantly different from total energy expenditure measured by the doubly labelled water, whereas the Block FFQ and DHQ significantly underestimated the doubly labelled water by approximately 27%. Similarly, mean absolute nutrient intakes measured by the AMPM did not significantly differ from those recorded by the food diaries, but the Block FFQ and DHQ produced significantly lower results than the other two methods (Blanton *et al.*, 2006). Therefore, the AMPM provides a valid measure of dietary intake at the group level. However these results may be optimistic as the study was performed on a small sample of highly motivated women. Nevertheless, this method has been used in the National Health and Examination Survey (NHANES) since 2001.

**Table 1.1 The five-step multiple-pass approach**

| Step | Process |
|---|---|
| Quick List | Uninterrupted list of all foods and beverages consumed during the previous day |
| Forgotten Foods | Interviewer prompts for foods forgotten from the quick list using a list of 9 food categories |
| Time & Occasion | Collect time of day and name of eating occasion for each food |
| Detail & Review | Collect detailed description of foods, portion sizes consumed and additions. Review day and probe for forgotten foods in between eating occasions |
| Final Probe | Final probe for anything else consumed |

In a sub-sample of the NutriNet-Santé cohort study, a self-administered web-based 24 hour recall was compared with an interviewer-administered telephone 24 hour recall (Touvier *et al.*, 2011). The web-based recall relied on a meal-based approach to record food items using three methods: selecting specific food items from expandable broad food groups, a search engine for food items which accepts spelling errors and manual typing of food items which were not identified using the first two methods. Three food photographs with varying portion sizes are presented onscreen to facilitate estimation of the amount of foods consumed. Agreement between the two methods was high, although this may be overestimated considering that the telephone method was employed immediately after the web-based method. Whilst there were no significant differences in Pearson's correlations of gender or education of the participants who completed the web-based recall, the mean correlations were higher amongst participants who were under 60 years of age and those who categorised themselves as experienced or expert with computers. The web-based system was preferred by 66.1% of users and 92.7% considered it user friendly (Touvier *et al.*, 2011). In addition, if the web-based system was used in the total 500,000 participant sample of the NutriNet-Santé study, this system would save €19 million compared with the interviewer-assisted telephone recalls (Touvier *et al.*, 2011).

In the US, the Automated Self-Administered 24 Hour Dietary Recall (ASA24) (Subar *et al.*, 2007) has been developed for adults, which is based on the Food Intake Recording Software System (FIRRst) that was designed for use in children (Baranowski *et al.*, 2002). ASA24 is web-based, uses the automated multiple pass method (see Table 1.1) and utilises the FNDDS to automatically code food items and assigns portion sizes and nutrient data. Participants are able to report food consumption by either browsing through a food list or using a manual search function. Almost 7000 items are included in the food list, which are organised into 24 broad food groups and 243 subgroups and more than 1100 different probes collect details about the consumption of these foods (Zimmerman *et al.*, 2009). After assessing the accuracy and preference of portion sizes using a range of different camera angles, images of food and images of food mounds and household measures for food photographs, it was found that aerial photographs were preferred and that for some foods, images of food mounds and household measures were as accurate as images of food. Additionally, the display of eight portion size images was more accurate than four (Subar *et al.*, 2010). These results have been incorporated into the design of the system, with the presentation of eight images of food mounds and household measures for each food item for when there are no images available for food images.

The relative validity of ASA24 has recently been conducted, whereby the performance of the tool was compared with measures of true intake and an interviewer-led recall. The interviewer-led recall performed slightly better than ASA24, with participants reporting 83% of their true intake using the conventional method and 80% using ASA24 (Kirkpatrick *et al.*, 2014). However, ASA24 offers considerable reductions in investigator time and study costs and it has already been used by a large number of participants.

The EPIC-SOFT is an interviewer-administered computerised 24 hour dietary recall programme, which was developed to standardise data collection across the 22 centres and nine countries participating in the EPIC study (Slimani *et al.*, 1999). The programme is user-friendly and was adapted to be specific to each of the participating countries, in order for it to be applied to large populations of differing origins. Individual foods and mixed dishes are entered into two different food lists, containing approximately 1500–2200 foods and 150–350 mixed dishes, depending on the country-specific version. If a food item is eaten which does not appear on the lists, the interviewer follows default options for describing, quantifying and checking the new item reported. Information on food preparation and cooking methods is collected and portion sizes are estimated by using six methods: food photographs/ shapes, household measurements, standard units, standard portions, gram: volume method, and the ‘unknown’ method. A food photograph book is used, containing photos of 94 foods and 46 recipes with four to six portion sizes in increasing size. The gram: volume method is used for known quantities of ingredients in recipes before preparation and/ or cooking and for when the precise weight of the portion consumed is known. The ‘unknown’ method is used when either a participant cannot estimate how much was consumed or an item does not appear on the food database. EPIC-SOFT has also been used in other studies, including the European Food Consumption Validation (EFCOVAL) Study (Crispim *et al.*, 2011; De Boer *et al.*, 2011; Ocké *et al.*, 2011; Slimani *et al.*, 2011), the

Norwegian Calibration Study (Brustad *et al.*, 2003) and has also been applied to children (Trolle *et al.*, 2011). However, this tool would incur higher costs to research studies, due to it being interviewer-administered and not web-based.

Whilst the above described tools have been developed for use with adults, they have not been specifically developed for use with an older adult population who may consume different dietary patterns than their younger counterparts. A number of computerised 24 hour recalls have also been developed for use with children.

A self-administered web-based Food Behaviour Questionnaire (FBQ), which includes a 24 hour dietary recall, assesses food and physical activity behaviour of Canadian children and adolescents (Woodruff and Hanning, 2010). For the 24 hour recall, food intake from meals and snacks is recorded using a food list containing approximately 500 items, and prompts are given to obtain complete data. Portion sizes are established from food photographs. Positive feedback about the aesthetics and process of data collection of this tool was provided during user-testing (Hanning *et al.*, 2009). However, systematic bias was observed in under-reporting of energy intake by females and those with a higher BMI (Vance *et al.*, 2009).

The Young Adolescents' Nutrition Assessment on Computer (YANA-C) was developed in Europe (Vereecken *et al.*, 2005). The programme is structured around six eating occasions throughout the day and questions about the previous day's activities are asked to provide a context and aid recall. Foods are selected from 18 broad food groups containing over 400 items, and for unlisted items, participants can add another food group called "items not found". Portion sizes are estimated using 800 food photographs, with the option to select more or less than the amount shown. In addition, food probes are attached to 134 food items which are usually consumed in combination with others. When self-completed recalls using YANA-C were compared with a one-day estimated weight food diary and an interviewer-administered recall using YANA-C, the tool generally recorded higher energy and nutrient intakes than the food diary, but there were no significant differences between the self-completed and the interviewer-administered recalls (Vereecken *et al.*, 2005). When this programme was later evaluated against interviewer-administration, whilst there was a small underestimate of energy and fat intake when self-administered, both administration modes agreed very well (Vereecken *et al.*, 2008). YANA-C has since been further developed and renamed as Self-Administered Children and Infant Nutrition Assessment (SACINA), for use within the Identification and Prevention of Dietary- and Lifestyle- Induced Health Effects in Children and Infants (IDEFICS) study (Hebestreit *et al.*, 2014). However, the differences between the two systems have not been described.

The Synchronised Nutrition and Activity Program (SNAP) is a self-reported web-based programme which measures the frequency of energy balance related behaviours at the group or population level (Moore *et al.*, 2008). The programme is designed for use with children and is structured in a segmented school-day format, with visual memory prompts to aid recall. Forty nine food items are pictorially displayed and frequencies of consumption are assessed instead of portion sizes. Therefore, this tool is restricted by its limited food list and by being unable to evaluate nutrient intakes. As the authors state, its use is intended for intervention and evaluation studies, not for use in nutritional epidemiology (Moore *et al.*, 2014).

SNAP has since been applied for use with adults, with the new system being named Synchronised Nutrition and Activity Program for Adults (SNAPA) (Hillier *et al.*, 2012). Approximately 82% of food items reported using SNAPA matched those consumed via direct observation (Hillier *et al.*, 2012). However, this tool was developed to assess fruit and vegetable consumption, the percentage of food energy from fat and the time spent doing moderate-to-vigorous physical activity. Therefore it is not a suitable tool to assess the whole diet, as only 120 food items are incorporated into the system.

Finally, the Self Completed Recall and Analysis of Nutrition (SCRAN24) is a computerised 24 hour dietary recall which is based on the multiple-pass method (Blanton *et al.*, 2006) and was developed for use with children aged 11-16 years (Foster *et al.*, 2014b). Foods selected and portion sizes depicted in the tool are based on the foods and portion sizes served to children who took part in the National Diet and Nutrition Surveys (NDNS) in the UK. For each food selected, the system presents seven food photographs of varying portion sizes of equal increments, on a log scale between the 5$^{th}$ and 95$^{th}$ centile of the weight of food served. Prompts, probing questions and a function for individuals to add to the system are included to collect sufficient information. A small scale relative validation study of the system was conducted with a concurrent one day weighed food diary, which was completed by the child's parent. Items were coded as an exact match, an appropriate match (same food but slightly different variant), an omission (food recorded in the food diary but not in SCRAN24) and an intrusion (food item recorded in SCRAN24 but not in the diary). Although SCRAN24 had lower accuracy and precision than 7-day weighed food diaries and interviewer-administered 24 hour recalls, the level of food matches, omissions and intrusions were found to be comparable with other self-administered computerised 24 hour recalls (Baxter *et al.*, 1997; Baranowski *et al.*, 2002). Usability testing was also performed which helped shape the design of the tool. Overall, SCRAN24 was very well received, suitable for use at home and at school and was relatively quick to complete.

SCRAN24 has been further developed (and has since been renamed INTAKE24), to become web-based for use in future Scottish food and nutrition surveys with young people aged 11-24 years (Foster *et al.*, 2013). Approximately 400 new foods were added to the system, including foods commonly consumed by this age group during the NDNS (Gregory *et al.*, 2000; Henderson *et al.*, 2002; Bates *et al.*, 2010), alcoholic drinks and regional Scottish foods (Foster *et al.*, 2013). Usability testing found that the mean completion time of INTAKE24 (mean 13.4 minutes) was considerably faster than SCRAN24 (mean 22.3 minutes) (Foster *et al.*, 2013). Relative validation of INTAKE24 was recently conducted, by comparing dietary intake reported by four 24 hour dietary recalls using the system, with four concurrent interviewer-led 24 hour recalls. There was good agreement between the two methods and INTAKE24 was found to under-estimate mean energy intake by just 1% (Foster *et al.*, 2014a). These results shows that INTAKE24 has the potential to collect accurate measures of dietary intake, which are comparable to those reported in an interviewer-led recall.

## 1.6 Research study plan

### *1.6.1 Introduction to the study*

Whilst life expectancy has risen, healthy life expectancy has not risen as fast, resulting in more years of chronic ill-health towards the end of life and proportionally greater demands on public health services (Stanner and Denny, 2009). Recognising the need for lifestyle-based interventions to prolong the healthy lifespan, the LiveWell Programme was established in 2010 and funded by the UK's Lifelong Health and Wellbeing Initiative (www.mrc.ac.uk/research/initiatives/lifelong-health-wellbeing/). The LiveWell Programme is a 5-year research project which aims to develop and pilot a suite of pragmatic dietary, physical activity and social interventions which can be delivered in the peri-retirement window, to promote health and wellbeing in later life (http://research.ncl.ac.uk/livewell/). The peri-retirement window (the period just before, during or just after the main income provider in a household retires from full-time work, which has been operationalized as the 55-70 year age group (Hobbs *et al.*, 2013)) was chosen because it is a critical stage of lifestyle transition and presents an opportunity when individuals may be more compliant with behaviour change interventions. In addition, the LiveWell Programme aims to develop a suite of measures which capture and quantify the Healthy Ageing Phenotype (HAP) and which could be used as outcome measures in interventions to promote healthy ageing (Lara *et al.*, 2013).

This Ph.D. project is being undertaken within the LiveWell Programme and is linked with the dietary intervention aspect, which focuses on promotion of the Mediterranean dietary pattern. This dietary pattern is not only associated with increased longevity, but nutritional interventions are more likely to be safer and have lower costs than prescribing novel drugs (Cole *et al.*, 2010). This Ph.D. project has been designed to identify and test age-appropriate dietary assessment methods suitable for measuring change in eating behaviour (including change in the MD pattern of diet), as a consequence of lifestyle-based interventions. To fulfill these aims, INTAKE24, an online 24 hour dietary recall tool (Foster *et al.*, 2013) will be tested with people in the retirement transition. In addition, the project aims to identify and test a Mediterranean diet scoring system which is suitable for quantifying change in adherence to the MD following an intervention, such as that developed within the LiveWell Programme. This MDS will also be applied to dietary data collected during the testing of INTAKE24, to identify the compatibility of the two tools.

### *1.6.2 Overall aims*

This project has been designed to contribute to the LiveWell Programme's aims of testing and validating tools to measure dietary change in response to lifestyle-based interventions, for use with people within the peri-retirement window. This Ph.D. project has two main aims:

1. To investigate and test approaches for characterising and quantifying the Mediterranean dietary pattern.

2. To identify, test and validate tools which are suitable for measuring change in the diets of older adults participating in a Mediterranean dietary intervention.

### *1.6.3 Objectives*

To address these aims, this project will undertake the following objectives:

***Objective 1****:* To apply selected Mediterranean diet scores to a pre-existing dataset from a Mediterranean dietary intervention study.

***Objective 2:*** To assess the ability of these Mediterranean diet scores to quantify changes in adherence to the Mediterranean diet after an intervention.

***Objective 3:*** To propose one of these Mediterranean diet scores as suitable for use within an intervention study involving older adults, to assess change in the Mediterranean dietary pattern.

***Objective 4:*** To evaluate the usability of INTAKE24 as a method of computer-assisted dietary assessment with retirement-age participants.

***Objective 5:*** To determine the relative validity of INTAKE24 in assessing dietary intake and the adherence to a Mediterranean diet by adults in the peri-retirement window.

# Chapter 2 Assessment of Mediterranean Diet Scores

## 2.1 Introduction

For the past 20 years, *a priori* Mediterranean diet scores (MDS) have been the preferred method to measure adherence to a Mediterranean diet (MD). These scores group foods together, based on scientific knowledge of their effects on health and usually follow guidelines from a Mediterranean diet pyramid. Since the first MDS was composed by Trichopoulou *et al.* (1995), there has been a wealth of applications of MDS to dietary data and the development of new scores. Whilst the majority of MDS were designed to be applied to data collected by methods such as food frequency questionnaires (FFQs), some such as the Mediterranean Diet Adherence Screener Score (MEDAS) (Estruch *et al.*, 2006) remove the necessity of these tools to collect dietary data, as they were proposed as questionnaire-style scores (although they can equally be applied to data collected via dietary assessment tools if desired). The attraction of these types of scores is that they can be self-completed by participants and can provide a rapid assessment of adherence to the MD. However, the benefit of all MDS is that they can be applied to large studies with relative ease, using standardised scoring systems and they can be used to provide comparisons of MD adherence between groups of individuals.

However, most of the studies which have utilised MDS have been cross-sectional and cohort studies and, therefore, the ability of these scores to measure the impact of a MD intervention on adherence to the MD is not well documented. Furthermore, Mediterranean dietary interventions among people of retirement age are scarce (Lara *et al.*, 2014), thus highlighting the need for future MD intervention studies involving older adults.

This chapter describes the identification of published Mediterranean diet scores, the method used to reduce these to a smaller number and the subsequent testing of these selected scores with dietary data from a MD intervention study. The purpose of this work was to compare the ability of the selected MDS to assess adherence to a MD pre- and post-intervention, to determine which MDS is the most suitable for measuring dietary change following a MD intervention. The flow of work undertaken in this chapter is presented in Figure 2.1.

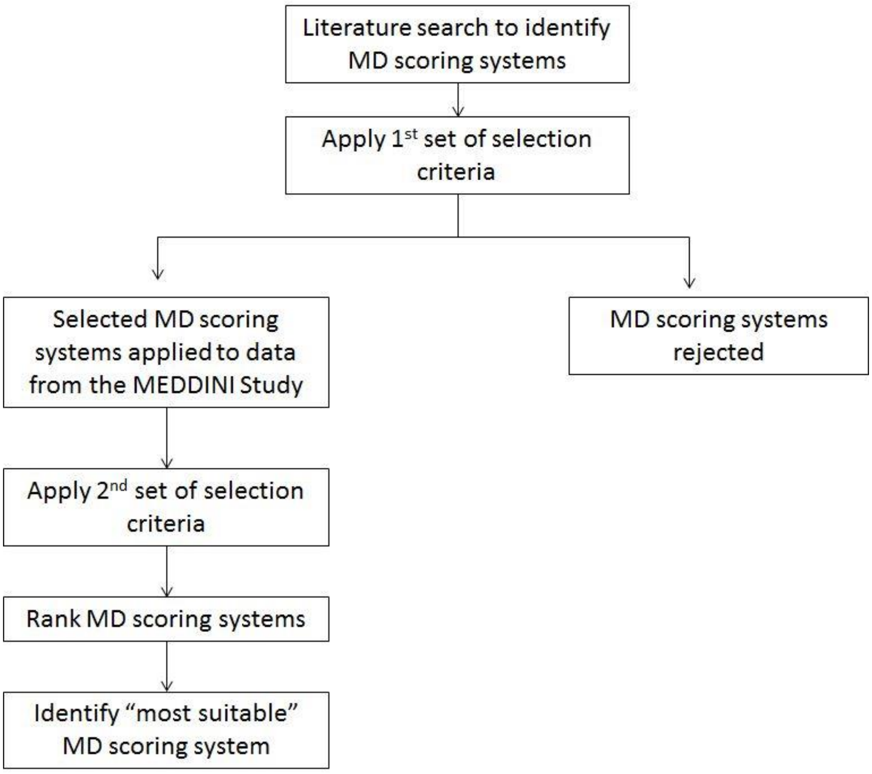



**Figure 2.1 Flow of work undertaken in Chapter 2**

### *2.1.1 Objective*

The two aims of this chapter were:

1. To investigate and test approaches for characterising and quantifying the Mediterranean dietary pattern.
2. To identify which tools are suitable for measuring change in diets of adults participating in a Mediterranean dietary intervention.

To fulfil these aims, the following objectives were developed:

1. To apply selected Mediterranean diet scores to a pre-existing dataset from a Mediterranean dietary intervention study.
2. To assess the ability of these scores to quantify changes in adherence to the Mediterranean diet after an intervention.

3. To propose one of these Mediterranean diet scores as suitable for use within an intervention study involving older adults, to assess change in the Mediterranean dietary pattern.

## 2.2 Identification of Mediterranean diet scores and selection of scores to test with dietary data

### *2.2.1 Identification and classification of Mediterranean diet scores*

A literature review was conducted to identify published MDS. In July 2012, Scopus, the largest online database of peer-reviewed literature (Elsevier, 2015), was searched from inception. A search strategy was produced, combining keywords from three concepts: i) Mediterranean diet ii) scores and iii) development of these MDS. The following search terms were used: ("med* diet*" OR "med* diet* pattern*" OR "med* food* pattern*") AND (score* OR index* OR indices OR adherence) AND (develop* OR creat* OR valid*). Papers were limited to English. An alert was set up within Scopus to email the researcher monthly of any new publications fitting these search criteria.

To ascertain which papers returned from the literature review described the development of original Mediterranean diet scores and to evaluate how the scores were composed, a quality assessment form was created and completed for 26 MDS described in 58 papers (see Appendix B). These scores were divided into two groups, which were categorised as "parent" and "offspring" Mediterranean diet scores, depending on whether the scores were unique or whether they were modifications of pre-existing scores. Figure 2.2 shows the relationships between the MDS. Those with arrows pointing towards them are offspring scores, modified from the parent score to which they are linked. Scores which are not linked to another are parent scores which have not since been adapted (although the majority of these have since been used, either by the authors of the scores, or by different research groups).

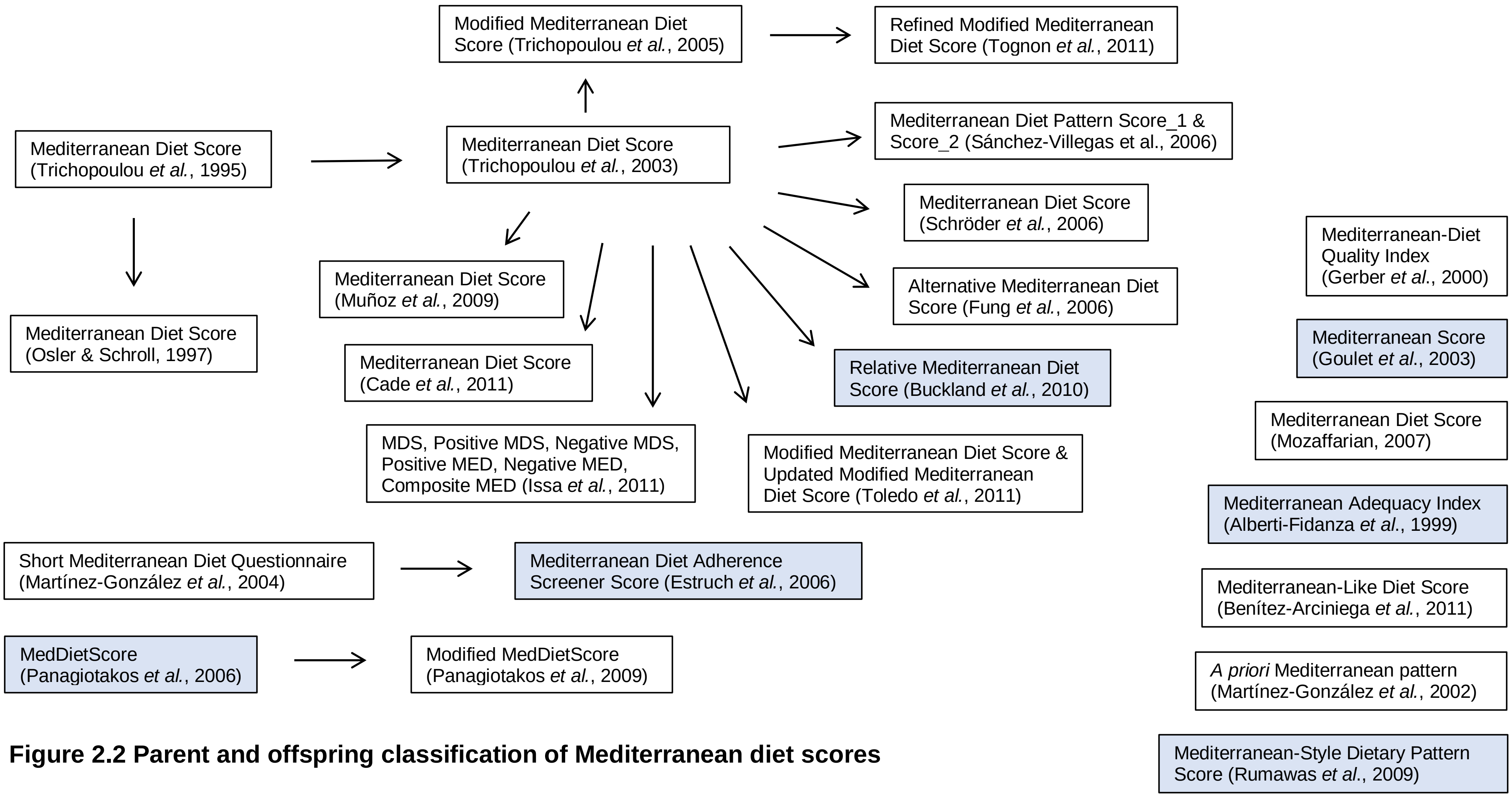



**Figure 2.2 Parent and offspring classification of Mediterranean diet scores**

Parent scores = arrow (or no arrow) pointing away from them. Offspring scores = arrow pointing towards them. Highlighted scores were chosen for testing with dietary data.

### *2.2.2 Selection of Mediterranean diet scores to test*

To achieve objective one of this chapter, it was decided that six Mediterranean scores would be selected. These top six scores were chosen on the basis of 10 selection criteria, including ability of a score to detect small changes in diet after a MD intervention (see Appendix C). The rationale for these criteria is provided in Appendix D. Each criterion was allocated 0-3 points, resulting in a maximum score of 30. The scores for the "parent" MDS are shown in Table 2.1 and for the "offspring" MDS in Table 2.2. The six highest achieving MDS (highlighted in Figure 2.2) were the Mediterranean Adequacy Index (MAI) (Alberti-Fidanza *et al.*, 1999), Mediterranean Score (Goulet *et al.*, 2003), Mediterranean-Style Dietary Pattern Score (MSDPS) (Rumawas *et al.*, 2009), Relative Mediterranean Diet Score (rMED) (Buckland *et al.*, 2010), Mediterranean Diet Adherence Screener Score (MEDAS) (Estruch *et al.*, 2006) and the MedDietScore (Panagiotakos *et al.*, 2006b).

**Table 2.1 Selection criteria points awarded to parent Mediterranean diet scores**

| Author | Mediterranean Diet Score Name | Total Points* |
|---|---|---:|
| Alberti-Fidanza *et al.* (1999) | Mediterranean Adequacy Index (MAI) | 25 |
| Benítez-Arciniega *et al.* (2011) | Mediterranean-Like Diet Score (MLDS) | 16 |
| Gerber *et al.* (2000) | Mediterranean Diet Quality Index (Med-DQI) | 15 |
| Goulet *et al.* (2003) | Mediterranean Score | 21 |
| Martínez-González *et al.* (2002) | Mediterranean Pattern (*a priori* score) | 15 |
| Martínez-González *et al.* (2004) | Short Mediterranean-diet questionnaire | 12 |
| Mozaffarian *et al.* (2007) | Mediterranean Diet Score | 11 |
| Panagiotakos *et al.* (2006b) | MedDietScore | 18 |
| Rumawas *et al*. (2009) | Mediterranean-Style Dietary Pattern Score (MSDPS) | 20 |
| Trichopoulou *et al*. (1995) | Mediterranean Diet Score (MDS) | 12 |

* Maximum possible score was 30

**Table 2.2 Selection criteria points awarded to offspring Mediterranean diet scores**

| Author | Mediterranean Diet Score Name | Total Points* |
|---|---|---|
| Buckland *et al.* (2010) | Relative Mediterranean Diet Score (rMED) | 19 |
| Cade *et al.* (2011) | Mediterranean Diet Score | 12 |
| Estruch *et al.* (2006) | Mediterranean Diet Adherence Screener Score (MEDAS) | 19 |
| Fung *et al.* (2005) | Alternate Mediterranean Diet Score (aMED) | 15 |
| Issa *et al.* (2011) | MDS, Positive MDS, Negative MDS, Positive MED, Negative MED Composite MED | 13 |
| Muñoz *et al.* (2009) | Mediterranean Diet Score (MDS) | 11 |
| Osler and Schroll (1997) | Mediterranean Diet Score | 13 |
| Panagiotakos *et al.* (2009) | Modified MedDietScore | 14 |
| Sánchez-Villegas *et al*. (2006) | Mediterranean Dietary Pattern Score_1 | 13 |
| Sánchez-Villegas *et al*. (2006) | Mediterranean Dietary Pattern Score_2 | 10 |
| Schröder *et al*. (2006) | Mediterranean Diet Score (MDS) | 13 |
| Tognon *et al.* (2011) | Refined Modified Mediterranean Diet Score (refined mMDS) | 13 |
| Toledo *et al.* (2010) | Modified Mediterranean Diet Score (MMDS) | 11 |
| Toledo *et al.* (2010) | Updated Modified Mediterranean Diet Score (UMMDS) | 14 |
| Trichopoulou *et al.* (2003) | Mediterranean Diet Score (MDS) | 17 |
| Trichopoulou *et al.* (2005) | Modified Mediterranean Diet Score (modified MDS) | 17 |

* Maximum possible score was 30

### *2.2.3 Calculation of the chosen Mediterranean diet scores*

The food groups belonging to each of the six chosen MDS and the range of points in their scores are included in Table 2.3. Although each MDS is comprised of a list of different food groups, there are some similarities between them. For example, olive oil, fruit, vegetables, legumes, vegetables, fish, meat and dairy products are included in all six scores. However, there are subtle differences between the foods included in these groups (e.g. the MAI and rMED only include fresh fruit in their fruit food group, but the remaining four scores include dried and tinned fruit in their fruit food groups). Some food groups are also unique to a particular score, such as sofrito (a tomato-based sauce) which features in the MEDAS. Furthermore, the MSDPS is the only score to consider the whole diet, whereby foods that are consumed which cannot be categorised in to the Mediterranean food groups are categorised as non-Mediterranean foods.

The way in which food groups are calculated (and the range in points) also differs between the scores. The MAI and rMED calculate intakes of food groups as a proportion of the total daily energy intake, whilst the Mediterranean Score, MSDPS, MedDietScore and MEDAS are calculated according to daily, weekly or monthly food frequencies. The recommended intakes of the food groups featured in each MDS also differs. For example, the MedDietScore awards the maximum number of points for the poultry food group if it is never consumed, whereas the MSDPS and the Mediterranean Score award the maximum number of points available for the poultry group if it is consumed four times or three times per week, respectively. The calculation of all six MDS is included in Appendix E.

**Table 2.3 Food groups and range of points in the chosen Mediterranean diet scores**

| Mediterranean Diet Score | | | | | |
|---|---|---|---|---|---|
| MAI (0 - >100 points) | rMED (0 - 18 points) | Mediterranean Score (0 - 44 points) | MSDPS (0 - 100 points) | MEDAS (0 - 14 points) | MedDietScore (0 - 55 points) |
| Bread | Cereals | Wholegrains | Wholegrains | Legumes | Wholegrains |
| Cereals | Legumes | Legumes, nuts & seeds | Olives, legumes & nuts | Vegetables | Legumes |
| Legumes | Vegetables | Vegetables | Vegetables | Fruit | Vegetables |
| Vegetables | Fruit, nuts & seeds | Fruit | Fruit | Fish | Fruit |
| Fresh fruit | Fresh fish | Fish | Fish | Olive oil | Fish |
| Fish | Olive oil | Olive oil, olives & olive oil margarine | Olive oil | Wine | Olive oil |
| Vegetable oils | Alcohol | Red & processed meat | Wine | Red & processed meat | Alcohol |
| Wine | Total meat | Poultry | Meat | Preference of poultry over red meat | Potatoes |
| Meat | Dairy products | Dairy products | Poultry | Butter, margarine & cream | Red meat & products |
| Milk | | Eggs | Dairy | Sweet & carbonated beverages | Poultry |
| Cheese | | Sweets | Eggs | Commercial sweets & pastries | Full fat dairy products |
| Animal fats & margarine | | | Potatoes | | |
| Eggs | | | Sweets | | |
| Potatoes | | | | | |

| Mediterranean Diet Score | | | | | |
|---|---|---|---|---|---|
| MAI (0 - >100 points) | rMED (0 - 18 points) | Mediterranean Score (0 - 44 points) | MSDPS (0 - 100 points) | MEDAS (0 - 14 points) | MedDietScore (0 - 55 points) |
| Nuts<br>Sweet beverages<br>Cakes, pies & cookies<br>Sugar | | | Non-MD foods: all other foods consumed which do not fit into the above categories | Nuts<br>Sofrito sauce | |

## 2.3 Testing Mediterranean diet scores with MEDDINI study data

### *2.3.1 The MEDDINI study*

The Mediterranean Diet in Northern Ireland (MEDDINI) study is a pilot randomised controlled, parallel group trial, which aimed to determine whether coronary heart disease (CHD) patients from Belfast, Northern Ireland, would adopt and maintain a MD, and to assess the effectiveness of different methods aimed at improving compliance (Logan *et al.*, 2010). Sixty one participants were recruited between December 2004 and December 2005 from the Royal Victoria Hospital, Belfast, who received a diagnosis of myocardial infarction or unstable angina within four weeks of enrolment. Participants were randomised to one of three treatment groups: either conventional dietetic advice (CDA) for CHD; advice to implement a MD using nutritional counselling (MDNC); or advice to implement a MD using behavioural counselling (MDBC). The dietary advice given to participants in all treatment groups was provided by the same research dietitian, to avoid inter-investigator bias. Participants were assessed at baseline, after 6 months and, for a subset of the sample (n=36), at 12 months. The MEDDINI study data were collected between 2004 and 2006. All data analysed in the present study were obtained via a collaboration with Professor Jayne Woodside from Queen’s University Belfast.

### *2.3.2 Dietary interventions*

#### *2.3.2.1 Conventional dietetic advice group*

This was considered the control group of the study. Participants received the same dietary advice as was current practice during hospital admission, in the form of a diet sheet. This included general advice to adopt a low-fat, cardioprotective diet, such as to replace saturated fats with mono- or polyunsaturated fats, to increase oily fish intake to two or three portions per week and to increase consumption of wholegrain cereals. Advice was delivered by the research dietitian at baseline, with no further contact until follow up assessment at six and 12 months (Logan *et al.*, 2010).

#### *2.3.2.2 Mediterranean diet using nutritional counselling*

Participants in both experimental groups were encouraged to adopt a Mediterranean diet similar to that developed by de Lorgeril *et al.* (1994). This included advice to consume seven to 10 daily portions of fruit and vegetables, to increase intakes of whole grains and fish (four portions per week, with two to three portions from oily fish), and to reduce intakes of meat to once a week, replacing red meat with poultry. Butter and cream should be substituted with an olive-based margarine and olive and rapeseed oils should be used exclusively. Moderate wine consumption with meals and snacking on unsalted nuts were also advised (Logan *et al.*, 2010).

Those randomised to the MDNC group received a diet sheet which not only included the dietary advice and information on the MD, but also its potential health benefits, recipe suggestions and a sample meal plan. The research dietitian conducted home visits at week one and months one, two and four. Participants could also telephone the research dietitian for further advice during the course of the study (Logan *et al.*, 2010).

#### *2.3.2.3 Mediterranean diet using behavioural counselling*

Participants in this group received the same diet sheet as those in the MDNC treatment group. They also had the same number of home visits and the opportunity to contact the research dietitian. Additionally, behavioural counselling was used to deliver the dietary intervention, which was based on methods of encouraging behaviour change that are dependent on an individual's motivational readiness. Each intervention was personalised to the individual, with tailored advice to setting short and long term goals based on their readiness to adopt a MD. A "Help to Change" booklet was also provided which included a list of common barriers to change and suggestions to overcome these (Logan *et al.*, 2010).

### *2.3.3 Data collection during the MEDDINI study*

#### *2.3.3.1 Food frequency questionnaires*

Habitual dietary intake was measured using a 130-item food frequency questionnaire (FFQ) validated for the UK population from the European Prospective Investigation into Cancer and Nutrition (EPIC) study (Bingham *et al.*, 2001) at baseline, 6 months and 12 months follow up. Two food items ("Monounsaturated reduced fat spread, e.g. Bertolli" and "Monounsaturated low fat spread, e.g. Golden Olive") were added to the FFQ, to measure adherence to the advice to substitute butter and cream with olive-based margarines given to participants randomised to the MDNC and MDBC interventions. For each item in the FFQ, participants were asked to indicate their usual intake (over the preceding year at baseline and over the previous six months at follow-up assessments), by choosing one of nine frequency categories. These categories ranged from "never or less than once/ month" to "6 times per day". An average portion size was assigned to each food item, unless specified as units (e.g. one biscuit) or household measures (e.g. one glass). A second part to the FFQ included additional questions on the type and brand of breakfast cereal, type of fat used during cooking, the amount of visible fat on meat and the type and quantity of milk consumed.

#### *2.3.3.2 Diet histories*

In addition to the food frequency questionnaires, participants were asked to complete seven-day diet histories at baseline, six month and 12 month appointments with the research dietitian. All foods and drinks were recalled for seven consecutive days, from midnight to midnight, including portion sizes, additions such as condiments and preparation or cooking methods.

#### *2.3.3.3 Assessment of sociodemographics and health status*

Baseline demographic information including gender, age and smoking status was recorded. Participants were defined as non-smokers if they had stopped smoking prior to hospital admission. Weight and height were measured at each time point to calculate change in BMI, which is defined as weight (kg)/height ($m^2$).

### 2.3.4 Methodology of MEDDINI study data analysis

#### 2.3.4.1 Modification of an FFQ database

To date, the dietary data from the MEDDINI Study which are used in this chapter had not been analysed. Moreover, the FFQs had not been entered into a database to produce a nutrient output, so the original paper-based FFQs completed by the MEDDINI participants were shipped from Queen's University Belfast to Newcastle University. A Microsoft Access database built for the analysis of the EPIC-FFQ used in the Newcastle 85+ study (Adamson *et al.*, 2009) was used to analyse the MEDDINI FFQs. This database was adapted by adding 15 new food items from part one (the main food list) of the MEDDINI FFQs. The average portion sizes of food items in the database were based on those consumed by participants of the Family Food and Health Project (Curtis *et al.*, 2012). Each food item within the FFQ was included in a food group within the database. For example, the FFQ food item "wholemeal bread and rolls" encompassed wholemeal bread, toasted wholemeal bread and wholemeal rolls within the database. The average portion size and nutrient composition of each FFQ food item was weighted proportionally according to the frequency of consumption and mean portion size of the sub-group food items that were consumed in the Family Food and Health Project. To calculate the overall average portion size of an FFQ item (e.g. wholemeal bread and rolls), the frequency of consumption of each sub-group food item (e.g. wholemeal bread) was multiplied by its average portion size. These were then summed and divided by the total frequency of consumption of all sub-group food items.

For the foods that were added to the database (such as "Ready-made cakes, e.g. fruit, sponge"), nutrient compositions and average portion sizes were copied from very similar items which already existed in the database (e.g. "Cakes"). This method was applied to eight of the 15 new foods. Where similar items did not pre-exist in the database (e.g. "Monounsaturated low fat spread, e.g. Golden Olive"), their nutrient compositions were identified from corresponding items (e.g. “Low fat spread, not PUFA, olive”) in the Public Health England and Food Standards Agency’s (FSA) UK Nutrient Databank (NatCen Social Research *et al.*, 2015), used in all of the National Diet and Nutrition Surveys (NDNS). These were then cross-referenced with the average portion sizes and frequencies of consumption by the 19-64 year olds participating in the NDNS (Henderson *et al.*, 2002) and the same method of proportionally weighting these was used to find an average portion size for each of the 15 items added to the database. An exception to this rule was for crispbreads, as the FFQ stated that one serving equated to one crispbread. In this instance, the average portion size was derived from the average weight of six types of crispbreads in a food portion size reference book (Foods Standards Agency, 2002) and equal weighting was given to corresponding food items from the NDNS nutrient databank.

Data on milk consumption were also added to the database, as milk contributed to food groups within the chosen Mediterranean diet scores to test and the database did not previously incorporate this information. Information on milk was collected in part two of the FFQ, by two questions for the type of milk consumed and the daily quantity, measured in fractions of pints. Where the type of milk consumed was not included in the list to choose from, there was a space for participants to write it in. Only one participant consumed a type of milk not included as an option (one percent milk) and the decision was taken not to add it to the database, due to the time taken to make amendments outweighing the relatively small contribution of milk to overall food intake by the participant.

The nutrient composition of each type of milk was derived from the NDNS nutrient databank. The quantities of milk were converted from pints to grams. For the option of more than one pint of milk consumed per day, the mean consumption was calculated from the NDNS (Henderson *et al.*, 2002) for those consuming more than 568g per day. A table containing the names of all foods added to the database and the sources of their nutrient compositions and average portion sizes is included in Appendix F.

### *2.3.4.2 Data entry of the MEDDINI FFQs*

The data from the paper-based FFQs were entered into the modified database, using a tick-box method. Whilst entering the FFQs, assumptions were made based on missing data or mistakes made by participants completing the questionnaires, to ensure a full dataset. Where participants had not selected a food frequency, a response of "never" was chosen. Occasionally participants would make mistakes by selecting two food frequencies for a single item and then omit a frequency for the next food in the list. As it was uncertain which tick was intended for which food item, a standard operating procedure was developed. The entry with missing data was coded as never consumed, whereas one of two methods was chosen for the food item with two frequencies. The median frequency was selected when there was an odd number of food frequency boxes between the two responses, whilst a conservative approach was taken to select the lowest frequency when there was an even number of, or no, frequency boxes between the two responses.

In three FFQs, participants selected using more than one type of milk and in six FFQs, participants selected using more than one type of fat in part two of the questionnaire, when only one answer was required on the most regularly used type. In this instance, the responses from the same participant's other two FFQs were referred to (preferably their response from the previous FFQ), to decide which type of milk or fat was most likely to be consumed.

In the second section of the FFQ, participants were also asked to handwrite any foods consumed once a week or more that did not fall into any of the food categories previously mentioned in the 132-item list. Details on brands, food names, the number of times the foods were consumed per week and average portion sizes were requested. Nineteen participants answered this question in 23 FFQs. Of the 40 food items reported in this section, 18 foods were excluded from being added to the database, due to insufficient information (i.e. missing food frequencies and portion sizes and vague food descriptions), or they provided little contribution to the overall nutrient intake of participants (e.g. seeds). The remaining 22 foods reported by participants featured within the food list in the previous section of the FFQ. These were categorised according to the relevant food items within the list and the weekly number of portions merged with the responses previously given to the corresponding foods, to produce a recalculation of food frequencies. Therefore, no new foods derived from the “other foods” section of the FFQ were added to the database.

Data entry of the FFQs was checked by a second observer unrelated to this project. Ten percent of the sample was chosen for checking, equating to 14 FFQs, by selecting every tenth FFQ according to the chronological order of participant ID numbers. Two errors in two FFQs were identified and amended. Since this represented an error rate of less than 1% in the whole sample (assuming the same rate of errors in all FFQs), a decision was made not to check the remaining FFQs for data entry errors.

#### *2.3.4.3 Application of Mediterranean diet scores to dietary data*

FFQ data entered into the Access database were exported to Microsoft Excel. The output included information on participant ID numbers and the time point and food items were expressed as daily intakes expressed as grams, energy and frequency of consumption. A pivot table was produced to alter the order of data in the file and this was exported to SPSS statistical software (version 21, IBM, USA) for analysis. Food items from the FFQs were categorised into the food groups which featured in each of the six Mediterranean diet scores chosen for testing. To ensure accuracy in this task, the authors of the papers describing all six scores were contacted. Every author replied and provided guidance on the food groupings used in the derivation of their scores.

The MAI, Mediterranean Score, MSDPS and MedDietScore required refined breakfast cereals to be excluded from their cereals food groups. Whilst the FFQ contained a question on porridge intakes which could contribute to wholegrain intake, refined and wholegrain breakfast cereals were included within a single food item. Information on the type and brand of breakfast cereal was asked for later in part two of the FFQ. A number of assumptions were made based on their responses. Participants who specified only one type of breakfast cereal in part two were assumed to be sole consumers of either refined or whole grains in the preceding period. When both refined and wholegrain breakfast cereals were specified, the daily output was halved to provide an estimated contribution of whole grain breakfast cereal to the cereals food group within a score. For those who indicated consuming breakfast cereals but did not later specify the type and brand, they were assumed to have just consumed refined grains.

The Mediterranean Score, MSDPS and MedDietScore calculate milk consumption based on frequencies. As the FFQs collected data on the type and total daily intake of milk only, a proxy measurement of frequency was derived from the sum of frequencies of foods containing or consumed with milk. These included hot beverages, breakfast cereals and porridge.

Assumptions were also made to calculate alcohol intake. The FFQ's food items measuring alcohol consumption were "wine", "beer, lager or cider", "port, sherry, vermouth, liqueurs" and "spirits". The Mediterranean Score was the only score not to include alcohol as a food group, whist the other scores calculated it by the type of beverage (either wine or all alcoholic beverages) and either by contribution to energy intake or by grams consumed. The rMED was unique in calculating total alcohol intake by grams of ethanol consumed. As alcohol was not included in the nutrient output from the database, this was calculated from the NDNS nutrient databank, by calculating the mean ethanol content of foods matching those in the FFQ per 100g and multiplying by each individual's daily portion size.

The Mediterranean diet pyramid advises a limited intake of meat and considers poultry more favourably than red meat. Whilst all the MDS included meat groups and assigned higher points to restricted intakes, MEDAS was the only score to specifically measure the preference of poultry over red meat. This was not a question in the MEDDINI FFQs, so it was assumed that individuals preferred poultry if their reported intake of poultry was higher than that of red meat.

As not all components of every Mediterranean diet score could be calculated from the FFQs, data from the seven-day diet histories were used, so as not to exclude food groups from the scores and, in turn, alter the scoring systems of the MDS. Information on the use of vegetable oil, olive oil, olives and sofrito (tomato-based) sauce was derived from the diet histories. Although these foods had not been previously analysed, they had been entered into WISP nutritional analysis software (Tinuviel Software, 2014) by the MEDDINI study team to produce nutrient outputs. As this software is not used at Newcastle University, the data were delivered to Newcastle University in the form of an Excel file, accompanied by a printed copy of all the food codes and their food names that are incorporated into the WISP software. Using the accompanying print out, WISP food codes corresponding to vegetable and olive oils, olives and tomato-based sauces were identified and then matched with intakes from the diet histories data file. Data were then manipulated to provide daily dietary intake expressed as the same variables as those from the database.

Once all the assumptions had been made and the dataset was complete, daily intakes of food items categorised into food groups within a score were summed to provide the total daily intake of each food group. Data were then manipulated, according to instructions of each MDS, to produce a score for each participant at each time point. The SPSS output produced from calculating the MDS was then checked for errors by a colleague unrelated to the project. Only one mistake was found in the output from one score and this was amended and the score recalculated.

#### *2.3.4.4 Participant characteristics*

Baseline participant characteristics were analysed in SPSS statistical software (version 22; IBM, USA). One-way analysis of variance (ANOVA) was used to test for differences between treatment groups in the continuous variables age and BMI. Chi-square was used to test for differences between groups in the categorical variables gender and smoking status.

### 2.3.4.5 Comparison of Mediterranean diet scores

As the second aim of this chapter was to identify which MDS were most suitable for measuring changes in diet in response to an intervention, the MDS produced from the MEDDINI data were analysed for between-group effects. To identify whether participant adherence to a Mediterranean diet was similar between groups before treatment, one-way Analysis of Variance (ANOVA) was used to test for differences in baseline values of the MDS. Orthogonal contrast was used in Stata statistical software (version 13.1; StataCorp, Texas, USA) to analyse differences in MDS between groups at 6 months follow up and at 12 months follow up, with baseline values added as a covariate. Within this analysis, differences in scores were compared between the control CDA group and both MDNC and MDBC intervention groups and then for between-intervention differences in the MDNC and MDBC groups. Clustered boxplots were generated in SPSS to view the range in MDS scores by intervention group and time point.

Whilst the main focus of the analysis was to identify between-group effects on dietary change, further analyses were conducted to measure within-group effects. Paired sample t-tests were used to identify differences in the mean scores of each treatment group between baseline and 6 months and baseline and 12 months (calculated at 6 months or 12 months follow up minus baseline values). Scatterplots were also prepared, to view dietary change over time for each individual.

### 2.3.4.6 Identification of a suitable Mediterranean diet score to use in intervention studies

A second set of selection criteria were produced to help identify the most suitable Mediterranean diet score to use for future testing. These criteria were:

1. The coefficient of variation (CV) of the MDS;
2. The percentage change in MDS from baseline to 6 and 12 months, and
3. The number of assumptions that were made to calculate each score.

All three criteria were assigned points that were ranked according to how well the scores performed in comparison with each other. These points were summed and the MDS which received the most points was recognised as the most suitable Mediterranean diet score.

This coefficient of variation (CV) of each score was calculated for the three treatment groups at each time point, by dividing the standard deviation by the group mean and multiplying by 100. This percentage of variation in scores was compared between time points. A lower coefficient of variation indicates that the diets of individual participants are more similar to each other than if the coefficient of variation was larger. Therefore, the score which had the greatest reduction in the coefficient of variation between baseline and 6 months or baseline and 12 months was ranked first and awarded the most points. MDS were assigned 0-5 points at each time point, providing a total possible score of 10 points for this criterion.

Differences in the percentage change in scores from baseline to 6 months and from baseline to 12 months were analysed using one-way ANOVA. As each score is calculated differently, with variation in their range of points, the percentage change between intervention groups over time was calculated to offer a direct comparison. Again the scores were ranked, with the smallest p-value given the highest rank and awarded the maximum points. Similarly to the previous criterion, MDS were assigned 0-5 points at both time points, to produce a maximum score of 10 points.

The FFQ data collected in the MEDDINI study did not directly match the calculation of the MDS. Therefore, a number of assumptions were made and data incorporated from other sources to be able to produce the scores. By calculating scores in this way, the MDS produced by this study may produce different results than if they were calculated in the way in which they were composed by the authors. Therefore, a score which has been calculated making the least number of assumptions will be the most accurate in reference to its true calculation. This was considered the most important criterion in recommending a MDS to use in future and so it was awarded twice as many points as those offered at each time point by the other two criteria (0-10 points, with 30 points as the total number of points available). Again, MDS were ranked in order of the number of assumptions made in their calculation and the score with the least number of assumptions was awarded the maximum number of points available. In the occurrence that more than one MDS were calculated using the same number of assumptions, a mean of the points available for corresponding ranks was used.

### *2.3.5 Results*

#### *2.3.5.1 Participant flow and characteristics*

Sixty one participants were recruited to the MEDDINI study and randomised into one of three treatment groups. Three people were excluded due to ineligibility after changes were made to their treatment plans. Of the remaining 58 participants who completed a baseline assessment (Logan *et al.*, 2010), eight participants were excluded from the current analysis, due to a lack of data and inability to compare dietary changes over time (one person did not complete any FFQs and seven people completed the baseline FFQ only). Data from 50 participants at baseline, 49 participants at 6 months follow up and 34 participants at 12 months follow up were included in the present analysis.

Participants taking part in the study were aged between 39 and 77 years, with the mean age being 56.5 years. The majority were male (82%) and overweight, with a mean BMI of 30.2 kg/m$^2$. Twenty two percent of participants were current smokers at baseline. These characteristics are shown in Table 2.4. No significant differences were found between intervention groups at baseline.

**Table 2.4 Comparison of baseline participant characteristics by intervention group**

| Characteristic | Intervention Group<br>CDA (n=15) Mean (SD) | MDNC (n=20) Mean (SD) | MDBC (n=15) Mean (SD) | p-value |
|---|---|---|---|---|
| Age (years) | 55.1 (10.8) | 58.2 (7.6) | 55.7 (7.3) | 0.53 |
| Gender: male (%) | 80 | 80 | 86.7 | 0.85 |
| BMI (kg/m$^2$) | 28.9 (5.50) | 31.9 (5.8) | 29.4 (6.1) | 0.26 |
| Smoking status: smoker (%) | 20 | 20 | 26.7 | 0.87 |

CDA – Conventional Dietetic Advice

MDNC – Mediterranean Diet intervention using Nutritional Counselling

MDBC – Mediterranean Diet intervention using Behavioural Counselling

SD – Standard Deviation

p-value for age and BMI corresponds to one-way ANOVA using the General Linear Model

p-value for gender and smoking status corresponds to Chi-square

#### *2.3.5.2 Comparison of Mediterranean diet scores*

The points awarded by each Mediterranean diet scoring system to the diets of participants at baseline were analysed using one-way ANOVA. Significant differences were found between intervention groups for the rMED and MSDPS scores. When the mean scores produced by MSDPS were adjusted using the Bonferroni correction, the differences between the CDA group and the MDBC group were no longer significant (p=0.06). However, when the same adjustment was applied to rMED scores, the differences between the CDA group and the MDNC group retained the same level of significance (p=0.01). Between-group comparisons of baseline MDS are shown in Table 2.5.

**Table 2.5 Comparison of baseline Mediterranean diet scores by intervention group**

| | Intervention Group | | | |
|---|---|---|---|---|
| Characteristic | CDA (n=15) Mean (SE) | MDNC (n=20) Mean (SE) | MDBC (n=15) Mean (SE) | p-value |
| MAI (max score >100) | 0.81 (0.14) | 1.20 (0.12) | 0.97 (0.14) | 0.11 |
| rMED (max score 18) | 6.67* (0.70) | 9.55* (0.61) | 8.20 (0.70) | 0.01 |
| Mediterranean Score (max score 44) | 16.80 (1.29) | 18.75 (1.11) | 20.07 (1.29) | 0.21 |
| MSDPS (max score 100) | 15.44 (2.30) | 21.57 (1.20) | 23.31 (2.30) | 0.04 |
| MEDAS (max score 14) | 4.13 (0.46) | 5.05 (0.39) | 4.40 (0.46) | 0.29 |
| MedDietScore (max score 55) | 29.60 (1.43) | 32.15 (1.24) | 31.60 (1.43) | 0.39 |

CDA – Conventional Dietetic Advice
MDNC – Mediterranean Diet intervention using Nutritional Counselling
MDBC – Mediterranean Diet intervention using Behavioural Counselling
SE – Standard Error
p-value corresponds to one-way ANOVA using the General Linear Model
(*) p-value <0.05 by Bonferroni adjustment for multiple comparisons

Orthogonal contrast analysis was used to investigate the effects of the type of intervention on each MDS at 6 and 12 months follow up, using baseline values as a covariate. This was conducted in two stages: to compare differences in MDS between the CDA control group and both intervention groups (Contrast 1); and to compare differences in MDS between the two MDNC and MDBC interventions (Contrast 2). At 6 months follow up (results shown in Table 2.6), although the scores produced by all MDS appeared to be higher for those randomised to MDNC and MDBC, only the Mediterranean Score produced a significant difference between the control group and both intervention groups, with higher points awarded to the intervention groups. At 12 months follow up, no significant differences were observed between intervention groups (results shown in Table 2.6). Clustered boxplots displaying the mean and range of MDS, split by intervention group and time point, are included in Appendix G.

**Table 2.6 Adjusted mean Mediterranean diet scores by intervention groups at 6 months follow up**

| Mediterranean Diet Score | Intervention | | | p-value | |
|---|---|---|---|---|---|
| | CDA (n=14) Marginal Mean (Standard Error) | MDNC (n=20) Marginal Mean (Standard Error) | MDBC (n=15) Marginal Mean (Standard Error) | CDA vs. MDNC + MDBC | MDNC vs. MDBC |
| MAI | 1.63 (0.27) | 1.80 (0.23) | 1.85 (0.26) | 0.56 | 0.88 |
| rMED | 7.93 (0.76) | 8.55 (0.63) | 8.67 (0.69) | 0.47 | 0.90 |
| Mediterranean Score | 21.02 (1.25) | 25.47 (1.03) | 24.36 (1.20) | 0.01* | 0.49 |
| MSDPS | 24.77 (2.28) | 29.34 (1.83) | 28.83 (2.14) | 0.12 | 0.85 |
| MedDietScore | 34.21 (1.21) | 34.82 (1.00) | 34.71 (1.15) | 0.70 | 0.94 |
| MEDAS | 5.43 (0.51) | 6.54 (0.43) | 6.41 (0.49) | 0.09 | 0.86 |

CDA – Conventional Dietetic Advice

MDNC – Mediterranean Diet intervention using Nutritional Counselling

MDBC – Mediterranean Diet intervention using Behavioural Counselling

p-value corresponds to one-way ANOVA using orthogonal contrast, with adjustment for baseline Mediterranean diet scores

(*) p-value <0.05

**Table 2.7 Adjusted mean Mediterranean diet scores between intervention groups at 12 months follow up**

| Mediterranean Diet Score | Intervention | | | p-value | |
|---|---|---|---|---|---|
| | CDA (n=12) Marginal Mean (Standard Error) | MDNC (n=13) Marginal Mean (Standard Error) | MDBC (n=9) Marginal Mean (Standard Error) | CDA vs. MDNC + MDBC | MDNC vs. MDBC |
| MAI | 1.53 (0.31) | 1.44 (0.29) | 1.75 (0.34) | 0.93 | 0.49 |
| rMED | 8.49 (0.88) | 8.70 (0.85) | 7.55 (0.96) | 0.82 | 0.38 |
| Mediterranean Score | 21.35 (1.51) | 22.89 (1.43) | 23.69 (1.74) | 0.33 | 0.73 |
| MSDPS | 24.79 (2.94) | 28.26 (2.73) | 25.64 (3.32) | 0.53 | 0.54 |
| MedDietScore | 33.80 (1.56) | 33.86 (1.48) | 31.93 (1.74) | 0.71 | 0.40 |
| MEDAS | 5.61 (0.55) | 5.57 (0.52) | 6.03 (0.61) | 0.83 | 0.57 |

CDA – Conventional Dietetic Advice

MDNC – Mediterranean Diet intervention using Nutritional Counselling

MDBC – Mediterranean Diet intervention using Behavioural Counselling

p-value corresponds to one-way ANOVA using orthogonal contrast, with adjustment for baseline Mediterranean diet scores

Whilst only one significant difference was observed between intervention groups in the orthogonal contrast analysis, paired sample t-tests were used to investigate whether the mean adherence to a Mediterranean diet within each treatment group improved between baseline and 6 or 12 months (results are presented as 6 or 12 months follow up minus baseline values). There were significant within-group differences between baseline and 6 months follow up for all MDS, except for the rMED (for all three treatment groups) and the MEDAS for the control group (see Table 2.8).

When the differences in mean MDS between baseline and 12 months were analysed, the five scores retained significance (again, no differences were found in the rMED). However, the Mediterranean Score was the only MDS to have significant differences in the score within all three treatment groups (see Table 2.9). Furthermore, more significant differences between baseline and 12 months follow up were found for the control group than for either MD intervention groups.

**Table 2.8 Within-group differences in mean Mediterranean diet scores between baseline and 6 months follow up**

| Mediterranean Diet Score | Intervention | | | | | |
|---|---|---|---|---|---|---|
| | CDA (n=14) | | MDNC (n=20) | | MDBC (n=15) | |
| | Mean Difference (SD) | p-value | Mean Difference (SD) | p-value | Mean Difference (SD) | p-value |
| MAI | 0.62 (0.45) | <0.001** | 0.77 (1.16) | 0.01* | 0.83 (1.07) | 0.01* |
| rMED | 0.21 (2.42) | 0.75 | -0.20 (2.90) | 0.76 | 0.40 (3.07) | 0.62 |
| Mediterranean Score | 3.86 (4.62) | 0.01* | 6.75 (6.41) | <0.001** | 4.60 (6.65) | 0.02* |
| MSDPS | 7.32 (9.05) | 0.01* | 8.34 (9.55) | 0.001* | 6.86 (9.77) | 0.02* |
| MedDietScore | 3.79 (5.41) | 0.02* | 3.20 (5.33) | 0.02* | 3.33 (4.17) | 0.01* |
| MEDAS | 0.93 (2.37) | 0.17 | 1.75 (1.65) | <0.001** | 1.87 (2.00) | 0.003* |

CDA – Conventional Dietetic Advice

MDNC – Mediterranean Diet intervention using Nutritional Counselling

MDBC – Mediterranean Diet intervention using Behavioural Counselling

p-value corresponds to paired sample t-tests

(*) p-value <0.05

(**) p-value <0.001

**Table 2.9 Within-group differences in mean Mediterranean diet scores between baseline and 12 months follow up**

| Mediterranean Diet Score | Intervention | | | | | |
|---|---|---|---|---|---|---|
| | CDA (n=12) | | MDNC (n=13) | | MDBC (n=9) | |
| | Mean Difference (SD) | p-value | Mean Difference (SD) | p-value | Mean Difference (SD) | p-value |
| MAI | 0.50 (0.64) | 0.02* | 0.53 (0.87) | 0.05* | 0.80 (1.52) | 0.15 |
| rMED | 1.42 (2.97) | 0.13 | 0.00 (3.32) | 1.00 | -0.22 (3.38) | 0.85 |
| Mediterranean Score | 3.67 (5.26) | 0.03* | 4.31 (5.94) | 0.02* | 4.56 (5.48) | 0.04* |
| MSDPS | 6.82 (10.96) | 0.05* | 7.61 (10.52) | 0.02* | 4.23 (9.45) | 0.22 |
| MedDietScore | 4.50 (4.17) | 0.003* | 2.00 (7.33) | 0.34 | 0.78 (6.32) | 0.72 |
| MEDAS | 1.08 (2.15) | 0.11 | 1.46 (2.50) | 0.06 | 1.56 (1.13) | 0.003* |

CDA – Conventional Dietetic Advice

MDNC – Mediterranean Diet intervention using Nutritional Counselling

MDBC – Mediterranean Diet intervention using Behavioural Counselling

p-value corresponds to paired sample t-tests

(*) p-value <0.05

Scatterplots of MDS for all participants are included in Appendix H. With the exception of a few individuals, the majority of participants' scores improved from baseline values. A greater adherence to a Mediterranean diet was observed at 6 months follow up, with a decreasing trend by 12 months follow up (although this was still higher than at baseline).

#### *2.3.5.3 Identification of a suitable Mediterranean diet score to use in intervention studies*

The coefficient of variation (CV) was calculated to identify spread in the Mediterranean diet scores for each treatment group and time point. The CV at each time point and differences between baseline and follow up were identified. As the differences in CV between intervention groups differed between positive and negative values for all MDS, the criterion was awarded based on values from the whole sample. Change in CV from baseline to 6 months and baseline to 12 months was ranked in order of the highest reduction. MDS retained a similar order of change in CV between baseline to 6 months and baseline to 12 months (see Table 2.10).

The MSDPS scored the maximum 10 criteria points available. When the score was applied to dietary data, overall, the diets of participants became more similar after the MD intervention (particularly at 6 months follow up) and these effects were greater in participants who received the Mediterranean diet intervention with behavioural counselling than those who received the dietary intervention with nutritional counselling. Conversely, when applied to dietary data, the MAI and rMED showed that the variation in adherence to the MD increased at follow up for the two groups receiving a MD intervention.

**Table 2.10 Differences in the coefficient of variation in Mediterranean diet scores between baseline and follow up**

| | Intervention | | | | | | | | | Overall Difference in CV | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CDA | | | MDNC | | | MDBC | | | Baseline minus 6 months (Rank) | Baseline minus 12 months (Rank) |
| Mediterranean Diet Score | CV Baseline | CV 6 months | CV 12 months | CV Baseline | CV 6 months | CV 12 months | CV Baseline | CV 6 months | CV 12 months | | |
| MAI | 77.52 | 58.47 | 54.81 | 42.48 | 51.57 | 54.35 | 50.19 | 78.69 | 108.57 | -6.96 (6) | -22.15 (6) |
| rMED | 46.98 | 38.31 | 33.07 | 28.72 | 32.04 | 36.00 | 26.96 | 44.99 | 47.07 | -3.85 (5) | -3.06 (5) |
| Mediterranean Score | 28.12 | 22.04 | 28.29 | 21.95 | 19.77 | 24.88 | 30.69 | 16.90 | 21.85 | 6.18 (2) | 1.97 (2) |
| MSDPS | 55.73 | 35.61 | 61.29 | 34.65 | 29.46 | 32.52 | 46.48 | 33.16 | 27.02 | 12.19 (1) | 4.79 (1) |
| MedDietScore | 21.17 | 20.60 | 19.68 | 19.13 | 13.71 | 13.44 | 11.21 | 13.05 | 18.99 | 2.22 (4) | 0.77 (3) |
| MEDAS | 41.77 | 47.68 | 51.64 | 33.68 | 27.66 | 33.73 | 42.78 | 35.92 | 42.07 | 2.62 (3) | -3.00 (4) |

CDA – Conventional Dietetic Advice

MDNC – Mediterranean Diet intervention using Nutritional Counselling

MDBC – Mediterranean Diet intervention using Behavioural Counselling

CV – Coefficient of Variation

The second selection criterion was based on the percentage change in points awarded by the MDS. This was calculated between baseline and six months and baseline and 12 months follow up for each treatment group and analysed for significance using one-way ANOVA (see Table 2.11).

**Table 2.11 Percentage change in Mediterranean diet scores between baseline and follow up, by intervention group**

| | | Intervention | | | |
|---|---|---|---|---|---|
| | | CDA | MDNC | MDBC | |
| Time Point | Mediterranean Diet Score | Mean % Change (SE) | Mean % Change (SE) | Mean % Change (SE) | p-value |
| 6 months | MAI | 142 (40.9) | 90 (34.2) | 86 (39.5) | 0.55 |
| | rMED | 18 (11.1) | 0.4 (9.3) | 6 (10.7) | 0.48 |
| | Mediterranean Score | 34 (11.7) | 42 (9.8) | 34 (11.3) | 0.82 |
| | MSDPS | 98 (27.0) | 60 (22.6) | 50 (26.1) | 0.41 |
| | MedDietScore | 16 (5.1) | 13 (4.3) | 11 (4.9) | 0.81 |
| | MEDAS | 32 (16.5) | 48 (13.8) | 59 (15.9) | 0.50 |
| 12 months | MAI | 181 (64.1) | 50 (61.6) | 62 (74.1) | 0.30 |
| | rMED | 46 (16.1) | 4 (15.5) | 2 (18.6) | 0.11 |
| | Mediterranean Score | 27 (11.7) | 26 (11.2) | 31 (13.5) | 0.96 |
| | MSDPS | 62 (30.4) | 53 (29.2) | 33 (35.1) | 0.82 |
| | MedDietScore | 18 (6.5) | 10 (6.2) | 3 (7.5) | 0.34 |
| | MEDAS | 37 (22.0) | 57 (21.1) | 43 (25.4) | 0.81 |

CDA – Conventional Dietetic Advice

MDNC – Mediterranean Diet intervention using Nutritional Counselling

MDBC – Mediterranean Diet intervention using Behavioural Counselling

SE – Standard Error

p-value corresponds to one-way ANOVA using the General Linear Model

Table 2.11 presents the mean percentage change in MDS within each intervention group, for each scoring system. Within each intervention group, participants increased their mean adherence to a Mediterranean diet for all MDS, which is evident by positive values in the percentage change. However, whilst there appeared to be some differences in the percentage change in scores between intervention groups, these intervention effects were not statistically significant.

The six MDS were ranked at each time point, according to the size of the p-value, with the smallest p-value given the highest rank. This showed that the points awarded to the percentage change in MDS at 6 months differed from those at 12 months. For example, the MSDPS was awarded the most points for differences in percentage change between groups from baseline and 6 months, but the rMED was awarded the most points for differences between baseline and 12 months.

The number of assumptions made in order to be able to calculate each MDS were summed and ranked in order. The rMED score scored the maximum 10 points available, as it required the least number of assumptions (two) to be calculated. Three scores required three assumptions to be made and so an average was taken of the points awarded to their corresponding ranks. The Mediterranean Score was awarded four points due to four assumptions made and the MSDPS was not awarded any points, as it required the greatest number of assumptions in order to calculate it using MEDDINI data.

Table 2.12 describes the selection criteria points awarded at each stage, in addition to the total number of points. The rMED score received 21 points in total and was identified as being the most appropriate Mediterranean diet score to use for future testing within intervention studies.

**Table 2.12 Selection criteria points awarded for recommending the most suitable Mediterranean diet score**

| Mediterranean Diet Score | Points Awarded | | | | | Total Points* |
|---|---|---|---|---|---|---|
| | CV at 6 months | CV at 12 months | Mean % Change at 6 months | Mean % Change at 12 months | Assumptions Made to Calculate Score | |
| MAI | 0 | 0 | 2 | 4 | 6 | 12 |
| rMED | 1 | 1 | 4 | 5 | 10 | 21 |
| Mediterranean Score | 4 | 4 | 0 | 0 | 2 | 10 |
| MSDPS | 5 | 5 | 5 | 1 | 0 | 16 |
| MedDietScore | 2 | 3 | 1 | 3 | 6 | 15 |
| MEDAS | 3 | 2 | 3 | 2 | 6 | 16 |

CV – Coefficient of Variation

*Maximum number of points available was 30

## 2.4 Discussion

### *2.4.1 Main findings*

The main aim of this study was to determine whether a selection of Mediterranean diet scores were able to detect changes in the diets of MEDDINI participants following a Mediterranean diet intervention. Six MDS were identified as being appropriate for use within the study population by the first set of 10 selection criteria (see Section 2.2.2). When these scores were applied to the dietary outcome data from the MEDDINI intervention study, only one significant difference was found in the Mediterranean Score between the control group and both MD intervention groups at 6 months follow up (see Table 2.6). When the points awarded by the Mediterranean Score were analysed at 12 months follow up, there was no longer a significant difference between these groups (see Table 2.7). Considering that only one of the six Mediterranean diet scores observed a significant difference at six not 12 months, this broadly suggests that the dietary interventions, which included more contact time with the research dietitian, had little if any significant improvements on adherence to a Mediterranean diet than the control group who received conventional dietary advice.

Furthermore, no significant differences in the scores were observed between the two MD intervention groups at either 6 or 12 months follow up (see Table 2.6 and Table 2.7). This indicates that, with the MEDDINI participants, a Mediterranean diet intervention supplemented with behavioural counselling did not have any additional benefits over a MD intervention using nutritional counselling. These results are comparable to those observed by Logan *et al.* (2010), who found no effects of the type of intervention on the points awarded by Martínez-González et al.'s short Mediterranean diet questionnaire (2004) in the same study participants. However, as the MEDDINI study was a pilot study, with small numbers of participants in each treatment group, it may not have been powered to detect significant between-group differences.

When the within-group differences in mean scores were analysed between baseline and six months follow up, there was a significant difference in the scores of all MDS within each treatment group, except for the rMED (for all three treatment groups) and the MEDAS for the control group (see Table 2.8). When the differences in mean MDS between baseline and 12 months were analysed, the five scores retained significance (again, no differences were found in the rMED). However, the Mediterranean Score was the only MDS to have significant differences in the score for all three treatment groups (see Table 2.9). Furthermore, the MDS were more likely to be different between baseline and 12 months follow up for the control group than for the MD intervention groups. These results suggest that overall, participants assigned to all three arms of the study made positive dietary changes towards a greater adherence to the MD at 6 months, but the improvements were less impressive after one year (depending on the type of MDS used to assess these changes).

These results are encouraging, considering that dietetic support was stopped after 6 months for the MDNC and MDBC groups and no support was given to the control group. In the Lyon Diet Heart Study, De Lorgeril *et al.* (1999) found that most participants randomised to a MD intervention still adhered to a MD after a mean follow up of 46 months and this sustained dietary change translated into a protective effect on cardiovascular outcomes when compared with the control group. Similarly to the Lyon Diet Heart Study, participants in the MEDDINI study were recruited after a myocardial infarction. It is possible that individuals diagnosed with a disease may be more motivated to change their diets and to maintain these changes for longer than disease-free individuals.

The MDS points awarded to participants in the MEDDINI Study at baseline were lower than those in the other populations for which each scoring system had been developed originally, except for the MedDietScore (where the baseline score was 30.39 compared with 26.33 of Greek participants (Panagiotakos *et al.*, 2006b)). However, at follow up, MDS improved and became more comparable with results found in the earlier studies. The mean MSDPS (developed to assess dietary conformity to a traditional MD in a non-Mediterranean population) for participants from the Framingham Heart Study

Offspring Cohort was 24.8 out of a maximum possible score of 100 (Rumawas *et al.*, 2009). Although mean baseline values in the MEDDINI Study were lower than this for each treatment group in this study, the MSDPS at both six and 12 months follow up were higher.

As anticipated, for the MDS that were produced in Mediterranean populations, scores were greater than those assigned to MEDDINI participants who came from a non-Mediterranean population. Estruch et al. (2013) reported baseline values of Spanish participants in the PREDIMED intervention study as approximately 8.5 out of a maximum 14 points for the MEDAS score, whilst the mean MEDAS score of each intervention group in the present study was only between five and six points, even after the dietary intervention (see Table 2.6 and Table 2.7).

A second set of three selection criteria was applied to the Mediterranean diet scores produced using data from the MEDDINI study, to help identify which of the six scores was most suitable for measuring changes in the diets of a non-Mediterranean population, in response to an intervention aiming to increase adherence to a Mediterranean diet. The second set of three criteria were based on: the percentage change in diet between intervention groups from baseline to 6 and 12 month follow up; the coefficient of variation of the whole sample from baseline to 6 and 12 month follow up; and the number of assumptions and modifications that were made in order to calculate the scores. After ranking the performance of the scores in relation to each other and assigning points to these ranks, the selection criteria points were summed to produce a total score out of 30 for each MDS (see Table 2.12). The MSDPS was awarded the most points for the smallest coefficient of variation (see Table 2.10) and closeness to significance for differences in percentage change between groups (see Table 2.11), however the rMED required the least number of assumptions to be made to fit the data around calculating the score. As a doubled weighting was applied to the points awarded to the number of assumptions made, the rMED received the highest selection criteria points and was identified as the most suitable score for future testing within intervention studies.

The rMED score was developed for use with data from participants who took part in the European-wide EPIC study. Associations between adherence to the MD (measured by rMED) and various health outcomes, in both Mediterranean and non-Mediterranean populations, have been investigated (Buckland *et al.*, 2010; Romaguera *et al.*, 2010; Buckland *et al.*, 2011; Romaguera, 2011; Buckland *et al.*, 2013; Sotos-Prieto *et al.*, 2014). The rMED score has been used in two studies which examined the effectiveness of dietary scores. The rMED and five other dietary scores were applied to data from a French cohort study to investigate relationships with 13-year weight change and obesity risk. Significant negative associations were found between rMED scores and weight change, independent of age, energy intake and number of dietary records completed, in both men and women, as well as between the score and the odds ratio of becoming obese after 13 years in men (Lassale *et al.*, 2012). When compared to the other dietary scores (including Trichopoulou *et al.*'s Mediterranean Diet Score (2003) and Rumawas *et al.*'s MSDPS (2009)), the rMED performed best at identifying these associations.

Milà-Villarroel et al. (2011) compared the reliability of dietary indices to measure adherence to the MD in Spanish undergraduate students. Ten scores were compared, including the six MDS that were used in the present study. The rMED score was highly correlated with Trichopoulou *et al.*'s MDS (2003). This is perhaps unsurprising, considering that the rMED score was based on the MDS, using the same food groups but a different scoring technique. The rMED expresses intakes of food groups as grams/1000kcal/day and assigns between one and three points to tertiles of intake, whereas the MDS awards either one or zero points to gram intakes/day above or below the median. The rMED score was also highly correlated with a MD pattern identified by factor analysis (Milà-Villarroel *et al.*, 2011). In addition to the analysis conducted by the present study, these two studies support the use of the rMED score in identifying adherence to the Mediterranean dietary pattern. However, it is important to note that these two comparison studies were performed with epidemiological cohorts, and as far the researcher is aware, the rMED has not been used in an intervention study to date.

### *2.4.2 Strengths and limitations*

To date, the FFQ and diet history dietary data from the MEDDINI Study which were used in Chapter 2 had not been analysed. Comparisons between MDS in respect of their efficacy to measure adherence to the MD diet and/ or associations with health have been investigated previously (Bach-Faig *et al.*, 2006; Knoops *et al.*, 2006; Puchau *et al.*, 2009; Beunza *et al.*, 2010; Toledo *et al.*, 2010; Milà-Villarroel *et al.*, 2011; Lassale *et al.*, 2012). However, all these comparisons were conducted with data from observational studies and no comparisons have used data from intervention studies. The six MDS used in this thesis have been compared together once before, but only using data from a cross-sectional study of 324 healthy undergraduate students from the University of Barcelona (Milà-Villarroel *et al.*, 2011).

The standardisation of procedures used in data entry of the MEDDINI FFQs and data analysis were considered a strength of the study. These same procedures were used to check for errors and, of which, very few were found (and then rectified). Additionally, the authors of the six MDS chosen for testing were contacted, to provide clarification of the foods included in each food group, to ensure the correct calculation of the scores.

Only one significant between-group difference in adherence to the MD was observed by the Mediterranean Score at six months. However, as the aim of the study was not to test the effectiveness of the type of treatment given, but to test the efficacy of the MDS to assess dietary change, this is not considered a limitation of the study.

Dietary recommendations for a MD provided by the research dietitian were in accordance with the way the MDS are scored for beneficial and detrimental food groups (Logan *et al.*, 2010). Therefore, if participants in the intervention groups had adhered to these dietary guidelines, the scores should have increased at follow up. Whilst the mean scores for the whole sample significantly increased between baseline and follow up, the scores produced for the control group also increased. One explanation could be that although control group participants were not given a MD intervention specifically, they still received advice to alter their eating habits for a cardio-protective effect on health (see Section 2.3.2.1). Many of these guidelines were similar in respect to the Mediterranean diet, such as to increase consumption of fruit and vegetables, wholegrain cereals and fish and to replace saturated fats with mono- and polyunsaturated fats. Whereas the guidelines for the MD interventions were to consume these foods in greater quantities, participants from the CDA group could have increased their food intakes to similar levels as advised in the MD groups.

One limitation of this study was the relatively small sample size. This was because the MEDDINI Study was a pilot study, which was designed primarily to determine whether coronary heart disease (CHD) patients in a Northern European population would adopt and maintain a MD (Logan *et al.*, 2010). The secondary aim of the MEDDINI Study was to compare the effectiveness of different methodologies aimed at improving compliance with a MD. For the present study, only 49 participants were included in the analysis at 6 months follow up and 34 in the sub-set follow up at 12 months. As the sample was divided into three interventions, there will have been limited power in detecting between-group differences (even when comparing both intervention groups vs. the control group). Furthermore, the MEDDINI study design (with a heavy preponderance of men) did not allow the present study to determine whether the Mediterranean diet scoring systems worked better for one sex than for the other.

There were also a number of limitations in the way dietary data were treated, due to reasons beyond the control of the researcher. Firstly, two methods were used to identify the average portion size of FFQ items in the database. The average portion sizes of food items which were already incorporated into the database were acquired from portion sizes consumed in the Family Food and Health Project, measured using estimated weight food diaries (Curtis *et al.*, 2012). However, some FFQ items were not originally present in the database, and in these instances, the researcher made logical decisions to produce average portion sizes and nutritional compositions for these foods (such as deriving portion sizes and nutritional information from the NDNS (Henderson *et al.*, 2002)).

Secondly, the MDS were applied to dietary data that were not recorded for this purpose. As the FFQs used in the study did not contain sufficient information as to directly apply the MDS, some data were included from other sources. For example, all six scores required quantitative intakes of olive and vegetable oils. Information on the most commonly used type of fat added during cooking only was requested in the FFQ, so quantities and frequencies of consumption were derived from the 7-day diet histories that participants also completed at each assessment. Assumptions were also made about the FFQ data, such as the preference of poultry over red meat used in the MEDAS score. Again, this was not a specific question in the FFQ, but this was answered by subtracting the combined values of red meat consumption from the value of poultry consumption and assigning a Yes/ No code to the results. Although the use of mixed methods to fit data into the formats in which the MDS are calculated is not ideal, logical processes were conducted at each stage to quantify data in the most accurate and comparative ways. Therefore, under the circumstances, these strategies could also be considered strengths of the study.

Some of the MDS tested were not originally developed for use with a UK/ non-Mediterranean population and therefore food groups within each score may contain food items which are different from those of the original populations for which the scoring system was devised. For example, one question in MEDAS requires the quantification of sofrito used in cooking. This is a tomato-based sauce usually containing olive oil, garlic and onions, which is commonly used in Mediterranean cooking and added to pasta or vegetables. A variation of this sauce may be consumed in the UK in recipes such as spaghetti Bolognese, but perhaps not in sufficient quantities to justify including it within a 14-point score. The preparation and ingredients of the sauce used in the UK population may also differ from that in Mediterranean countries. Additionally, if the MEDAS questionnaire was self-completed by UK participants as intended, the question about sofrito would need to be adapted to fit local terminology and the way it is consumed by this population.

Finally, selection criteria were applied at two stages in this study: firstly, to reduce the 26 MDS found in a literature search into a more manageable number for the subsequent quantitative comparisons. Then secondly, to further reduce this number down to one MDS, which would fit the remit of being sensitive to measure change in diet. The second set of selection criteria were different from the first set, so as not to repeat questions and possibly introduce selection bias. These criteria are subjective and based on the purpose in which the MDS will be used in future work. Therefore, they may not be appropriate for use in another study which may have different aims.

### *2.4.3 Conclusions*

In the present study, six Mediterranean diet scores were chosen to test with dietary data from the MEDDINI MD intervention study. These were the MAI (Alberti-Fidanza *et al.*, 1999), Mediterranean Score (Goulet *et al.*, 2003), MSDPS (Rumawas *et al.*, 2009), rMED (Buckland *et al.*, 2010), MEDAS (Estruch *et al.*, 2006) and the MedDietScore (Panagiotakos *et al.*, 2006b). When these scores were applied to the MEDDINI dietary data, only one significant difference was found in the Mediterranean Score between the control group and both MD intervention groups at only six months follow up. This broadly suggests that the interventions, which included more contact time with the research dietitian, had little if any significant improvements on adherence to a Mediterranean diet than the control group who received conventional dietary advice. Furthermore, no significant differences in the scores were observed between the two MD intervention groups at either 6 or 12 months follow up, however, it is unlikely that the study had sufficient statistical power to observe these differences.

When the within-group differences in mean scores were analysed between baseline and follow up, there were significant differences for five of the six MDS. These results suggest that overall, participants assigned to all three arms of the study made positive dietary changes towards a greater adherence to the MD at 6 months, but the improvements were less impressive after one year.

The set of three selection criteria were then applied to the MD scores produced from the MEDDINI data, to identify which of the scores was most suitable for measuring dietary change, in response to a MD intervention. These criteria were based on the percentage change in diet between intervention groups and the coefficient of variation of the whole sample from baseline to follow up, in addition to the number of assumptions and modifications that were made in order to calculate the scores. The performance of the scores for each criterion were ranked in relation to each other and assigned points, with 30 points being the total maximum score. The rMED was awarded the greatest number of points and was therefore identified as the most suitable score for future testing within intervention studies using non-Mediterranean populations.

# Chapter 3 User-testing of INTAKE24

## 3.1 Introduction

The majority of the Mediterranean diet scores previously mentioned in Chapter 2 were fundamentally designed to be applied to dietary data that have been collected by dietary assessment tools, such as food frequency questionnaires (FFQs). Therefore, in order to use the rMED (identified in Chapter 2 as the most appropriate score to use in intervention studies with non-Mediterranean populations), a dietary assessment tool which is suitable for use with the target population is required for use alongside a MDS.

The introduction of technological dietary assessment tools has enhanced epidemiological studies, as they are more time-effective (reducing the burden of food coding and data entry for the investigator) and can be administered at lower costs than conventional, paper-based techniques (Illner *et al.*, 2012). This consequently means that they can be used in large-scale studies, where traditional tools would be impractical. It is estimated that almost 80% of Americans aged 50-64 years and more than half aged over 65 and are now using the internet, with the majority of these people going online every day (Zickuhr and Madden, 2012). Therefore, employing online tools to collect dietary data in large studies, involving older adults who are representative of the general population, has now become feasible.

One web-based dietary assessment tool is INTAKE24. It is self-completed and follows the Automated Multiple-Pass Method (AMPM) (Blanton *et al.*, 2006), whereby all foods and drinks consumed over the previous 24 hours are entered, according to the time and meal occasion (e.g. breakfast, early snack or drink etc.). INTAKE24 was developed and tested by colleagues at Newcastle University, for use by older children and young adults aged 11-24 years (Foster *et al.*, 2013). This system is an adaptation of the Self Completed Recall and Analysis of Nutrition (SCRAN24), developed for use with 11-16 year old children (Foster *et al.*, 2014b), which, in turn, was an adaptation of the Interactive Portion Size Assessment System (IPSAS), for use with an even younger age group of 4-16 year olds (Foster *et al.*, 2014c). However, INTAKE24 has never been used with an older age group before.

This chapter describes the user-testing of INTAKE24 with a group of adults who had entered the peri-retirement window. The purpose of this was to evaluate the usability, functionality and aesthetics of the system, to determine whether it is appropriate, effective and easy to use for individuals of this particular age group.

### *3.1.1 Objective*

The aim of this chapter was:

1. To investigate whether INTAKE24 is suitable for measuring the diets, including the Mediterranean dietary pattern, of adults in the peri-retirement window.

In order to fulfil this aim, the following objectives were established:

1. To evaluate the usability of INTAKE24 with retirement-age participants.
2. To compare food and nutrient intakes reported using INTAKE24 with those reported in an interviewer-led recall.
3. To apply the Relative Mediterranean Diet score (rMED) to dietary data, to assess adherence to a Mediterranean diet.

## 3.2 Methodology

### *3.2.1 Utility of INTAKE24 for assessing the diets of retirement-age adults*

The foods included in SCRAN24 and IPSAS were based on the top 100 foods consumed by children of the same age groups (11-16 year olds for SCRAN24 and 4-16 year olds for IPSAS) taking part in the National Diet and Nutrition Surveys (NDNS) (Gregory *et al.*, 1995; Gregory *et al.*, 2000), according to the frequency of consumption, the weight of food consumed and the contribution to total energy intake (Foster *et al.*, 2014b; Foster *et al.*, 2014c). These foods were also incorporated into INTAKE24. When these foods were compared with a new search of the top 100 foods consumed by 17-24 year olds in the NDNS (Gregory *et al.*, 2000; Henderson *et al.*, 2002; Bates *et al.*, 2010), no additional foods needed to be added. However, approximately 400 new foods were added to the system to include alcoholic drinks, regional Scottish foods (as INTAKE24 was developed for assessing the diets of Scottish young people) and common foods missing from the system, which were identified using supermarket websites (Foster *et al.*, 2013).

To identify whether the foods in INTAKE24 were inclusive of those consumed by adults in the peri-retirement window (operationalised as 55-70 years), similar criteria were employed to ascertain the top 100 most commonly consumed foods by UK residents in this age group, using data from the NDNS. Three different bases were considered in identification of the top 100 foods i.e. by contribution to percentage of total energy intake; frequency of consumption; and amount (grams) consumed (thus providing three separate lists of the top 100 foods consumed). Whilst the NDNS was conducted in adults aged over 65 years (Smithers *et al.*, 1998), this dataset for the oldest participants was not used in the present study, because the data did not allow for separate analysis of age groups and, therefore, included data for much older people. The specific foods, and their portion sizes, consumed by the oldest old may be rather different from those of “younger old” people. Therefore, the diets of 65-70 year olds were assumed to be closer to those of the 50-64 year old subgroup from the NDNS of adults aged 19-64 year olds (Henderson *et al.*, 2002). In addition, this analysis included data from the Rolling Programme Years 1 and 2 for adults aged 19-64 years (Bates *et al.*, 2010) without any differentiation of age groups.

Six separate lists of the 100 most commonly consumed foods were composed (three lists of the contribution to percentage of total energy intake; frequency of consumption; and amount (grams) consumed, for each of the two NDNS datasets), before being merged together into one list of 600 foods and the duplicates removed. A final list of 238 food items was produced and compared with foods in INTAKE24. Only five of these 238 foods were not present in the system, which were garlic, artificial sweeteners, light spreadable butter, reduced fat spread with olive and plain flour after baking. The decision was taken not to add these foods to the INTAKE24 system because i) they contributed so little to overall nutrient intakes that the efforts to alter the system would not be worth it (i.e. sweeteners and garlic), ii) they were not considered as foods which users would be likely to report consuming (i.e. plain flour after baking), or iii) similar foods could be selected from the INTAKE24 lists by the user (e.g. "Olive spread e.g. Olivio" or "Low fat margarine" could be selected instead of reduced fat spread with olive). Because my intention was to use INTAKE24 in conjunction with a Mediterranean diet score to assess adherence to a Mediterranean diet (MD), foods in the system were compared with guidelines for a MD (Bach-Faig *et al.*, 2011). No foods were identified as missing from the system.

In addition to identifying whether foods commonly consumed by adults of peri-retirement age were incorporated into INTAKE24, a similar task was conducted to ensure that the portion sizes for these foods in the system were comparable to the portion sizes consumed by this age group. Food portion size photographs in INTAKE24 are presented in two formats: seven photographs for estimating the amount served and seven photographs for estimating leftovers for items which are not usually consumed in predetermined amounts (e.g. cucumber); and guide photographs of a range of similar products with varying weights, which are usually consumed in predetermined amounts (e.g. crisps, biscuits, slices of bread etc.) (Foster *et al.*, 2014c). For the foods not consumed in predetermined quantities, the portion sizes of the amount consumed were derived from equal increments of the $5^{th}$ to $95^{th}$ centile of weight served to children from the NDNS (Gregory *et al.*, 1995; Gregory *et al.*, 2000). For the leftovers, equal increments from the fifth centile to the smallest presentable portions were used (Foster *et al.*, 2014c).

For each of the 238 top 100 foods identified from the NDNS, portion sizes in INTAKE24 were compared with the mean and range in portion size from weighed intakes consumed by 50-64 year olds in the NDNS (Henderson *et al.*, 2002). Whilst the mean portion sizes for all 238 foods consumed in the NDNS were encompassed within corresponding portion sizes in INTAKE24, the range in portion sizes consumed was not a perfect match with the range in INTAKE24 for a number of items. However, this was not considered to be a significant problem for many of these foods consumed outside of the range in INTAKE24, because portion sizes of foods consumed in the NDNS are calculated according to eating occasions, whereby participants may have consumed more than one countable item (e.g. apples, biscuits, hot beverages etc.) within one eating occasion. Whilst portion sizes of foods in INTAKE24 are also calculated per meal occasion, countable foods are additionally recorded as the number eaten. Therefore, although the range in portion size of countable foods in INTAKE24 is presented up to the weight of one whole food item or full cup/ glass of a beverage, the total weight and number of countable foods consumed within one eating occasion can be recorded and will be comparable with the larger range recorded in the NDNS. Appendix I summarises the remaining discrepancies in the range of portion size of foods between INTAKE24 and the NDNS data.

### *3.2.2 Participant recruitment*

Ethics approval for the study was provided by Newcastle University's Faculty of Medical Sciences Ethics Committee in February 2014 (application number 00629_1/2014). Recruitment emails were sent to members of VOICENorth and to the Elders Council of Newcastle (see Appendix J for an example). Additionally, the researcher manned a stall at a retirement event held at Newcastle University, displaying recruitment posters (see Appendix K) and discussing the study with delegates. To take part in the study, participants were required to be aged from 55-70 years (based on the operationalised age for the peri-retirement window) and to have some familiarity with computers, including an active email address for correspondence with the researcher.

### *3.2.3 Data collection*

This study was conducted in April 2014. All participants had given consent to take part (see Appendix L) and had read the participant information sheet (see Appendix M) prior to user-testing. Participants were invited individually to attend the Campus for Ageing and Vitality, Newcastle University for approximately one hour during working hours. Participants were asked to complete both INTAKE24 and an interviewer-led recall on the same day, and were randomised according to the order of which recall they would complete first. The protocol for conducting the user-testing is included in Appendix N. Upon completion, participants were provided with a £10 gift card for a local shopping centre, as a token of appreciation.

#### *3.2.3.1 Demographics and lifestyle behaviours*

A questionnaire was used to gather data on participant demographics and lifestyle behaviours (See Appendix O). Questions on marital status, education level, occupational status and retirement were adapted from questionnaires used in the Newcastle Thousand Families Study (Pearce *et al.*, 2009), whilst questions on internet use were adapted from a self-completion questionnaire used in wave 6 of the English Longitudinal Study of Ageing (The Institute for Fiscal Studies, 2011).

To assess the socio-economic status of participants, the Index of Multiple Deprivation (IMD) was calculated based on their home address postcodes, using an online tool developed by the University of Oxford (2014). The IMD is presented as a score and in quintiles, where the lower the score, the less deprived an area is estimated to be.

#### *3.2.3.2 Anthropometry*

Height was measured to 0.1 cm with a Leicester portable height measure (Chasmors Ltd., London) and weight was measured to 0.1kg using Tanita scales (Type TBF-300 MA, Chasmors Ltd., London). Body mass index was calculated as weight (kg)/height ($m^2$).

#### *3.2.3.3 Interviewer-led 24 hour recall*

An interviewer-led 24 hour recall was conducted in person during the appointment with the participants, in order to compare food and nutrient intakes recorded with those recorded in INTAKE24. This was conducted using the same paper-based recall as was used in the Newcastle 85+ Study (Adamson *et al.*, 2009) (see Appendix P). Following a similar method to that used in the Low

Income Diet and Nutrition Survey (LIDNS) (Nelson *et al.*, 2007), participants were first asked to recall all items consumed in the previous 24 hours between midnight to midnight and to record them in the quick list column. For each food item, participants were asked to provide additional details on the time it was consumed, a full description of the food (e.g. whether the product was reduced or low fat/ calorie) and brand name, the cooking method, whether a meal was homemade or purchased, and the amount consumed. Participants were also prompted for any foods which were likely to have been eaten in combination, such as butter/ margarine/ jam etc. on toast.

Food portion sizes were quantified as the amount served and leftover, aided by the Young Person's Food Atlas for Secondary school-aged children (Foster *et al.*, 2010). This food atlas was used because the same photographs are used for portion size assessment in INTAKE24. Where food photographs could not be used to identify portion sizes, household measures (e.g. teaspoons of sugar) and amounts in relation to known packaging sizes were used.

Once all the information was collected for each food item, the interviewer reviewed these items in chronological order, prompted for any additional eating occasions or forgotten foods and checked for any missing or ambiguous data.

#### ***3.2.3.4 24 hour recall using INTAKE24***

A survey was set up in INTAKE24 solely for the purposes of this user-testing study, at http://workcraft.org/intake24/surveys/livewell/. A set of individual user names and passwords were created and uploaded into the system, using an administrator account. At participant appointments, the website was loaded onto a laptop and participants were asked to self-complete the recall and to follow on-screen instructions after logging in. Users were asked to adopt a "think aloud" method, by providing a running commentary whilst using the system, including what they thought the system was asking them to do at each stage and which aspects they liked or disliked. The researcher was present during this task to observe, take notes and to offer help to the participants if they found difficulties in completing tasks and asked for help. The recall process was audio-recorded, to capture all feedback whilst using the system. Both the interviewer-led and INTAKE24 recalls were timed so that comparisons could be made between completion times for each participant.

#### *3.2.3.5 Participant evaluation*

User-evaluation of INTAKE24 was assessed by a semi-structured interview and a system usability questionnaire, which were administered immediately after using INTAKE24. For the semi-structured interview, a guide list of 14 questions was written to gather feedback on the aesthetics of INTAKE24, on-screen instructions, selecting food items and their portion size pictures, any problems encountered and suggestions for improvement (see Appendix Q). The interview was audio-recorded to ensure all participant evaluation was captured. The system usability questionnaire was based on the System Usability Scale (SUS) (Brooke, 1996), which includes 10 statements, each of which was rated on a 5-point Likert scale. Participants were asked to rate the degree to which they agreed or disagreed with the statements. Participants were also asked to provide any further comments they had about the system (see Appendix R).

### *3.2.4 Data analysis*

#### *3.2.4.1 Participant characteristics*

SPSS statistical software (version 21, IBM, USA) was used to generate descriptive statistics i.e. the mean and standard deviation (SD) for participant age and BMI. Frequency tables were produced to characterise the number of participants in categories of gender, marital status, IMD quintile, ethnicity, occupational status, educational attainment, BMI (World Health Organisation, 2000), frequency of internet use and the number of devices on and the places from which participants accessed the internet.

#### *3.2.4.2 Food items coding from interviewer-led recalls*

Food items recorded in the interviewer-led recalls were assigned food codes according to comparable foods in the Year 4 NDNS Rolling Programme Nutrient Databank (NatCen Social Research *et al.*, 2015). Where items could not be matched exactly, the nearest matching food was chosen. Food portion sizes were identified from the Young Person's Food Atlas food codes and searched for within the accompanying Microsoft Access database. These NDNS food codes and portion sizes are used within the INTAKE24 system and can therefore provide direct comparisons of food and nutrient intakes.

#### *3.2.4.3 Time taken to complete INTAKE24 and the interviewer-led recall*

A paired samples t-test was performed in SPSS to test for a difference in the average time taken to complete INTAKE24 with the average time taken to complete the interviewer-led recall. In addition, Pearson correlation was used to assess whether the mean completion times were associated with the number of foods recorded.

#### *3.2.4.4 Comparison of estimates of food intake by INTAKE24 and by interviewer-led recall*

Using Microsoft Excel, the INTAKE24 and interviewer-led 24 hour recalls for each participant were compared to determine the number of food matches, omissions and intrusions. An exact match was defined as the same food item being reported in INTAKE24 as was recorded in the interviewer-led recall. An approximate match was defined as the same food but a slightly different variant, either by the type of food (e.g. semi-skimmed milk entered into INTAKE24 and skimmed milk recorded in the interviewer-led recall), or by the cooking method (e.g. raw tomatoes recorded in INTAKE24 and grilled tomatoes recorded in the interviewer-led recall). An omission was defined as a food recorded in the interviewer-led recall but not in INTAKE24, whilst an intrusion was defined as a food recorded in INTAKE24 but not in the interviewer-led recall.

### 3.2.4.5 Comparison of intakes of mass of foods, energy and macronutrients estimated by INTAKE24 and the interviewer-led recall

Paired samples t-tests were conducted to compare mean weight of food, energy and nutrient intakes recorded in INTAKE24 with those recorded in the interviewer-led recall. The variables included in this analysis were the weight of food, energy, carbohydrate, fat, protein and alcohol, all expressed as total daily intakes.

### 3.2.4.6 Accuracy and precision of INTAKE24

The Bland-Altman method (Bland and Altman, 1986) was used to identify any systematic differences in reported food weight, energy and nutrient intakes between INTAKE24 and the interviewer-led recall. Firstly, the difference in mean total intake reported in INTAKE24 and the interviewer-led recall was calculated and tested for significance using one-sample t-tests. The means and standard deviations from these tests were used to calculate upper and lower limits of agreement (to measure the precision of INTAKE24). These were calculated by: $d \pm 2s$ (where $d$ = mean difference in mean daily total nutrient intake and $s$ = the standard deviation of the difference). Bland-Altman plots for the mean total food and nutrient intakes were produced, where the difference between methods was plotted against the mean of both methods for each participant. Lines representing the mean, upper and lower limits of agreement of the difference in mean total daily intakes were added. Linear regression was used to test for systematic bias in the difference between recall methods related to total intake.

A ratio of the mean total food and nutrient intakes reported using INTAKE24 to those reported in the interviewer-led recall, was calculated for each participant. A ratio of less than one indicated an under-estimation of nutrient intake by INTAKE24 and a ratio of more than one indicated an over-estimation. A value of exactly one indicated an exact agreement between the two methods. Upper and lower limits of agreement were applied, using the same method as described above, so that 95% of the differences in mean intakes would lie between the limits.

#### *3.2.4.7 Audio recordings and researcher observations*

All audio recordings of participants "thinking aloud" whilst completing INTAKE24 were transcribed. These were entered into a Microsoft Excel spreadsheet together with the researcher observations and categorised according to the task being completed in the system. Audio recordings of the semi-structured interviews were transcribed and answers categorised according to the question. Both sets of audio recordings and researcher observations were analysed to produce a table of recommendations for future improvements of the system.

#### *3.2.4.8 Participant evaluation*

Responses to statements within the system usability scale (SUS, see Appendix R) were assigned points ranging from 0-4. For positively phrased statements (item numbers 1, 3, 5, 7 and 9), the score is the position on the 5-point Likert scale minus one point, for example, a "strongly agree" response to the question "I thought the system was easy to use" would result in 4 points. For negatively phrased statements (item numbers 2, 4, 6, 8 and 10), the score is 5 minus the position on the Likert scale (e.g. the response "strongly agree" to the question "I found the system unnecessarily complex" would result in 0 points). The scores were then summed and multiplied by 2.5 to ascertain the overall system usability value on a scale of 0-100 (Brooke, 1996). SUS scores above 68 were categorised as above average and scores below 68 were categorised as below average (Sauro, 2011).

#### *3.2.4.9 Application of the rMED to dietary data*

The Relative Mediterranean diet score (rMED) (Buckland *et al.*, 2010) was identified in Section 2.3.5.3 of Chapter 2 as being the most appropriate Mediterranean Diet Score (MDS) to use in future intervention studies. This score was applied to the dietary data collected in user-testing, to not only measure participant adherence to a Mediterranean diet, but also to assess whether this estimated adherence to a MD pattern significantly differed between the two methods of 24 hour recalls.

The food items recorded by participants in the interviewer-led recall and whilst using INTAKE24 were categorised into the food groups featured in the rMED and expressed as total daily intakes (g)/1000kcal. Calculation of the rMED is included in Appendix E. For the purposes of this study, modifications to the calculation of rMED were made based on participant intakes of two food groups. As legume consumption was recorded by only two participants in the interviewer-led recall and by one participant in INTAKE24, it was not possible to assign points according to tertiles of this food group. Calculation of this food group for the interviewer-led data followed that of the olive oil group, where non-consumers were not assigned points, the consumer above the median was awarded two points and the consumer below the median was awarded one point. The consumption of fresh fish was recorded by one participant in both the interview and INTAKE24. For this food group, non-consumers were not awarded points and the sole consumer was awarded two points. Points assigned to food groups were summed and differences in the mean rMED scores between INTAKE24 and the interviewer-led recall were tested using paired samples t-tests. A boxplot was created to visualise the spread of scores between methods.

## 3.3 Results

### *3.3.1 Participant flow and characteristics*

Seventeen participants were recruited to the study. After consenting to take part and being randomised as to which method they would complete first, two participants withdrew from the study due to personal circumstances. Therefore, a total of 15 participants completed user-testing.

The two participants who dropped out were randomised to complete INTAKE24 first, resulting in more participants completing the interviewer-led recall first (nine participants, compared with six participants completing INTAKE24 first). The mean age of the participants was 65.3 years (SD 4.56) and the mean BMI was 24.3 (SD 3.15). Table 3.1 shows the demographic and lifestyle characteristics of the participants. Twice as many females than males took part and the same proportion was categorised as having a healthy BMI (World Health Organisation, 2000). Overall, the majority of participants were married (78%), retired (67%), educated to degree level (53%), of white ethnicity (100%) and frequent users of the internet both inside and outside of the home.

**Table 3.1 User-testing participant characteristics**

| Characteristic (n=15) | Category | N |
|---|---|---|
| Gender | Males | 5 |
| | Females | 10 |
| BMI | Normal weight | 10 |
| | Overweight | 3 |
| | Obese | 2 |
| Marital Status (n=14) | Married | 9 |
| | Remarried | 2 |
| | Legally separated/ Divorced | 2 |
| | Widowed | 1 |
| IMD Quintile | 1 (least deprived) | 5 |
| | 2 | 3 |
| | 3 | 4 |
| | 4 | 3 |
| | 5 (most deprived) | 0 |
| Ethnicity | White | 15 |
| Occupational Status | Retired | 10 |
| | Working full-time | 2 |
| | Working part-time | 3 |
| Educational attainment | O-Levels/ A-Levels | 2 |
| | Undergraduate degree | 5 |
| | Postgraduate degree | 3 |
| | Professional qualifications | 5 |
| Frequency of internet use | Every day/ Almost every day | 14 |
| | At least once a week | 1 |
| No. of devices internet accessed | 1 | 6 |
| | 2 | 5 |
| | 3 | 3 |
| | 4 | 1 |
| Places internet is accessed | At home | 5 |
| | At home & outside the home | 10 |

### *3.3.2 INTAKE24 vs. interviewer-led 24 hour recall*

#### *3.3.2.1 Time taken to complete assessments*

Table 3.2 shows the mean, minimum and maximum times taken to complete both dietary assessment methods. There was little difference between the randomisation order and the mean time taken to complete each method. However, the mean time taken to complete INTAKE24 was significantly longer than the time taken to complete the interviewer-led recall (p=0.006). The number of foods recorded in INTAKE24 was correlated significantly with its completion time (mean 25.5 foods, p=0.01), whilst this correlation was not significant for the interviewer-led recall (mean 26.2 foods, p=0.07).

**Table 3.2 Mean, minimum and maximum times to complete INTAKE24 and the interviewer-led recall**

| | Randomisation Order | | |
|---|---|---|---|
| Time (min) | INTAKE24 first (n=6) | Interview first (n=9) | All (n=15) |
| Mean INTAKE24 | 25.5 | 24.1 | 24.7 |
| Mean Interview | 21.2 | 19.2 | 20 |
| Min INTAKE24 | 15 | 12 | 12 |
| Max INTAKE24 | 32 | 37 | 37 |
| Min Interview | 9 | 12 | 9 |
| Max Interview | 27 | 27 | 27 |

#### *3.3.2.2 Comparison of estimates of food intake by INTAKE24 and by interviewer-led recall*

Table 3.3 describes the food matches, omissions and intrusions of all the foods entered into INTAKE24 when compared with those recorded in the interviewer-led 24 hour recall. Over 400 food items were recorded as being consumed by the participants. Of these, 73% were exactly matched between the two methods and 14.4% were approximate matches. Almost 9% of all foods which were recorded in the interviewer-led recalls were missing from INTAKE24. Four percent of foods which were recorded in INTAKE24 were not evident in the interviewer-led recalls.

**Table 3.3 Matches, omissions and intrusions of all foods in INTAKE24 when compared with the interviewer-led recall**

| | Number of foods | Percentage of total foods recorded |
|---|---|---|
| Exact match | 295 | 73 |
| Approximate match | 58 | 14.4 |
| Omission | 35 | 8.7 |
| Intrusion | 16 | 4 |
| Total number of foods recorded | 404 | 100% |

Omission – Food item recorded in interviewer-led recall but not in INTAKE24
Intrusion – Food item recorded in INTAKE24 but not in interviewer-led recall

Table 3.4 shows that of the 35 omissions from INTAKE24, the majority of these were drinks and milk in drinks (37.1%) and fruit and vegetables (22.9%). Eleven omissions were due to participants incorrectly adding more than one food per line in the quick list, e.g. ham salad. In these instances, the system could identify only one food item from the description (e.g. ham) and the remaining food items were omitted (e.g. salad items). Table 3.4 also describes the type of foods that were omitted from the interviewer-led recall. The majority of intrusions were drinks and milk added to hot drinks (37.5%) and sugar (25%).

However, of these 16 intrusions, 37.5% were from duplicate entries in INTAKE24 e.g. adding sugar twice to hot beverages.

**Table 3.4 The type of omissions and intrusions from INTAKE24**

| Food Group | Number of Omissions | % Omissions | Number of Intrusions | % Intrusions |
|---|---|---|---|---|
| Butter/ Spreads | 5 | 14.3 | 1 | 6.25 |
| Drinks/ Milk in hot drinks | 13 | 37.1 | 6 | 37.5 |
| Fruit/ Vegetables | 8 | 22.9 | 0 | 0 |
| Breakfast cereals | 3 | 8.6 | 0 | 0 |
| Bread | 2 | 5.7 | 3 | 18.75 |
| Meat/ Meat dishes | 1 | 2.9 | 1 | 6.25 |
| Biscuits/ Cakes/ Desserts | 1 | 2.9 | 0 | 0 |
| Sugar | 0 | 0 | 4 | 25 |
| Additions (Sauces) | 2 | 5.7 | 0 | 0 |
| Miscellaneous | 0 | 0 | 1 | 6.25 |
| Total | 35 | 100% | 16 | 100% |

#### ***3.3.2.3 Comparison of intakes of mass of foods, energy and macronutrients estimated by INTAKE24 and the interviewer-led recall***

Table 3.5 describes the mean nutrient intakes for INTAKE24 and the interviewer-led recall, in addition to the differences in intakes between the two methods. Intakes of the total weight consumed, fat and alcohol calculated from INTAKE24 were below those recorded in the interviewer-led recall. However, there were no significant differences between methods for any of the major macronutrients, which suggests that there was no significant under or over-estimation of nutrient intakes in INTAKE24.

**Table 3.5 Comparison of mean intakes of food, energy and macronutrients estimated by INTAKE24 and the interviewer-led recall**

| | INTAKE24 Mean (SD) | Interview Mean (SD) | Difference (INTAKE24-Interview) | p-value |
|---|---|---|---|---|
| Weight of food (g) | 2842 (342.3) | 2933 (431.5) | -91 | 0.39 |
| Energy (KJ) | 8028 (1850.0) | 7926 (1237.2) | 102 | 0.78 |
| Energy (kcal) | 1907 (439.0) | 1886 (294.0) | 21 | 0.81 |
| Carbohydrate (g) | 249 (58.1) | 235 (54.7) | 15 | 0.17 |
| Protein (g) | 77 (31.9) | 72 (21.4) | -5 | 0.34 |
| Fat (g) | 66 (20.0) | 70 (21.6) | -4 | 0.38 |
| Alcohol (g) | 11 (13.7) | 12 (16.9) | -2 | 0.54 |

SD – Standard Deviation

p-value corresponds to paired samples t-tests

#### *3.3.2.4 Accuracy and precision of INTAKE24*

The Bland-Altman analysis plot for the mean total energy intake is shown in Figure 3.1. The mean difference in total energy intake between INTAKE24 and the interviewer-led recall is represented as the middle horizontal line, whilst the upper and lower limits of agreement are represented as the top and bottom horizontal lines on the plot. Using a one sample t-test, the difference in the mean total energy intake recorded in INTAKE24 and the interviewer-led recall was not statistically significant (p=0.78). When linear regression was applied, no significant proportional bias was found (p=0.07).

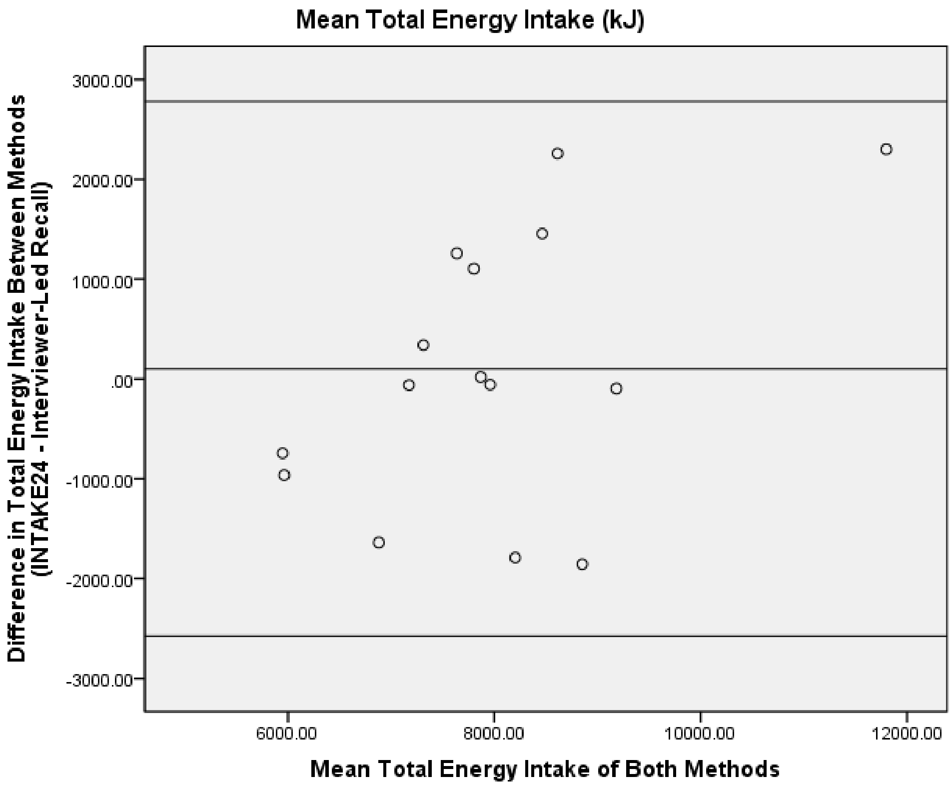



**Figure 3.1 Bland-Altman plot of mean total energy intake (kJ)**

The Bland-Altman plot for the mean daily total weight of food consumed is shown in Figure 3.2. Using a one sample t-test, the difference between the weight of food recorded in INTAKE24 and the interviewer-led recall was not statistically significant (p=0.32). There was also no significant systematic bias between methods (p=0.32).

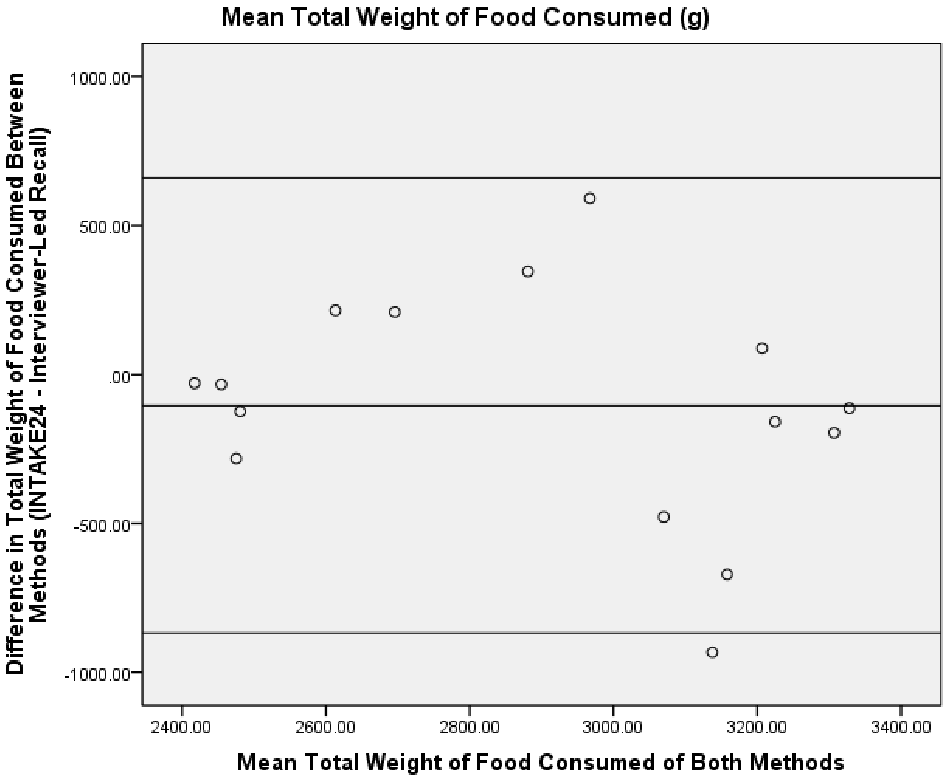



**Figure 3.2 Bland-Altman plot of mean daily total weight of food consumed**

Table 3.6 describes the accuracy and precision of mean daily nutrient intakes estimated using INTAKE24 compared with the interviewer-led recall, calculated as a ratio. Mean intakes of the macronutrients, alcohol and weight of food consumed reported using INTAKE24 were close to those reported in the interviewer-led recall. On average, INTAKE24 was found to over-estimate energy intake by just 0.1%, with the limits of agreement ranging from an under-estimate of 32%, to an over-estimate of 34%, compared with the interviewer-led recall. The widest limits of agreement were for protein, which ranged from an under-estimate of 63%, to an over-estimation of 79%. This is likely to be related to the omissions of meat, milk from drinks, breakfast cereals and bread from INTAKE24, and also from the substitution of meat-based meals for vegetarian alternatives which do not exist in the INTAKE24 system e.g. vegetarian shepherd's pie.

**Table 3.6 Accuracy and precision of food and macronutrient intakes using INTAKE24**

| | Mean Ratio (INTAKE24: Interview) | Limits of Agreement | |
|---|---|---|---|
| | | Lower | Upper |
| Weight of food (g) | 0.98 | 0.72 | 1.24 |
| Energy (KJ) | 1.01 | 0.68 | 1.34 |
| Energy (kcal) | 1.01 | 0.68 | 1.34 |
| Carbohydrate (g) | 1.07 | 0.74 | 1.40 |
| Protein (g) | 1.08 | 0.37 | 1.79 |
| Fat (g) | 0.96 | 0.41 | 1.51 |
| Alcohol (g) | 1.01 | 0.32 | 1.71 |

### *3.3.3 Application of the rMED to dietary data*

The mean rMED score of INTAKE24 data was 6.07 and the mean score of the interviewer-led recall was 6.13. The very small difference in rMED scores (0.06 units) between the two methods was not statistically significant (p=0.87). Figure 3.3 visually displays the range in rMED scores for each dietary assessment method. Scores of foods recorded in INTAKE24 had a slightly greater spread around the mean (SD 2.1) than those for the interview (SD 2.0).

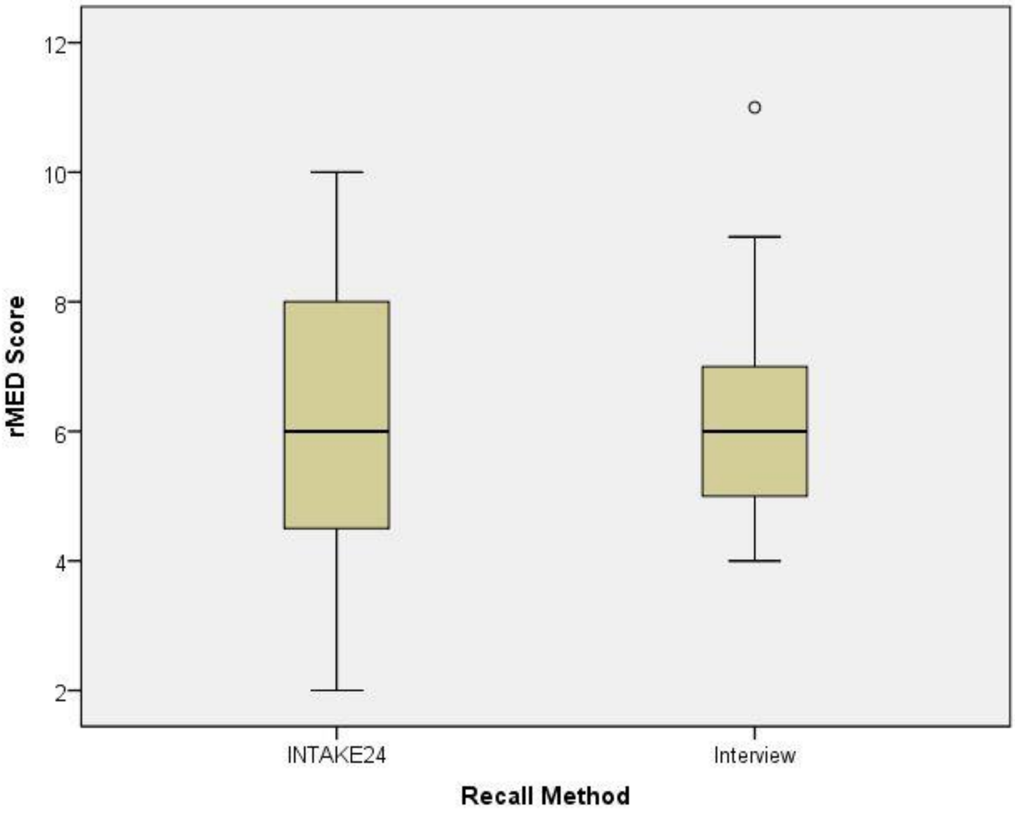



**Figure 3.3 Boxplot of rMED scores for INTAKE24 and for the interviewer-led recall**

### *3.3.4 Participant evaluation*

Table 3.7 describes the participant responses to the SUS, which were categorised as above or below an average value of 68 (Sauro, 2011). One participant did not complete this form and so 14 participants were included in this analysis. Overall, usability of INTAKE24 was evaluated as above average. Scores ranged from 47.5 to 85.

**Table 3.7 System usability scale responses**

| System Usability Scale Points (n=14) | | | |
|---|---|---|---|
| Mean | SD | Below Average | Above Average |
| 73.8 | 10.7 | 4 | 10 |

Not all of the participants left comments in the free text available in the SUS. In response to a question about the prompts for forgotten foods, seven participants described them as useful and helpful. One participant suggested that the prompts should appear only if a food item has been omitted, but this would not be possible, as INTAKE24 does not know the true food intakes of participants prior to testing. The participant who scored the lowest SUS suggested that the system had scope for development. Interestingly, this participant omitted 29% of all omitted foods from INTAKE24 and had the fifth longest completion time, which suggests that this participant had some difficulties in using the system.

Participant responses to the semi-structured interview are included in Appendix S, which are categorised according to the question number. Reassuringly, responses to questions closely matched researcher observations of the participants whilst completing INTAKE24. Data collected from all participant observations and evaluation and approximate matches/ omissions/ intrusions of foods recorded in INTAKE24 were used to produce a list of recommendations for future improvement of the system for use with older adults (see Table 3.8).

### *3.3.5 Direct observations of participants completing INTAKE24*

A table of researcher observations and participants thinking aloud whilst using INTAKE24 is included in Appendix T. These are categorised according to the stage of completion. All 15 participants were observed as having some level of difficulty in at least one stage of using the system. Some technical issues with the system arose, with the position of the page loading in the wrong place being the main source of frustration.

## 3.4 Discussion

### *3.4.1 Main findings*

The main objective of this study was to determine the usability of INTAKE24, a self-completed online 24 hour recall, with retirement-aged adults. Using the SUS score cut-off, 10 out of 14 participants perceived the usability of the system as above average (see Table 3.7). Overall feedback from the semi-structured interview was positive (see Appendix S), with only one participant indicating that they did not like the system very much (which was reflected in the lowest SUS score). However, all of the participants experienced at least one difficulty when completing INTAKE24, either due to technical errors or misunderstanding what the system was asking of them (see Appendix T). To improve the usability of INTAKE24 for older adults in future studies, a number of recommendations were proposed (see Table 3.8 at the end of this chapter).

The third version of INTAKE24 was used in this study, which was developed by colleagues at Newcastle University. When this version was user-tested with twenty 11-24 year olds, the mean completion time was considerably shorter at 13.4 minutes (Foster *et al.*, 2013) than the mean completion time (24.7 minutes) for the older adult participants in the present study (see Table 3.2). However, the average time taken to complete the interviewer-led recall in the younger age group was 14.6 minutes and the mean number of food items recorded by the younger participants was 17.9 (Foster *et al.*, 2013), compared with 26.9 food items recorded by the older participants. This suggests that the main difference in completion times between the groups may be due to the number of foods consumed, rather than the age of the participants. Furthermore, a paired samples t-test found that the mean time taken to complete INTAKE24 by the older age group was significantly associated with the number of foods entered (mean 25.5 foods, p=0.01, correlation=0.78) (see Section 3.3.2.1).

Whilst participants took longer to complete INTAKE24, using the online system offered considerable researcher time-efficiency. Whereas a food and nutrient data output can be quickly and easily downloaded from the researcher interface of the INTAKE24 website, the paper-based recalls required manual coding of foods and portion sizes consumed, entry of these data into Microsoft Excel and the subsequent calculation of food and nutrient intakes. Taking all these steps into consideration, INTAKE24 saved approximately 55 minutes per recall, when compared with the completion of both the participant and researcher duties of the interviewer-led recall. More comparable with the findings in the present study, the mean completion time of the interviewer-administered computerised 24 hour recall, EPIC-Soft, was 22 minutes for Germans aged 14-80 years and 30 minutes for Belgians aged 15-97 years (Huybrechts *et al.*, 2011a).

The second objective of this study was to compare intakes of food and nutrients reported using INTAKE24 with those reported in the interviewer-led recall. Foods recorded in INTAKE24 matched closely those recorded in the interviewer-led recall. Of the 404 food items recorded, 87.4% of those recorded in INTAKE24 were either exact or approximate matches with those recorded in the interviewer-led recall (see Table 3.3). This is comparable with 88% of matching foods recorded by young people (Foster *et al.*, 2013). Amongst older adults, the greatest proportion of omissions from INTAKE24 were drinks (37.1%) and fruit and vegetables (22.9%, see Table 3.4). The high incidence of drinks omissions is likely due to the absence of a facility within INTAKE24, to ask the user whether more than one cup or glass of the same beverage was consumed within the same meal. In comparison, fruit and vegetables were the main source of omissions in tests of the Synchronised Nutrition and Activity Program for Adults (SNAPA) (Hillier *et al.*, 2012) and the Automated Self-Administered 24-hour Recall (ASA24) (Kirkpatrick *et al.*, 2014).

When the rMED score was applied to foods recorded by both dietary assessment methods, no significant differences were found ($p>0.05$). Mean rMED scores were 6 out of a possible 18 points (see Figure 3.3). Comparatively, MEDDINI participants had a higher adherence to the MD at baseline (mean score 8.28, Chapter 2).

No significant differences were found in nutrient intakes between estimates obtained in the interviewer-led recall and those obtained by INTAKE24 (see Table 3.5). Additionally, estimates of intakes

obtained using INTAKE24 were found to be more similar to those from the interviewer-led recall in older than young participants, with an over-estimation of energy intake by just 0.1% (see Table 3.6), which was the same finding as observed when 19-82 year olds used the Oxford WebQ online 24 hour dietary recall (Liu *et al.*, 2011). Young people were less able to accurately record energy intake using INTAKE24 and under-estimated energy by 11%, when compared with an interviewer-led recall (Foster *et al.*, 2013). Furthermore, Bland-Altman analysis showed no evidence of bias between the methods across the range of estimated total daily intakes of energy and the weight of food consumed (see Figure 3.1 and Figure 3.2). This indicates that there were no systematic differences in the estimation of energy and food intake between the two recall methods.

### *3.4.2 Strengths and limitations*

Whilst computerised and online 24 hour recalls have been used previously with older adults (Mennen *et al.*, 2002; Zoellner *et al.*, 2005; Arab *et al.*, 2011; Huybrechts *et al.*, 2011a; Liu *et al.*, 2011; Touvier *et al.*, 2011; Frankenfeld *et al.*, 2012; Hillier *et al.*, 2012; Kirkpatrick *et al.*, 2014), to the researcher's knowledge, the user-testing of INTAKE24 was the first study to compare the usability of a self-completed 24 hour recall system with a paper-based interviewer-led 24-hour recall with older adults.

Data were gathered using several methods, including direct researcher observations, audio recordings, a system usability questionnaire and semi-structured interviews. These provided both quantitative and qualitative data for evaluating INTAKE24. A multi-method approach is beneficial for identifying the majority of problems which may arise when users test a system (Kushniruk *et al.*, 2000). Secondly, a validated interviewer-led 24 hour recall (Nelson *et al.*, 2007; Adamson *et al.*, 2009) was used to test the reliability of INTAKE24. Analysis showed that there was good agreement between the two methods.

Nielsen (1993) suggested that a sample size of five participants is sufficient to identify 85% of usability issues on websites. A sample size of 15 participants was used in this study, which should therefore have had the power to detect most of the difficulties which may be encountered by older adults using INTAKE24. However, the participants involved in this study were generally well educated and frequent internet users. Had the testing been conducted with participants who were less computer-literate, the usability may be lower and, therefore, these results should not be generalised to the whole older adult population.

The nature of this testing meant that participants were able to ask the researcher how to solve problems when they got stuck. This may have affected the user's experience and data entry than if they were completing the recall alone (Jordan, 2000). In addition, system errors, such as navigation problems (e.g. issues with page scrolling) and not understanding instructions may reduce data validity (Wyatt, 2000; Da Costa *et al.*, 2013). Therefore, recommendations to improve these are included in Table 3.8.

Another limitation of the study is that only one round of user-testing was conducted. I had intended to conduct a second round of user testing following improvements to the INTAKE24 website based on participant experiences in the first round. However, in the event, this became impossible due to the unavailability of the website programmers to undertake this additional work. If the list of recommendations for modification had been addressed and the website iteratively tested, then perhaps the usability may have improved and the rate of omissions reduced. For example, had the option been available to add milk to herbal tea and decaffeinated tea and coffee, five milk entries would not have been omitted. Foster *et al*. (2013) conducted four rounds of user-testing INTAKE24 with young people prior to the present study and this improved not only completion times, but also the accuracy and precision of the tool.

### 3.4.3 Conclusions

In the present study, the usability of INTAKE24 was evaluated by older adults. Overall, the system was evaluated as above average and feedback received via a semi-structured interview was positive. Intakes of food, energy and macronutrients reported using INTAKE24 were also compared with an interviewer-led recall. A good level of agreement was observed between the two methods for these variables and no systematic bias was found. Additionally, this study showed that the INTAKE24 method of data collection and its data output were compatible with subsequent use of the rMED method of scoring adherence to the Mediterranean dietary pattern.

However, there is scope for further development to improve the usability and accuracy of INTAKE24, which would be advisable to amend prior to using this tool in a large-scale observational or intervention study. These include adding a set of instructions to improve the user's understanding of the system and removing technical errors, such as setting the webpage to always load at the top of the page.

**Table 3.8 Recommendations for future improvement of INTAKE24 for use with older adults**

| Parts of the system | Recommendations for improvement |
|---|---|
| Instructions | • Alter welcome page instructions to remove school references. Instead of “Were you at school, college, home, work?” use "Were you at home, work, someone else's house, or at a café/ restaurant?"<br>• Add the purpose of the study to the welcome page instructions, including reassurance of anonymity.<br>• Provide an option to make instructions throughout one font size bigger/ bold for those with impaired vision.<br>• Add written instructions/ video at the start, to provide a worked example of how to use the system.<br>• Change "I have finished, continue" buttons to green, to aid completion of each step. |
| Entering foods into meals | • Add an extra meal before breakfast. Name this “early morning snack or drink”, and rename what was “early morning snack or drink” to “mid-morning snack or drink”. |
| Search terms of foods | • Match search term “red bush tea” with tea entries.<br>• Match low fat and full fat margarines with search term "spread". Also add "margarines" and "butter, margarine, oils" groups to the “Search by food category” section for the search term “spread”.<br>• Add doritos, quavers, wotsits, monster munch, skips, pringles and tortilla chips to search term “crisps”.<br>• No matching item returned when searching for “quavers”. They appear in portion size pictures for "Corn snacks e.g. Transform-a-snack" under “Crisps & snacks” section. Perhaps change food name to "Corn snacks e.g. skips, quavers" and link to search terms for skips and quavers.<br>• Match search term “cocoa” to hot chocolate entries. |

| Parts of the system | Recommendations for improvement |
| --- | --- |
| Search terms of foods continued | • Match rocket leaves with search terms “lettuce”, “salad” and “greens”.<br>• Match lettuce with search terms “salad”, “leaves” and “greens”.<br>• Match search term "fruit juice" with fruit juices within system. Currently, mixed fruit juices, ice lollies and fruit canned in juice are returned.<br>• Match search term "tea loaf" to fruit cakes. Currently only teas come up as matching foods.<br>• Match rice cakes with search term “rice crackers”.<br>• Match chocolate biscuits with marshmallow with search term “chocolate teacake”. |
| Missing foods | • Goat's milk (NDNS code 623)<br>• Reduced fat margarine (NDNS code 10043)<br>• Reduced fat margarine with olive e.g. Bertolli light, Flora pro activ olive (NDNS code 10042)<br>• Vegetarian hot dogs/ frankfurters (NDNS code 9572)<br>• Juice from lemons (NDNS code 2064) and limes (NDNS code 2065)<br>• Spreadable butter (NDNS code 9407)<br>• Light spreadable butter (NDNS code 3891)<br>• Vegetarian shepherd's pie (NDNS code 8589) |
| Portion sizes/ pictures | • Add ability to enter more than one glass/ cup/ mug for drinks e.g. hot beverages, alcohol, fruit juice, fizzy drinks, water and energy drinks.<br>• Make the ability to add fractions for countable foods more obvious. |

| Parts of the system | Recommendations for improvement |
|---|---|
| | • Add sizes of pizza in inches to pictures.<br>• Line up bowls straight as done for mugs, for easier size comparison.<br>• Consider increasing the portion size of cauliflower (when eaten as cauliflower cheese) |
| Prompts | • Add pickles and chutneys to list of matching foods for the prompt for sauces with poppadoms.<br>• Change prompt for sugar/ sauce on porridge to sugar/ honey/ syrup.<br>• Add button "I have already entered it" on prompts for items previously added that are commonly consumed with other items.<br>• Add prompt for milk in decaf tea and coffee.<br>• Remove prompt for leftovers of baked potatoes as there are no leftovers pictures (Currently if option to add leftovers is selected, nothing happens on-screen). |
| Technical issues | • Set the website to automatically load pages from the top. On laptops, the whole page does not fit on-screen and is loaded in the same position as on the previous page - so when scrolling down to select the portion size, the instructions/ prompts at the top of the next page are not visible.<br>• Start food matching & selecting portion sizes of meals in a chronological order.<br>• Load the picture for the option of jam spread on bread (when presented side by side with spoonfuls).<br>• Highlight individual bounty chocolate bars when the cursor is moved over them in guide picture.<br>• Highlight individual lion/ toffee crisp/ drifter chocolate bars when the cursor is moved over them in guide picture.<br>• Highlight individual chocolate biscuits with marshmallow when the cursor is moved over them in guide picture and add option to select whole numbers/ fractions consumed. |

# Chapter 4 Relative validation of INTAKE24

When user-testing of INTAKE24 was conducted with adults in the peri-retirement window (described in Chapter 3), the results indicated that the tool was both acceptable to, and provided reliable estimates of dietary intake with, this age group. On average, participants evaluated the usability of INTAKE24 as above average and there was a good level of agreement between estimated intakes of foods and nutrients reported using the tool, when compared with an interviewer-led recall. However, this earlier study was conducted over a single day and such short-term assessments are unlikely to be representative of an individual's habitual diet. To address the day-to-day variability in dietary intake, multiple days of recall are needed to measure average food and nutrient intakes (Basiotis *et al.*, 1987). A validated tool which can accurately estimate dietary intake is essential for assessing the effectiveness of dietary interventions (Ma *et al.*, 2009).

For the first time with older adults, this chapter describes the comparison of dietary intake recorded in four 24 hour dietary recalls using the most recent version of INTAKE24 with four interviewer-led recalls. This study was not intended to be a full validation of the system, but to provide a comparison of INTAKE24 with a validated reference method, over a longer duration and with a larger sample size than was utilised in the user-testing study (Chapter 3). This relative validation study was performed with a view to determining whether INTAKE24 would be suitable for assessing dietary intake (and, in particular, adherence to the Mediterranean diet) among older people.

### *4.1.1 Objectives*

The aims of this chapter were:

1. To determine the relative validity of INTAKE24 in assessing intake of foods, energy and macronutrients by adults in the peri-retirement window.
2. To determine the relative validity of INTAKE24 in assessing adherence to the Mediterranean diet by adults in the peri-retirement window.

In order to fulfil these aims, the following objectives were established:

1. To compare mean daily intakes of foods, energy and macronutrients reported by four recalls using INTAKE24 with those reported in four comparable interviewer-led recalls, conducted on the same days.

2. To assess adherence to a Mediterranean diet by applying the Relative Mediterranean Diet score (rMED) to mean food and nutrient intakes from the four recording days.

## 4.2 Methodology

### *4.2.1 Participant recruitment*

Ethics approval for the study was provided by Newcastle University's Faculty of Medical Sciences Ethics Committee in February 2014 (reference number 00629_1/2014). A sample size calculation was performed, based on a Type I error of 5% and the standard deviation of 3416 kJ of the difference in mean total energy intake between INTAKE24 and interviewer-led recalls, reported by young people in a similar comparison study of INTAKE24 (Foster *et al.*, 2014a). With a statistical power of 80% to detect a difference in mean energy intake of 1550 kJ reported by the two methods, 30 participants were required. Allowing for 20% attrition, the aim was to recruit 36 participants aged 55-70 years.

Recruitment emails were sent to members of the Elders Council of Newcastle and to participants who had either previously taken part in, or were ineligible to take part in other research studies conducted by the Human Nutrition Research Centre. The study was also advertised to members of VOICENorth on their website (http://www.ncl.ac.uk/ageing/partners/voicenorth/#joinin). Additionally, the researcher manned a stall at a retirement event held at Newcastle University, displaying recruitment posters (see Appendix U) and discussing the study with delegates. Participants were also recruited via personal contacts and word of mouth.

To take part in the study, participants were required to be aged from 55-70 years (based on the operationalised age for the peri-retirement window) and to have regular internet access via a laptop, computer or tablet and an active email address for correspondence with the researcher. A stratified sampling technique was employed to recruit participants with an approximately equal mix of gender and an even spread of age (with approximately 12 participants recruited to each age group of 55-59, 60-64 and 65-70).

### *4.2.2 Data collection*

This study was conducted between October and December 2014. All participants had given consent (see Appendix L) and had read the participant information sheet (see Appendix V) prior to taking part. Participants were asked to complete both INTAKE24 and an interviewer-led recall on the same day, over four non-consecutive days within one month.

On the first recording day, participants were invited individually to attend the Campus for Ageing and Vitality, Newcastle University for approximately one hour during working hours. The order of administering INTAKE24 or the interviewer-led recall first was randomised prior to the appointment. At this appointment, participants were asked to complete a demographics and lifestyle behaviours questionnaire (see Appendix O). The Index of Multiple Deprivation (IMD) quintile was calculated as a measure of socio-economic status, based on the participants' post codes (University of Oxford, 2014). Height was measured to 0.1 cm with a Leicester portable height measure (Chasmors Ltd., London) and weight was measured to 0.1kg using Tanita scales (Type TBF-300 MA, Chasmors Ltd., London). Body mass index was calculated as weight (kg)/height ($m^2$). Participants were asked to recall all foods and drinks consumed on the previous day from midnight to midnight for the interviewer-led recall, using the same protocol as described in Section 3.2.3.3 of Chapter 3. The Young Person's Food Atlas for Secondary school-aged children (Foster *et al.*, 2010) was used to estimate the amount of food consumed.

Participants were again asked to recall all items consumed on the previous day and record these by self-completing INTAKE24 on a laptop provided, using their unique user name and password at the website address https://intake24.co.uk/surveys/livewell. During the five months between the user-testing (Chapter 3) and relative validation (this chapter) studies, INTAKE24 was modified to incorporate more colour in its interface, to remove some glitches, to update some search terms of foods and to make it compatible with tablets. As feedback and observations from user-testing showed that all participants struggled with at least one aspect of completing INTAKE24, separate sets of instructions were produced for laptops/ computers and tablets. These included colour screen shots of the final version of the system at each stage of completion, with instructions incorporating the areas of difficulty identified from user-testing (Chapter 3, see Appendix W for an example of the computer instructions). Participants were given the opportunity to read these instructions prior to completing INTAKE24. Researcher observations of any difficulties or technical errors encountered whilst using the system were recorded.

Upon completion of INTAKE24, participants were asked to evaluate the website using the System Usability Scale (SUS), as described in Section 3.2.3.5 of Chapter 3 (see Appendix R). In this questionnaire, space was provided to give participants the option to add free text to further evaluate INTAKE24. A question was added to this section to ask about their opinions of the instruction booklet composed for this study.

Participants were then informed that the three remaining recording days would occur over the next three weeks, with at least one reporting on a weekend day's food intake. Instructions were given to maintain the same order of administration as used on the first recording day. To reduce costs of running the study and to evaluate the acceptability, usability and relative validity of INTAKE24 in the real world, the remaining recalls were completed at home, without the presence of the researcher. The interviewer-led recalls were conducted over the telephone, with both the researcher and participant using a food photograph atlas to estimate portion sizes. The researcher instructed the participant to turn to specific pages with pictures of foods consumed by the participant and then asked them to report the image codes representing the portion sizes consumed of those foods. The dates of the remaining recording days and times to complete the telephone interviews were arranged according to participant availability. A copy of the INTAKE24 instructions, a food photograph atlas and a stamped addressed envelope to return the atlas to the researcher were provided, as well as a letter detailing the order of randomisation, the dates and times to complete the recalls and the website address and login details (see Appendix X for an example of when INTAKE24 was administered first). The researcher also provided contact details in case participants encountered any problems with using INTAKE24 or needed to change their recording days. A protocol of this appointment schedule is included in Appendix Y.

Participants were sent reminders by email or text on their recording days to aid the completion rate. The time taken to complete each interviewer-led recall was recorded on a stopwatch at the first recall and identified from the telephone call duration for the three subsequent recalls. The time taken to complete each recall submitted to INTAKE24 was provided automatically in the system output. Participants were asked whether they experienced any difficulties using INTAKE24 after each recall. Once participants had completed all four recording days and had returned the food photograph atlas to the researcher, they were sent a £10 gift card for a local shopping centre, as a token of appreciation for taking part.

### *4.2.3 Data analysis*

#### *4.2.3.1 Participant characteristics*

SPSS statistical software (version 21, IBM, USA) was used to generate descriptive statistics i.e. the mean and standard deviation (SD) for participant age and BMI. Frequency tables were produced to characterise the number and percentage of participants in categories of gender, marital status, IMD quintile, ethnicity, occupational status, educational attainment, BMI (World Health

Organisation, 2000), frequency of internet use and the number of devices on, and the places from, which participants accessed the internet.

#### *4.2.3.2 Coding of food items from interviewer-led recalls*

Food items recorded in the interviewer-led recalls were assigned food codes according to comparable foods in the Year 4 NDNS Rolling Programme Nutrient Databank (NatCen Social Research *et al.*, 2015). Where items could not be matched exactly, the nearest matching food was chosen. Food portion sizes were identified from the Young Person's Food Atlas food codes and searched for within the accompanying Microsoft Access database.

#### *4.2.3.3 Time taken to complete INTAKE24 and the interviewer-led recall*

The mean time taken to complete all four recalls using INTAKE24 and the mean time taken to complete the four interviewer-led recalls were calculated for each participant. The means of the times taken to complete INTAKE24 and for the interviewer-led recall were then calculated and a paired samples t-test was performed to test for a difference between the two methods. In addition, Pearson correlation was used to assess whether the group mean completion times were associated with the mean number of foods recorded.

#### *4.2.3.4 Comparison of estimates of food intake by INTAKE24 and by interviewer-led recall*

Using Microsoft Excel, the INTAKE24 and interviewer-led 24 hour recalls from corresponding recording days for each participant were compared to determine the numbers of food matches, omissions and intrusions. An exact match was defined as the same food item being reported in INTAKE24 as was recorded in the interviewer-led recall. An approximate match was defined as the same food but a slightly different variant, either by the type of food (e.g. semi-skimmed milk entered into INTAKE24 and skimmed milk recorded in the interviewer-led recall), or by the cooking method (e.g. raw tomatoes recorded in INTAKE24 and grilled tomatoes recorded in the interviewer-led recall). An omission was defined as a food recorded in the interviewer-led recall but not in INTAKE24, whilst an intrusion was defined as a food recorded in INTAKE24 but not in the interviewer-led recall.

#### *4.2.3.5 Comparison of intakes of mass of foods, energy and macronutrients estimated by INTAKE24 and the interviewer-led recall*

The mass of food, energy and macronutrients consumed were expressed as mean total daily intakes for each participant. Paired samples t-tests were conducted to compare the mean daily mean weight of food, energy and nutrient intakes recorded in INTAKE24 with those recorded in the interviewer-led recall. The variables included in this analysis were the weight of food, energy, carbohydrate, fat, protein and alcohol, all expressed as total daily intakes.

#### *4.2.3.6 Accuracy and precision of INTAKE24*

The Bland-Altman method (Bland and Altman, 1986) was used to investigate systematic differences in reported mean daily total food weight and energy intake between INTAKE24 and the interviewer-led recalls. Firstly, the difference in mean daily total intake reported in INTAKE24 and the interviewer-led recalls was calculated and tested for significance using one-sample t-tests. The means and standard deviations from these tests were used to calculate upper and lower limits of agreement (to measure the precision of INTAKE24). These were calculated by: $d \pm 2s$ (where $d$ = mean difference in mean daily total nutrient intake and $s$ = the standard deviation of the difference). Bland-Altman plots for the mean daily total food and nutrient intakes were produced, where the difference between methods was plotted against the mean of both methods for each participant. Lines representing the mean, upper and lower limits of agreement of the difference in mean total daily intakes were added. Linear regression was used to test for systematic bias in the difference between recall methods related to total intake.

A ratio of the mean total daily nutrient intakes reported using INTAKE24 to those reported in the interviewer-led recall, was calculated for each participant. A ratio of less than one indicated an under-estimation of nutrient intake by INTAKE24 and a ratio of more than one indicated an over-estimation. A value of exactly one indicated an exact agreement between the two methods. Upper and lower limits of agreement were applied, using the same method described above, so that 95% of the differences in mean intakes would lie between the limits. As the majority of variables were not normally distributed (identified using the Shapiro-Wilk test), the ratios were logarithmically transformed (except for the mean daily total weight of food consumed). The values presented are the geometric mean ratios (i.e. the antilog of the mean log ratio).

Estimates of energy misreporting by participants were obtained for both methods of 24 hour recall, using the energy intake (EI) to predicted basal metabolic weight (BMR) approach. Using BMR equations for males (0.0543 x weight kg + 2.37) and females (0.0429 x weight kg + 2.39) aged 60-70 years (Henry, 2005), the ratio of EI to BMR (EI: BMR) was calculated. An EI: BMR cut-off of 1.06 was applied to identify under-reporting (Goldberg *et al.*, 1991) and a cut-off of 2.11 applied to identify over-reporting (Sánchez-Castillo *et al.*, 2001) of mean daily total energy intake.

#### *4.2.3.7 Application of the rMED to dietary data*

To measure participant adherence to a Mediterranean diet, the Relative Mediterranean diet score (rMED) (Buckland *et al.*, 2010) was applied to mean total daily food intake, and measures of adherence between the two methods of dietary recalls were compared.

The food items recorded by participants in INTAKE24 and the interviewer-led recall were categorised into the food groups which featured in the rMED and expressed as total daily intakes (g)/1000kcal (except for olive oil and alcohol). The method of calculating the rMED is included in Appendix E.

For the purposes of this study, a slight modification was made to the scoring system of three food groups within the rMED, based on the reported participant intakes. In the usual rMED calculation, the legumes and fresh fish food groups are scored according to tertiles of intakes. As these foods were not consumed by the majority of participants in the present study, the tertile allocation was heavily skewed. Therefore, the same method used for calculating the olive oil intake score (Chapter 2) was adopted for legumes and for fresh fish. In essence, non-consumers were awarded zero points and the participants who consumed above and below the median were awarded two points or one point respectively. Only one participant recorded consuming olive oil in INTAKE24 and, for this food group, non-consumers were awarded no points and the sole consumer was awarded two points.

Points assigned to the nine food groups were summed and differences in the mean rMED scores between INTAKE24 and the interviewer-led recall were tested using paired samples t-tests. A boxplot was created to visualise the spread of scores between methods.

#### *4.2.3.8 Participant evaluation*

Responses to statements within the System Usability Scale (SUS) were assigned points ranging from 0-4. For positively phrased statements (item numbers 1, 3, 5, 7 and 9), the score is the position on the 5-point Likert scale minus one point. For example, a “strongly agree” response to the question “I thought the system was easy to use” would result in 4 points. For negatively phrased statements (item numbers 2, 4, 6, 8 and 10), the score is 5 minus the position on the Likert scale (e.g. the response “strongly agree” to the question “I found the system unnecessarily complex” would result in 0 points). The scores were then summed and multiplied by 2.5 to ascertain the overall system usability value on a scale of 0-100 (Brooke, 1996). SUS scores above 68 were categorised as above average and scores below 68 were categorised as below average (Sauro, 2011).

## 4.3 Results

### *4.3.1 Participant flow and characteristics*

Thirty three participants were recruited to the study. After consenting to take part, three participants withdrew due to illness before arranging their first appointment. Therefore, 30 participants took part in the study. Half of the group were randomised to complete the dietary recall using INTAKE24 first and half were randomised to complete the interviewer-led recall first. All participants adhered to the same order of administration for all of their recording days. Although all the participants completed four days' dietary recall on the arranged days, one of the recalls using INTAKE24 was not submitted properly to the server for two participants and did not generate a data output. The comparative interviewer-led recalls from these two days were rejected from the analysis, leaving a total of 238 recalls measuring dietary intake over 119 days included in the analysis.

The mean age of the participants was 62.9 years (SD 5.09) and the mean BMI was 27.6 (SD 6.26). Table 4.1 shows the demographic characteristics of the participants. Fifty seven percent of participants were female and the same proportion was categorised as overweight or obese (World Health Organisation, 2000). The majority of participants were married (53%), retired (55%), educated to degree level (60%) and of white ethnicity (97%). Appendix Z provides further information on the participants' internet usage. The majority of participants used the internet every day or almost every day (93%) and accessed the internet via one device (37%) both inside and outside the home (73%).

**Table 4.1 Participant demographic characteristics**

| Characteristic (n=30) | Category | N | % Participants |
|---|---|---|---|
| Gender | Males | 13 | 43.3 |
| | Females | 17 | 56.7 |
| BMI | Normal weight | 13 | 43.3 |
| | Overweight | 10 | 33.3 |
| | Obese | 7 | 23.3 |
| Marital Status | Married | 12 | 40 |
| | Remarried | 4 | 13.3 |
| | Legally separated/ Divorced | 5 | 16.7 |
| | Widowed | 3 | 10 |
| | Single | 5 | 16.7 |
| | Cohabiting | 1 | 3.3 |
| IMD Quintile | 1 (least deprived) | 15 | 50 |
| | 2 | 3 | 10 |
| | 3 | 5 | 16.7 |
| | 4 | 2 | 6.7 |
| | 5 (most deprived) | 5 | 16.7 |
| Ethnicity | White | 29 | 96.7 |
| | Non-white | 1 | 3.3 |
| Occupational Status (n=29) | Retired | 16 | 55.2 |
| | Working full-time | 4 | 13.8 |
| | Working part-time | 3 | 10.3 |
| | Self-employed | 4 | 13.8 |
| | Unemployed | 1 | 3.4 |
| | Unable to work | 1 | 3.4 |
| Educational attainment | O-Levels/ A-Levels | 4 | 13.3 |
| | Undergraduate degree | 10 | 30.3 |
| | Postgraduate degree | 9 | 30 |
| | Professional qualifications | 7 | 23.3 |

### 4.3.2 INTAKE24 vs. interviewer-led recall

#### 4.3.2.1 Time taken to complete assessments

The times taken to complete the recalls using INTAKE24 were downloaded from the system output. However, for 10 recalls, the reported time taken to complete these recalls was extremely long. The majority of these participants reported experiencing technical issues with INTAKE24, whereby when they logged on to complete a recall, the system still had the list of foods onscreen which were entered during the previous recall. Therefore, these 10 recall times were excluded from the analysis and the mean time taken for each participant to complete the recall using INTAKE24 was calculated from between two and four recalls.

Table 4.2 describes the mean, minimum and maximum times taken to complete both dietary assessment methods for all participants. There was little difference between the randomisation order and the time taken to complete each method. However, the group mean of the within-person mean time taken to complete the recalls using INTAKE24 was significantly longer (by 4 minutes) than the time taken to complete the interviewer-led recalls ($p<0.001$). The number of foods recorded in the interviewer-led recall was correlated significantly with its completion time (mean 26.1 foods, $p=0.001$, correlation=0.56), whilst this correlation was not significant for INTAKE24 (mean 25.8 foods, $p=0.06$, correlation=0.35).

**Table 4.2 Mean, minimum and maximum times to complete INTAKE24 and the interviewer-led recalls**

| | Randomisation Order | | |
|---|---|---|---|
| Time (min) | INTAKE24 first (n=15) | Interview first (n=15) | All (n=30) |
| Mean INTAKE24 | 21.4 | 21.3 | 21.3* |
| Mean Interview | 16.7 | 17.8 | 17.2 |
| Min INTAKE24 | 8 | 9 | 8 |
| Max INTAKE24 | 40 | 38 | 40 |
| Min Interview | 10 | 10 | 10 |
| Max Interview | 34 | 35 | 35 |

*Excludes 10 individual recalls (out of a total of 118 recalls), where the time to complete the task was not determined reliably, because of technical issues with the INTAKE24 system.

#### *4.3.2.2 Comparison of estimates of food intake by INTAKE24 and by interviewer-led recall*

Table 4.3 shows the food matches, omissions and intrusions of all the foods entered into INTAKE24 when compared with those recorded in the interviewer-led 24 hour recalls. Almost 3300 food items were recorded as being consumed by the participants. Of these, 71% matched exactly between the two methods and 13.4% matched approximately. Almost 10% of all foods which were recorded in the interviewer-led recalls were missing from the recalls using INTAKE24. Six percent of foods which were entered into INTAKE24 were not recorded in the interviewer-led recalls.

**Table 4.3 Matches, omissions and intrusions of all foods in INTAKE24 when compared with the interviewer-led recall**

| | Number of foods | Percentage of total foods recorded |
|---|---|---|
| Exact match | 2330 | 71 |
| Approximate match | 438 | 13.4 |
| Omission | 311 | 9.5 |
| Intrusion | 201 | 6.1 |
| Total number of foods recorded | 3280 | 100% |

Omission – Food item recorded in interviewer-led recall but not in INTAKE24
Intrusion – Food item recorded in INTAKE24 but not in interviewer-led recall

Table 4.4 shows that of the food omissions and intrusions from INTAKE24, the majority were from drinks (19% of omissions, 25% of intrusions), milk added to hot beverages and cereals (20% of omissions and intrusions), fruit, vegetables and legumes (21.5% of omissions, 14% of intrusions) and butter and spreads (8% of omissions, 12% of intrusions).

Three participants reported technical errors with INTAKE24, where they were asked to choose portion sizes twice for foods in the same meals. These contributed to the 100 foods omitted from the interviewer-led recalls (50% of all intrusions) which were duplicates of foods and entire meals/ snacks previously entered in INTAKE24. The second greatest proportion of omissions from INTAKE24 was from milk. Of these 62 items, 36 (58%) were due to the inability to add milk to decaffeinated tea or coffee and herbal drinks in the system.

**Table 4.4 Foods contributing to omissions and intrusions from INTAKE24**

| Food Group | Number of Omissions | % Omissions | Number of Intrusions | % Intrusions |
|---|---|---|---|---|
| Drinks | 59 | 19 | 51 | 25.4 |
| Milk | 62 | 19.9 | 40 | 19.9 |
| Alcohol | 4 | 1.3 | 1 | 0.5 |
| Fruit/ Vegetables/ Legumes | 67 | 21.5 | 28 | 13.9 |
| Butter/Spreads | 26 | 8.4 | 25 | 12.4 |
| Bread/ Crackers/ Grains | 10 | 3.2 | 17 | 8.5 |
| Breakfast cereals | 5 | 1.6 | 2 | 1 |
| Sauces/ Oil/ Vinegar | 25 | 8 | 8 | 4 |
| Sugar | 5 | 1.6 | 12 | 6 |
| Meat | 9 | 2.9 | 2 | 1 |
| Cheese/ Yoghurt | 14 | 4.5 | 3 | 1.5 |
| Nuts | 2 | 0.6 | 3 | 1.5 |
| Eggs | 1 | 0.3 | 3 | 1.5 |
| Fish | 2 | 0.6 | 2 | 1 |
| Chocolate/ Sweets | 5 | 1.6 | 0 | 0 |
| Crisps | 3 | 1 | 0 | 0 |
| Other | 6 | 1.9 | 2 | 1 |
| Total | 311 | 100% | 201 | 100% |

#### *4.3.2.3 Comparison of intakes of mass of foods, energy and macronutrients estimated by INTAKE24 and the interviewer-led recall*

Table 4.5 summarises the mean daily energy and macronutrient intakes estimated using data from the INTAKE24 and the interviewer-led recalls. In addition, Table 4.5 details the differences in mean daily intakes between the two methods. Estimates of the mean daily total weight of food consumed and fat intake reported in INTAKE24 were slightly less than those recorded in the interviewer-led recall. However, there were no significant differences between methods for any of the variables, which suggests that there was no significant under or over-estimation of the mass of food consumed, energy and macronutrient intakes recorded in INTAKE24, compared with the interviewer-led approach.

**Table 4.5 Comparison of mean intakes of food, energy and macronutrients estimated by INTAKE24 and the interviewer-led recall**

| | INTAKE24 | | Interview | | Difference (INTAKE24-Interview) | p-value |
|---|---|---|---|---|---|---|
| | Mean | (SD) | Mean | (SD) | | |
| Weight of food (g) | 3187 | (670.2) | 3266 | (588.6) | -79 | 0.29 |
| Energy (kJ) | 8717 | (3494.5) | 8395 | (2099.3) | 322 | 0.54 |
| Energy (kcal) | 2073 | (831.5) | 2008 | (486.0) | 65 | 0.60 |
| Carbohydrate (g) | 255 | (124.9) | 237 | (67.7) | 18 | 0.22 |
| Protein (g) | 77 | (23.1) | 75 | (18.8) | 2 | 0.52 |
| Fat (g) | 78 | (41.1) | 80 | (31.6) | -1 | 0.85 |
| Alcohol (g) | 15 | (15.1) | 15 | (15.2) | 0 | 0.91 |

SD – Standard Deviation

p-value corresponds to paired sample t-tests

#### *4.3.2.4 Accuracy and precision of INTAKE24*

The Bland-Altman analysis plot for the mean daily total energy intake is shown in Figure 4.1. The mean difference in mean daily total energy intake between INTAKE24 and the interviewer-led recalls is represented as the middle horizontal line, whilst the upper and lower limits of agreement are represented as the top and bottom horizontal lines on the plot. When linear regression was applied, a significant proportional bias was found (p=0.02), likely due to an outlier of extreme energy intake (highlighted in Figure 4.1) which skewed the data. This participant reported consuming almost twice as much energy using INTAKE24 as in the interviewer-led recalls. This was due to a large number of intrusions from duplicating several meals or snacks each day.

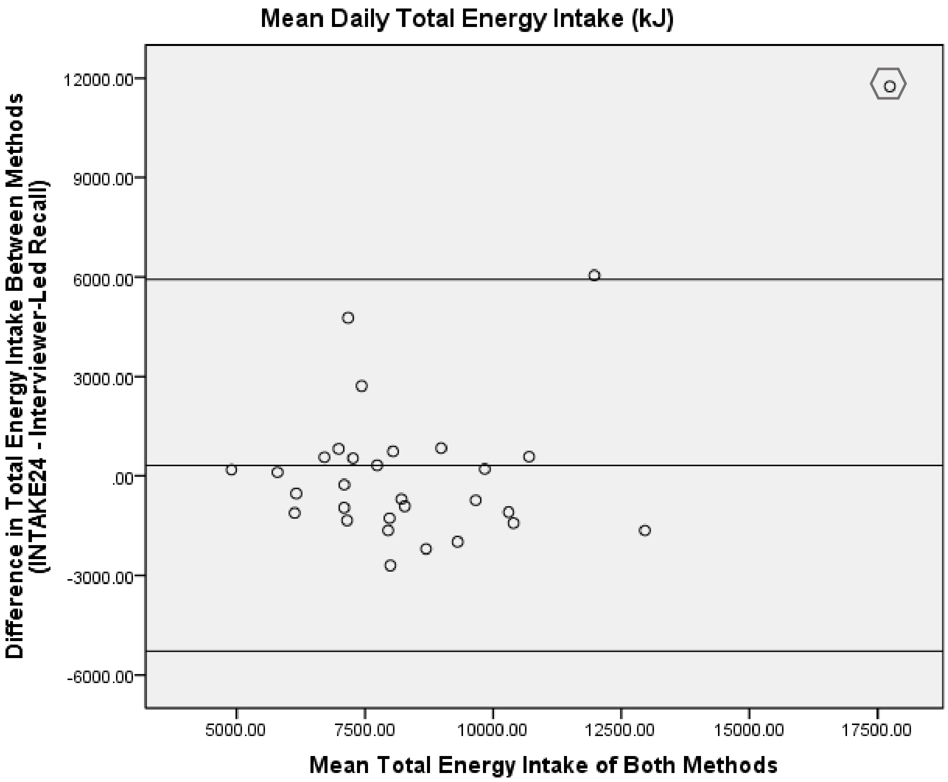



**Figure 4.1 Bland-Altman plot of mean daily total energy intake (kJ)**

The Bland-Altman analysis for mean daily total energy intake was rerun after excluding the extreme outlier of energy intake (see Figure 4.2). This demonstrated that the mean difference of -72.2 kJ between the mean daily total energy intake reported in INTAKE24 and the interviewer-led recall was not significant using the one-sample t-test (p=0.84). In addition, linear regression showed that there was no longer any significant proportional bias in estimates of energy intake between the 2 methods (p=0.81). These observations suggest that there was good agreement between INTAKE24 and the interviewer-led recall for the reported total energy intake, across a three-fold range in estimated energy intake.

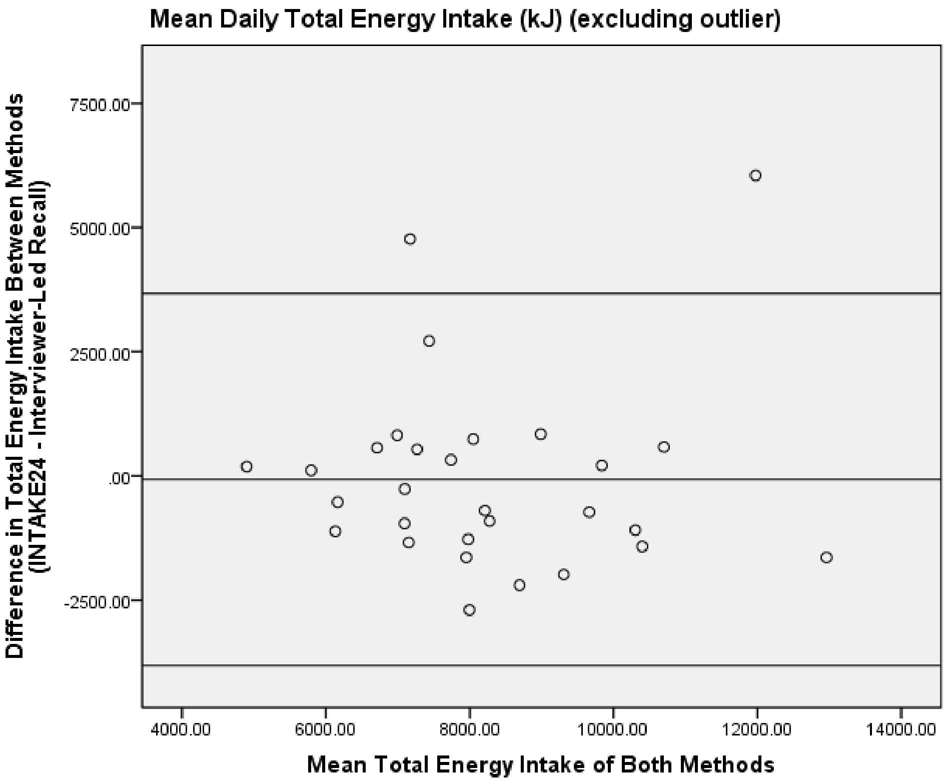



**Figure 4.2 Bland-Altman plot of mean daily total energy intake (kJ), excluding the extreme outlier**

The Bland-Altman plot for the mean daily total weight of food consumed is shown in Figure 4.3. The difference in the weight of food recorded in INTAKE24 and the interviewer-led recall was not statistically significant (p=0.29). In addition, there was no significant systematic difference between methods across the range of intakes (p=0.25). Notably, the outlier of energy intake observed in Figure 4.1 did not skew the data for the total weight of food consumed shown in Figure 4.3. This was because this participant had an energy-dense diet, mostly comprised of bread rolls, butter and sugar added to hot beverages. These observations suggest that there was good agreement between INTAKE24 and the interviewer-led recall for the reported total food mass of food consumed.

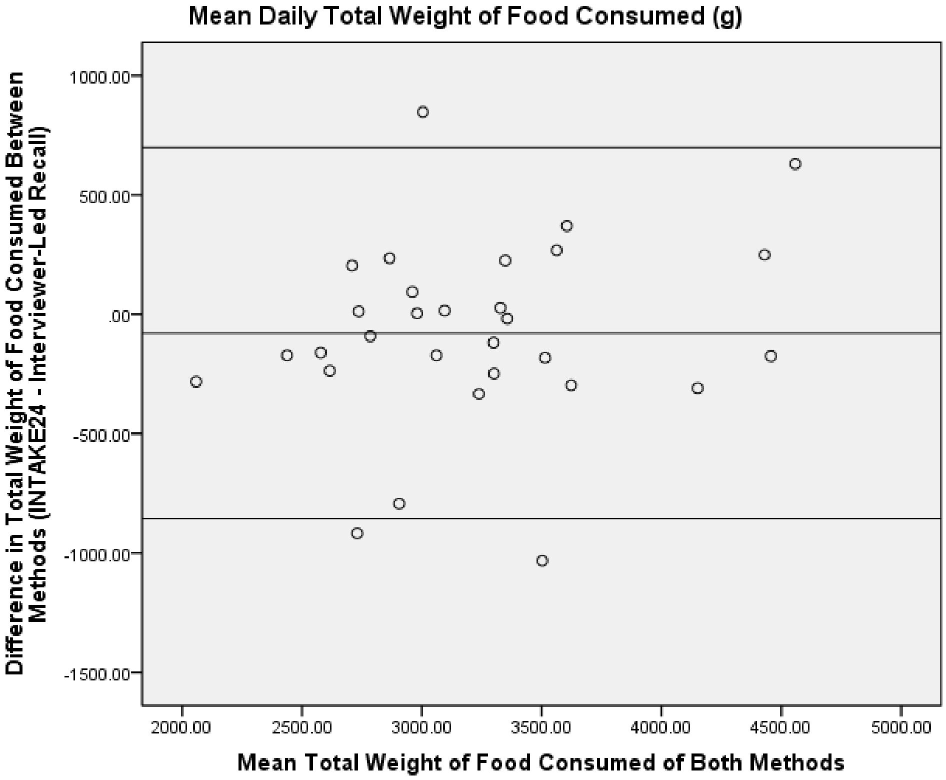



**Figure 4.3 Bland-Altman plot of mean daily total weight of food consumed**

Table 4.6 describes the accuracy and precision of mean daily nutrient intakes estimated using INTAKE24 compared with the interviewer-led recall, calculated as a ratio. Mean intakes of the macronutrients, alcohol and weight of food consumed reported using INTAKE24 were close to those reported in the interviewer-led recall. On average, INTAKE24 over-estimated energy intake (kJ) by just 0.2%, with the limits of agreement ranging from an under-estimate of 38%, to an over-estimate of 67%, compared with the interviewer-led recall. The widest limits of agreement were for alcohol, which ranged from an under-estimate of 55%, to an over-estimation of 132%. This was due to both the omission of alcoholic beverages from one of the methods and the inability to specify whether more than one glass of the same drink was consumed within the same meal in INTAKE24 (unless specifically entered more than once).

**Table 4.6 Accuracy and precision of mean daily total food and macronutrient intakes using INTAKE24**

| | | Limits of Agreement | |
|---|---|---|---|
| | Mean Ratio (INTAKE24: Interview) | Lower | Upper |
| Weight of food (g) | 0.98 | 0.74 | 1.22 |
| Energy (kJ) | 1.02 | 0.62 | 1.67 |
| Energy (kcal) | 1.01 | 0.63 | 1.60 |
| Carbohydrate (g) | 1.04 | 0.71 | 1.52 |
| Protein (g) | 1.02 | 0.68 | 1.52 |
| Fat (g) | 0.95 | 0.47 | 1.93 |
| Alcohol (g) | 1.02 | 0.45 | 2.32 |

Table 4.7 describes the number of under- (UR) and over-reporters (OR) of mean daily total energy intake (kJ) when cut-offs were applied (Goldberg *et al.*, 1991; Sánchez-Castillo *et al.*, 2001). The same number of participants over-reported energy intake in INTAKE24 as the interviewer-led recall, whereas 6 more participants under-reported energy intake in the interviewer-led recall than in INTAKE24. Energy under-reporters were more likely to be female.

**Table 4.7 Numbers of under- and over-reporters of energy intake estimated using INTAKE24 and interviewer-led recall**

| | INTAKE24 | | Interview | |
|---|---|---|---|---|
| | UR | OR | UR | OR |
| Males (n=13) | 1 | 1 | 2 | 1 |
| Females (n=17) | 4 | 1 | 6 | 1 |
| All (n=30) | 5 | 2 | 8 | 2 |

UR - Under-reporter

OR - Over-reporter

One third of all participants were identified as under-reporters of energy intake for either one or both methods of 24 hour dietary recall (see Figure 4.4). Of these 10 participants, three under-reported energy in both INTAKE24 and the interviewer-led recalls. Two under-reported energy intake only when using INTAKE24, whereas five under-reported energy intake in the interviewer-led recalls only. Of the under-reporters using INTAKE24, 87.5% were overweight or obese, whereas 80% of under-reporters from the interviewer-led recalls were overweight or obese. Four participants were identified as energy over-reporters, all of whom over-reported energy intake in one of the recall methods.

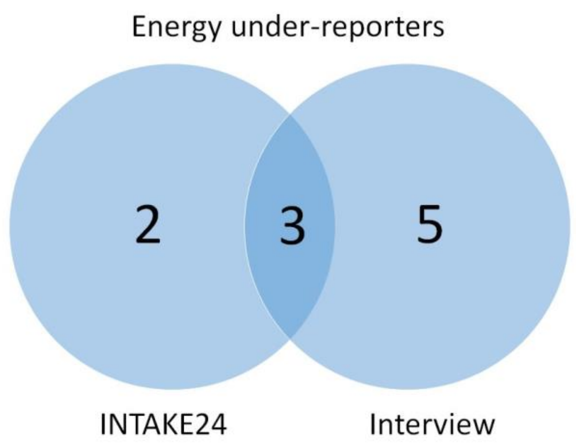



**Figure 4.4 Numbers of participants who under-reported energy intake, for either one or both dietary recall methods**

### *4.3.3 Application of the rMED to dietary intake data obtained using both approaches*

The mean rMED score derived from data obtained by INTAKE24 was 7.27 and the mean score from the interviewer-led recall was 7.33. The very small difference (0.06 units) between methods for rMED scores was not statistically significant (p=0.86). Figure 4.5 visually displays the range in rMED scores for each dietary assessment method. Scores of foods recorded in the interviewer-led recall had a slightly greater spread around the mean (SD 3.1) than those reported using INTAKE24 (SD 2.7).

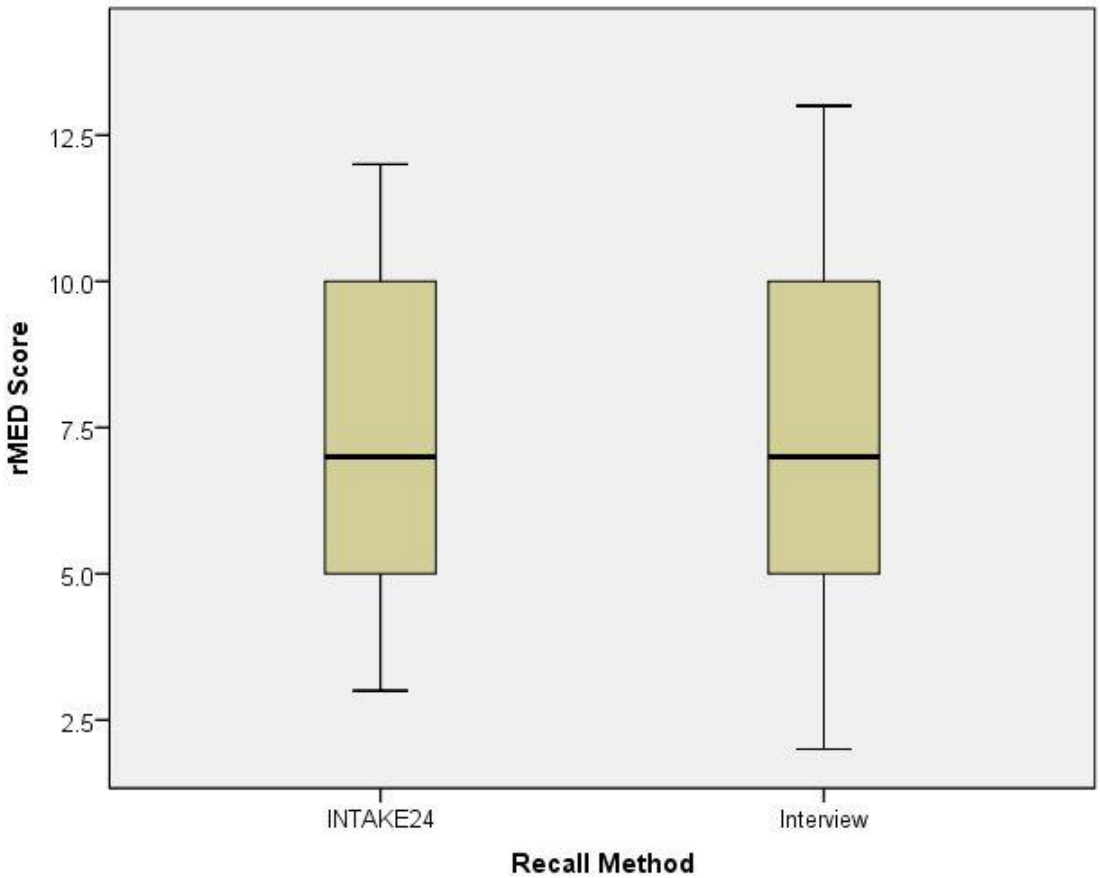



**Figure 4.5 Boxplot of rMED scores for INTAKE24 and for the interviewer-led recalls**

### *4.3.4 Participant evaluation*

Table 4.8 shows the participant responses to the SUS, which were categorised as above or below a cut-off value of 68 – the average for a range of other digital applications (Sauro, 2011). Overall, usability of INTAKE24 was evaluated as above average. Four of the ten participants who evaluated the system as below average scored half a point below the 68-point threshold and so were very close to the cut-off. Scores ranged from 37.5 to 90 points.

**Table 4.8 System usability scale responses**

| System Usability Scale Points (n=30) | | | |
|---|---|---|---|
| Mean | SD | Below Average | Above Average |
| 71.7 | 13.5 | 10 | 20 |

SD – Standard Deviation

Most of the participants left comments in the free text box available in the SUS evaluation form. All of the participants who responded to the question about prompts for forgotten foods described them as “useful”, “helpful” and “a good idea”. Twenty one participants reported positive feedback on the instruction booklet, describing it as “easy to follow”, “a good aid to the website” and “comprehensive”. Two participants described the font size of the text on the screen shots of the system as a little small and three participants commented that they preferred to use INTAKE24 without referring to the instructions. Table 4.9 describes the participant feedback on the question asking about any further comments on INTAKE24. Whilst half of the comments were complimentary, others indicated that there was scope for improvement.

**Table 4.9 Participant feedback of INTAKE24**

| Further comments about INTAKE24 |
|---|
| • Easy to use once started<br>• A lot easier to use than the Weight Watchers website<br>• I think it needs more food categories<br>• Easy to follow after a few pages<br>• Portion sizes take a while to relate to actual food<br>• It did not flow very well – I had to keep scrolling up and down<br>• Comprehensive. Easy to use<br>• The system perhaps does not take sufficient account of various ethnicities' eating habits<br>• Really interesting!<br>• Would add scope for unusual/ rare foods<br>• For an older person it may be difficult to use it<br>• Need foods written down before entering on system<br>• I like it!<br>• The system looks OK but is repetitive in many aspects |

## 4.4 Discussion

### *4.4.1 Main findings*

The main objective of this study was to assess the relative validity of INTAKE24 by comparing the mean daily estimated intakes of foods, energy and macronutrients recorded in four 24 hour recalls using INTAKE24, with those recorded in four interviewer-led 24 hour recalls. These assessments were carried out for the same 4 non-sequential days for both methods (over 4 weeks) and included at least one weekend day. Foods recorded in INTAKE24 matched closely with those recorded in the interviewer-led recall. Of all foods recorded, 84.4% of those reported in INTAKE24 were either exact or approximate matches with foods recorded in the interviewer-led recall (see Table 4.3). This is comparable with 82.2% of matching foods recorded in a comparison study of INTAKE24 with young people (Foster *et al.*, 2014a). When participants took part in a feeding study, 79.6% of foods reported by participants in the Automated Self-Administered 24-hour Recall (ASA24) matched those recorded by the investigators (Kirkpatrick *et al.*, 2014). Whereas, when participants' food consumption was observed, 81.7% of foods reported using the Synchronised Nutrition and Activity Program for Adults (SNAPA) matched those recorded by the investigators (Moore *et al.*, 2008). The number of foods omitted from INTAKE24 (9.5% of all foods recorded in the present study and 10.7% of foods recorded in the study with young people (Foster *et al.*, 2014a)) were considerably lower than the 20.4% omission rate for ASA24 (Kirkpatrick *et al.*, 2014). INTAKE24 may have performed better on this task because the participants' actual food intake was unknown and, therefore, comparisons could not be made between the foods recorded using the system or an interviewer-led recall and actual food intakes (as recorded by the ASA24 investigators).

No significant difference was found in the mean rMED scores between INTAKE24 and the interviewer-led recalls (p=0.86). The mean rMED scores were 7 out of a possible 18 and were one point higher than the rMED scores of participants who participated in the user-testing of INTAKE24 (see Section 3.3.3 of Chapter 3). The mean rMED score of participants in the present study was similar to, if slightly lower than, the mean rMED score of 7.8 observed in the diets of 20,986 British individuals who took part in the European Prospective Investigation into Cancer (EPIC)-Norfolk study (Sotos-Prieto *et al.*, 2014). However, direct comparisons in rMED scores cannot be made between studies involving different populations, as this score is calculated based on the distribution of data within a sample, rather than against cut-offs of absolute intake.

Estimates of the mean daily total weight of foods consumed and intakes of energy and macronutrients were very similar for the interviewer-led recalls and those obtained by INTAKE24 (see Table 4.5). In addition, there was no evidence of bias between methods across the range of total daily intakes of energy and weight of food consumed (see Figure 4.2 and Figure 4.3). This indicates that there were no systematic differences in the estimation of energy and food intake between methods.

Under- and over-estimation of mean daily intakes by INTAKE24 were very small and closely matched values observed in user-testing (see Table 3.6 of Chapter 3). INTAKE24 was found to over-estimate energy intake (kJ) by just 0.2% (see Table 4.6), compared to an under-estimate of 1% in a comparison study of INTAKE24 with interview-led recall in younger participants (Foster *et al.*, 2014a). Adults aged 19-82 years over-estimated energy intake using the online 24 hour recall Oxford WebQ by 0.1% compared with interviewer-led recalls. (Liu *et al.*, 2011). These data also did not show any systematic differences in nutrient estimates between methods (Liu *et al.*, 2011). Whilst the mean under- or over-estimates of carbohydrate, fat, protein and alcohol obtained from INTAKE24 were slightly greater in the present study than those observed with younger participants, the limits of agreement were smaller (Foster *et al.*, 2014a). These suggest that inter-individual variation in differences in estimates of macronutrient intakes between INTAKE24 and interviewer-led recalls is smaller for older participants.

Misreporting of dietary intake is an ubiquitous problem with all commonly-used dietary assessment methods (Goldberg *et al.*, 1991), occurs with population groups across the life-course, and is more prevalent with females than males and among the overweight than in normal weight individuals (Lentjes *et al.*, 2014). Energy misreporting was also identified in the current study. Using an EI: BMR cut-off of 1.06 (Goldberg *et al.*, 1991), 10 participants were found to under-report energy intake in either one or both of the two recall methods (see Figure 4.4). This was equivalent to five participants (17% of the sample) under-reporting when using INTAKE24 and eight participants (27% of the sample) under-reporting in the interviewer-led recalls (see Table 4.7). Participants who under-reported energy intake were also more likely to be overweight and obese. However, in an earlier study, the incidence of under-reporting by young adults aged 17-24 years when using INTAKE24 was higher. The percentage of young males and females who under-reported energy intake at an EI: BMR below 1.0 was 35% and 36% respectively, which rose to 50% and 53% when an EI: BMR ratio cut-off below 1.2 was used (Foster *et al.*, 2014a).

One explanation for the difference in energy misreporting between the younger and older participants may be due to the way in which they were recruited. The older participants were recruited by the author of this thesis and were in contact with this single researcher only, whereas Ipsos MORI, a leading UK research company (Ipsos MORI, 2015), was responsible for recruiting the majority of 17-24 year olds. The older participants were highly motivated, with an interest in research and all participants who joined the study completed the 4 days of assessment. In contrast, Foster *et al.* (2014a) reported much lower retention and compliance rates (for example, of 411 participants recruited, 159 completed the study).

The mean time taken to complete INTAKE24 was 21 minutes. This was four minutes shorter than the mean completion time by participants during user-testing as reported in Chapter 3, despite the mean number of food items reported by both methods remaining the same between the two studies (26 foods). The improvement in mean completion times of INTAKE24 between user-testing and relative validation could be due to the improvement of the system between the studies, the introduction of an instruction booklet, and/ or the repetition and consequent familiarisation of using the system in the relative validation study (recalls were made on 4 days in the latter study) (Baker *et al.*, 2014).

The difference of four minutes in the average time taken to complete INTAKE24 and the interviewer-led recalls in this relative validation study, was same as the difference in the time taken to complete the NutriNet-Santé online 24 hour recall when compared with an interviewer-led recall (taking on average 31 minutes and 27 minutes to complete, respectively) (Touvier *et al.*, 2011). However, both methods took much longer (about 50% longer) in the French NutriNet-Santé study. Whilst the interviewer-led recalls took on average 17 minutes to complete in the present study, each recall took an approximately further 60 minutes to code, enter and calculate the nutrient output. Therefore, the difference in completion time between the methods was approximately 56 minutes. Liu *et al*. (2011) also reported a considerable difference in the times taken to complete and code both the Oxford WebQ and the interviewer-led recalls (46 minutes).

Using the System Usability Score cut-off, two thirds of the participants reported that the usability of INTAKE24 was above average and the mean score was 71.7 (see Table 4.8). This is slightly less than the mean score of 73.8 evaluated by participants during user-testing (Chapter 3). The version of INTAKE24 used during this comparative study was the most up to date version currently available and was a slightly updated version of that used in user-testing. The differences between the two versions included the incorporation of more colour and a plain background in its interface (see Figure 4.6), the removal of some glitches, updating the search terms of some foods and making it compatible with tablets.

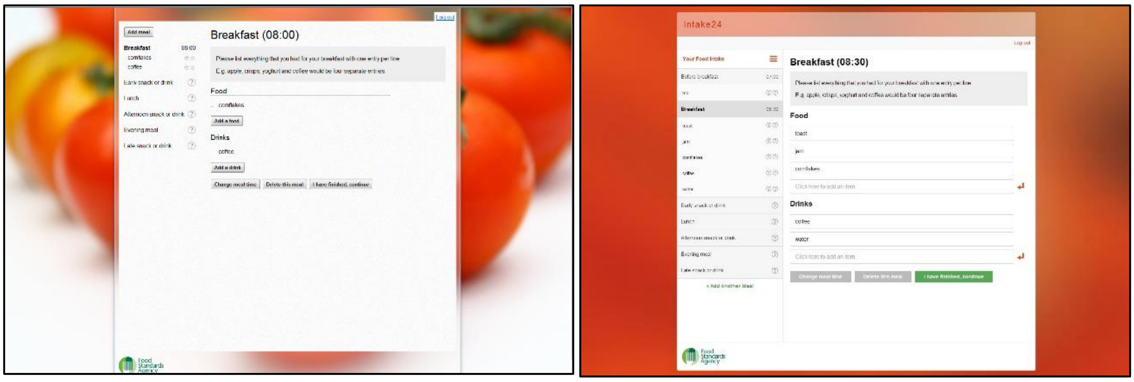



**Figure 4.6 Comparison of the INTAKE24 interface between the user-testing (Chapter 3) (left) and the current relative validation (right) studies**

Some of the feedback received and researcher observations of participants completing INTAKE24 during user-testing were addressed in the most recent version. These were:

- Guiding users to follow the next step by making “continue” buttons green.
- Adding the button "I have already entered it, continue" on prompts for items previously added that are commonly consumed with other items e.g. butter on bread.
- Adding quavers to the list of matching foods when it is searched for.
- Adding the food “Chocolate teacake e.g. Tunnock’s”.

- Removing the prompt for leftovers of baked potatoes (as there are no leftovers pictures in the system).
- Removing the glitch for pictures of jam spread on bread, so that it now appears when the user is asked to choose between seeing images of jam spread on bread or jam in spoonsful.

In the present study, an instruction booklet was produced for use alongside INTAKE24, which included screenshots of the system at each stage and annotations of how to perform a particular task (see Appendix W). These were tailored according to feedback and observations made during user-testing (Chapter 3), to aid the usability of the system. However, the mean SUS score given to the usability of INTAKE24 was slightly lower during the comparison study than in user-testing. The SUS was administered on the first recording day and, therefore, is comparable with the procedure in the user-testing study (Chapter 3), when measurements were made on one day only. It is not known whether the SUS score would have been different if the questionnaire had been administered again at the end of data collection i.e. after a further 3 days of use at home. Although the participants who read the instruction booklet commented that it was useful, not all the participants looked at it before using the INTAKE24 system. Anecdotally, the participants who did not look at the booklet required more help from the researcher than those who did.

Most participants experienced at least one difficulty when completing INTAKE24. These included technical errors with the system or misunderstandings of what the system was asking of them. For example, as a check for completeness towards the end of the process, prompts appear to ask the user whether they consumed anything between the meals that they entered (e.g. "Did you have any meals, snacks or drinks between your early snack or drink and your lunch?"). This confused one of the participants into thinking that they did not enter all the snacks that they had consumed, when in reality, they already had. As a result, this participant duplicated meals, and this led to him recording the greatest number of intrusions. This was the same participant who was the extreme outlier of energy intake (with a mean difference of 11,751 kJ between methods), and who was excluded from the re-run of the Bland Altman analysis for energy intake (see Figure 4.1 and Figure 4.2).

### *4.4.2 Strengths and limitations*

Analysis of the accuracy and precision of INTAKE24 showed that there was good agreement between estimates of the mean daily total intake of food, energy and macronutrient recorded in INTAKE24 and those in the interviewer-led recalls. A strength of this study is use of the Bland-Altman analysis and the identification of energy misreporters, which are not always considered in relative validation studies (Timon *et al.*, 2015).

Another strength of this study is that INTAKE24 was relatively validated in the "real world" setting. Whilst the first recording day was conducted in an experimental-style environment with the researcher present, the following three recording days were conducted at the participant's home, without the researcher being present and at a time which suited the individual participant. The decision to conduct three interviewer-led recalls over the telephone rather than in person resulted in lower running costs of the study and greater effectiveness of use of researcher time. In addition, conducting the dietary assessment over four non-consecutive recording days over the course of one month and including weekend days improves the probability that habitual dietary patterns and a greater diversity of food consumption will have been recorded. Arranging recording days and times to telephone participants to suit the participant's availability probably helped to lead to the excellent compliance and retention rates of 100% (N.B. two recalls did not record properly in INTAKE24, but this was outside the control of the participant or researcher). Additionally, the estimation of intakes using INTAKE24 and the interviewer-led recall concurrently provided the opportunity for direct comparison of estimated food and nutrient intakes.

INTAKE24 offers the potential for greater standardisation of recall procedures i.e. removes possible interviewer-associated variation and so may enhance the quality of the data collected. In addition, because of the built-in food coding system, the use of INTAKE24 removes the burden and potential errors associated with manual data coding. INTAKE24 includes a researcher interface, with the ability to download participant activity and nutrient data, which eliminates the task of coding and entering dietary data. Participants took, on average, four minutes longer to complete INTAKE24 than the time taken to complete the interviewer-led recalls. However, even for this relatively small study assessing the dietary intake of just 30 participants, INTAKE24 saved approximately 112 hours of researcher time, when the time taken to code, enter and calculate nutrient data for the interviewer-led recalls was accounted for. This emphasises the potential for INTAKE24 to reduce costs in larger studies and, probably, improve the quality of the recorded data.

A potential limitation of the study is that the participants were interested in research, as the majority were recruited via VOICENorth (a community engagement panel at Newcastle University), or due to their involvement with other nutrition studies. As such, these participants may be more highly motivated and more competent in using computer-based tools than the general older adult population. This could be explored by extending the testing to wider population groups.

Another limitation of the study is that due to the inability to modify INTAKE24 during or after user-testing according to the requirements of older adults, many of the issues reported during user-testing (Chapter 3) were still evident when it was used in the present study. To address this issue, an instruction booklet was developed and provided to aid participants in using the system, but not all of the participants read this and so may have had more difficulties in coping with the technical errors which arose. To improve the usability of INTAKE24 for older adults in future studies, a number of recommendations were proposed. Those which emerged from feedback and observations during this study were added to those derived from the user-testing study. These can be viewed in Table 5.1 of Chapter 5.

### *4.4.3 Conclusions*

In the present study, INTAKE24 was relatively validated for use with older adults by comparison with interviewer-led recalls. This demonstrated good agreement between the approaches for estimates of intakes of food, energy and macronutrients. Additionally, this study showed that the INTAKE24 method of data collection and its data output were compatible with subsequent use of the rMED method of scoring adherence to the Mediterranean dietary pattern.

The excellent compliance (100%) with the study protocol recorded in this study shows clearly that older participants were willing to use INTAKE24 over the course of one month. In addition, they rated its mean usability as above average. This suggests that there is potential for INTAKE24 to be used in prospective studies conducting repeated measures or involving periods of follow-up, as an alternative to the traditional 24 hour recall. However, there is scope for further development to improve the usability and accuracy of the system, such as matching more search terms with foods currently in the system and removing technical errors.

# Chapter 5 Discussion

## 5.1 Introduction

This Ph.D. project was embedded within the LiveWell Programme (http://research.ncl.ac.uk/livewell/), which developed and piloted a suite of pragmatic dietary, physical activity and social interventions which can be delivered in the retirement window, and which were intended to enhance healthy ageing. This Ph.D. is linked with the dietary intervention aspect of the LiveWell Programme, which focused on the Mediterranean dietary pattern (MD). The main aim of this project was to investigate, test and identify age-appropriate dietary assessment tools which are suitable for measuring change in diet (particularly adherence to the MD), as a consequence of lifestyle-based interventions.

For this purpose, I scanned the literature to identify publications describing scoring systems for the MD and I identified 26 different MD scoring systems. From this panel of systems, I used an explicit set of selection criteria to select six different approaches to quantify the Mediterranean diet. I then applied all 6 scoring systems to dietary data from the Mediterranean Diet in Northern Ireland (MEDDINI) intervention study (Logan *et al.*, 2010). Based on the perceived ability to measure dietary change and the assumptions made to apply the Mediterranean diet scores (MDS) to the MEDDINI data, I selected one MDS (the rMED scoring system (Buckland *et al.*, 2010)) as the most suitable scoring system for testing the efficacy of dietary interventions, in respect of change in adherence to a MD pattern.

The next stage of the work was to investigate the utility of INTAKE24, an online 24 hour recall, as a method for assessing the diet of retirement-age adults. This aspect of the Ph.D. was driven by the need for a dietary assessment tool which i) could be used to provide quantitative data on dietary intake by people in the appropriate life-stage, ii) would be compatible with the rMED system for quantifying adherence to the MD and iii) would be usable with relatively large numbers of participants i.e. the likely hundreds of people who would be required for a definitive RCT testing the LiveWell Programme intervention suite. The INTAKE24 tool was developed originally for use with young people, is delivered via the internet and is intended to be used for large scale surveys, principally the Food Standards Agency-led surveys of the diets of Scottish inhabitants. The present study was the first time that INTAKE24 had been used with an older age group. To test the usability of the system and its utility in providing reliable assessments of the diets of older adults, user-testing and relative validation studies were performed using INTAKE24. The main findings of these investigations are summarised below.

## 5.2 Synthesis of findings

### *5.2.1 Assessment of Mediterranean diet scores*

Based on a set of 10 selection criteria, the six highest scoring MDS were selected, from a total of 26 scoring systems identified from a review of the literature (see Appendix C). These were the Mediterranean Adequacy Index (MAI) (Alberti-Fidanza *et al.*, 1999), Mediterranean Score (Goulet *et al.*, 2003), Mediterranean-Style Dietary Pattern Score (MSDPS) (Rumawas *et al.*, 2009), Relative Mediterranean Diet Score (rMED) (Buckland *et al.*, 2010), Mediterranean Diet Adherence Screener Score (MEDAS) (Estruch *et al.*, 2006) and the MedDietScore (Panagiotakos *et al.*, 2006b). To investigate their utility for the purpose of the present Ph.D. project, each of these MDS were applied to dietary data from the MEDDINI study.

Participants in the MEDDINI study were randomly allocated to a control group who received conventional dietetic advice (CDA, n=15), or one of two MD intervention groups receiving either nutritional counselling (MDNC, n=20) or behavioural counselling (MDBC, n=15) (Logan *et al.*, 2010). Orthogonal contrast analysis was used to investigate the effects of the type of dietary intervention on each MDS at six and 12 months follow up. This was conducted in two stages: to compare differences in MDS between the CDA control group and both intervention groups (Contrast 1); and to compare differences in MDS between the two MDNC and MDBC interventions (Contrast 2). Although the mean scores produced by all MDS were higher for the MDNC and MDBC groups than the CDA group at six months, only the Mediterranean Score was different significantly between treatment groups in Contrast 1 at 6 months follow up (p=0.01). No significant differences were observed between the types of MD intervention (Contrast 2, see Table 2.6 in Chapter 2).

When orthogonal contrast was applied at 12 months follow up, no significant differences were found in MDS between treatment groups for either contrast (see Table 2.7 in Chapter 2). Furthermore, the mean score of the CDA group was marginally higher than either the MDNC or MDBC groups for all MDS, except for the Mediterranean Score and the MSDPS. The orthogonal contrast results broadly suggest that the dietary interventions, which included more contact time with the research dietitian, had little if any significant improvements on adherence to a Mediterranean diet than the control group. These results are comparable to those observed by Logan *et al.* (2010), who found no effects of the type of intervention on the score using Martínez-González et al.'s short Mediterranean diet questionnaire (2004) with the same study participants.

Whilst the main focus of the analysis was to identify between-group effects on dietary change, the within-group change in MDS was also analysed using paired samples t-tests. There was a significant increase in the scores of all MDS for each treatment group at six months follow up, except for the rMED (for all three treatment groups) and the MEDAS for the control group (see Table 2.8 in Chapter 2). When the differences in mean MDS between baseline and 12 months were analysed, the five scores retained significance (again, no differences were found in the rMED). However, the Mediterranean Score was the only MDS to have significant differences in the score for all three treatment groups (see Table 2.9 in Chapter 2). Furthermore, the MDS were more likely to be different between baseline and 12 months follow up for the control group than for the MD intervention groups. These results suggest that overall, participants assigned to all three arms of the study made positive dietary changes towards a greater adherence to the MD at 6 months, but the improvements were less impressive after one year (depending on the type of MDS used to assess these changes). This is encouraging, considering that dietetic support was stopped after 6 months for the MDNC and MDBC groups and no support was given to the control group. In the Lyon Diet Heart Study, De Lorgeril *et al.* (1999) found that most participants randomised to a MD intervention still adhered to a MD after a mean follow up of 46 months and this sustained dietary change translated into a protective effect on cardiovascular outcomes, when compared with the control group.

Based on the degree of reduction in the coefficient of variation from baseline to follow up and the percentage change in diet between intervention groups at 6 months, the MSDPS was ranked the highest (see Table 2.12 in Chapter 2). This is concordant with the hypothesis that an MDS with a larger range may be more equipped to detect change in diet (Panagiotakos *et al.*, 2006b). However, the MSDPS required the most assumptions and modifications to apply it to the MEDDINI data, which may have produced different results than if it was calculated in the way it was composed by the authors. As the greatest mean percentage change at 12 months was found using the rMED and this score required the least number of assumptions to apply it to dietary data, the rMED was identified as the most suitable score to use for future testing within intervention studies.

The rMED performed well, if not better at measuring adherence to the MD in Spanish undergraduate students (Milà-Villarroel *et al.*, 2011) and at investigating relationships with 13-year weight change and obesity risk (Lassale *et al.*, 2012), when compared to other MDS. Whilst these were cohort studies (no intervention study has reported using the rMED), they support the use of the rMED score in identifying adherence to the Mediterranean dietary pattern.

Whilst the range of unique MDS have been described previously (Bach *et al.*, 2006; Waijers *et al.*, 2007), and the effectiveness of some have been compared (Knoops *et al.*, 2006; Puchau *et al.*, 2009; Beunza *et al.*, 2010; Toledo *et al.*, 2010; Milà-Villarroel *et al.*, 2011; Lassale *et al.*, 2012), to the author's knowledge, the present study was the first to develop and apply two sets of selection criteria, to ascertain which of the MDS identified from the literature is the most suitable for use within an investigation, and the first study to apply the chosen rMED score to data derived from an intervention study. The first set of selection criteria (see Appendix C) were developed specifically for use with an intervention study involving adults in the UK. However, they provide a novel method of rationalising the suitability of MDS, which could also be adapted to other investigations with different aims, study designs and populations.

The Mediterranean diet is by no means a singular global diet. Rather, it is heterogeneous between regions of the Mediterranean basin. Since the traditional diet was characterised in the early 1960s, the diets of people living in this region have evolved due to globalisation (Da Silva *et al.*, 2009). In 2011, Bach-Faig *et al*. presented an updated MD pyramid and guidelines to reflect these ongoing cultural changes in the MD. In these guidelines, the authors suggested that the MD should consist of traditional, local, biodiverse and environmentally friendly foods, in order to maintain sustainability. Based upon these values, a MD can be adhered to and adapted by people living outside of the Mediterranean region. For example, olive oil could be substituted for rapeseed oil (also known as canola oil) in areas where it is more widely produced, such as the UK and North America (Bere and Brug, 2010). However, MD intervention studies which recommend rapeseed oil would be limited to using scores which consider MUFA: SFA intakes rather than olive oil intakes, such as Trichopoulou *et al.*'s Mediterranean Diet Score (Trichopoulou *et al.*, 2003).

Mediterranean diet scores vary in their number of food/ nutrient groups, classification and range of points, and statistical methods of calculating dietary intake. It is for these reasons, and the geographical and cultural variations in diet, which limit the comparison of MDS between studies and populations – particularly for scores derived by the relative distribution of food intakes within a population group (such as the rMED), as opposed to those which are calculated according to cut-offs of absolute intake (e.g. MedDietScore). As the majority of MDS were developed for use with Mediterranean populations, future studies conducted outside of this region must consider the suitability of scores to measure adherence to the MD in non-Mediterranean populations (such as by applying the aforementioned selection criteria developed within this study).

Furthermore, in order to measure change in MD within an intervention study using scores based on the relative distribution of diet within a sample, baseline data should be considered within the calculation.

### *5.2.2 User-testing of INTAKE24*

User-testing of INTAKE24 was conducted with 15 participants aged 55-70 years old. Participants attended one appointment at Newcastle University and were asked to complete two 24 hour dietary recalls of the previous day's intake, using INTAKE24 and an interviewer-led recall. The main focus of the study was to gather feedback on the user's experience of the system and to compare the intakes of foods, energy and macronutrients recorded by each of the methods.

Of the 404 food items recorded by participants, 87.4% either exactly or approximately matched between the two recall methods, 8.7% of the food items were recorded in the interviewer-led recall but not in INTAKE24 (omissions) and 4% were recorded in INTAKE24 but not in the interviewer-led recall (intrusions, see Table 3.3 in Chapter 3). This is comparable with the report of 88% of matching foods, 7% of omissions and 5% of intrusions recorded during the user-testing of INTAKE24 with young people (Foster *et al.*, 2013). Amongst older adults, the greatest proportion of omissions from INTAKE24 were drinks (37.1%) and fruit and vegetables (22.9%, see Table 3.4 in Chapter 3). The absence of a facility within INTAKE24 to ask the user whether more than one cup or glass of the same beverage was consumed within the same meal was considered as a reason for the high incidence of drinks omissions. In comparison, fruit and vegetables were the main source of omissions in tests of the Synchronised Nutrition and Activity Program for Adults (SNAPA) (Hillier *et al.*, 2012) and the Automated Self-Administered 24-hour Recall (ASA24) (Kirkpatrick *et al.*, 2014).

Estimates of the mean total weight of food, energy and macronutrients intake were very similar between those obtained from INTAKE24 and the interviewer-led recalls (see Table 3.5 in Chapter 3). INTAKE24 over-estimated mean energy intake by just 0.1%, with the limits of agreement ranging from an under-estimate of 32%, to an over-estimate of 34%, when compared with the interviewer-led recall (see Table 3.6 in Chapter 3). This suggests that mean intakes of energy by groups of older people are measured well by INTAKE24, but that there may be considerable over- or under-estimates of intakes by certain individuals. In comparison, intakes of energy by younger participants aged 11-24 years using INTAKE24 were under-estimated by 11% when compared with face-to-face 24h recall (Foster *et al.*, 2013). When the rMED score was applied to foods recorded by older adults using both dietary assessment methods, there was no significant difference in the estimated MDS (mean score=6, $p>0.05$, see Section 3.3.3 of Chapter 3). This suggests that the two recall methods performed similarly when measuring consumption of the foods included in this diet score.

The mean time taken to complete INTAKE24 was 24.7 minutes, which was significantly longer than the 20 minutes taken to complete the interviewer-led recall ($p=0.006$, see Table 3.2 in Chapter 3). Whilst participants took longer to complete INTAKE24, using the online system offered considerable researcher time-efficiency. Whereas a food and nutrient data output can be quickly and easily downloaded from the INTAKE24 website, the paper-based recalls required manual coding of foods and portion sizes consumed, entry of these data into Microsoft Excel, and the subsequent calculation of food and nutrient intakes. Taking all these steps into consideration, it was estimated that the use of INTAKE24 saved approximately 55 minutes per recall in completing both the participant and researcher duties. The mean time taken to complete the same version of INTAKE24 by 11-24 year olds was considerably shorter, at 13.4 minutes (Foster *et al.*, 2013). However, as the mean number of food items recorded by the younger participants was 17.9 (Foster *et al.*, 2013), compared with 26.9 food items recorded by the older participants, this suggests that the main difference in completion times between the groups may due to the number of foods consumed, rather than the age of the participants. The mean completion time of the interviewer-administered computerised 24 hour recall, EPIC-Soft, was 22 minutes for Germans aged 14-80 years and 30 minutes for Belgians aged 15-97 years (Huybrechts *et al.*, 2011a), which are more comparable with the findings in the present study.

INTAKE24 was generally well-received by the participants. The mean System Usability Score (SUS) was 73.8 and 10 out of 14 participants rated the system as above average. However, researcher observation of participants using INTAKE24 (see Appendix T) and feedback received via a qualitative interview (see Appendix S), demonstrated that all participants encountered at least one difficulty when using INTAKE24. There were some technical issues with the system, with the position of the page loading being the main source of frustration (if the user scrolled down the page, the next page would load in the same position and obscure the top of the page from view). Based on these data, a list of recommendations for future modification of the system was produced (See Table 3.8 in Chapter 3).

Whilst computerised and online 24 hour recalls have been used previously with older adults (Mennen *et al.*, 2002; Zoellner *et al.*, 2005; Arab *et al.*, 2011; Huybrechts *et al.*, 2011a; Liu *et al.*, 2011; Touvier *et al.*, 2011; Frankenfeld *et al.*, 2012; Hillier *et al.*, 2012; Kirkpatrick *et al.*, 2014), to the researcher's knowledge, the user-testing of INTAKE24 was the first study to compare the usability of a self-completed 24 hour recall system with a paper-based interviewer-led 24-hour recall with older adults. This was also the first time that INTAKE24 had been tested with an older adult population.

### *5.2.3 Relative validation of INTAKE24*

A relative validation of INTAKE24 was performed, in which estimated dietary intake by 30 older adults in four 24 hour dietary recalls was recorded using the most recent version of INTAKE24, and compared with estimates from four concurrent interviewer-led recalls. The recalls on the first recording day were completed in the presence of the researcher at Newcastle University. For the remaining three recording days, participants completed INTAKE24 at home (or wherever was convenient for them) and the interviewer-led recalls were administered over the telephone. This was the first study to relatively validate a self-completed, web-based 24 hour recall tool, specifically with an older adult population.

Of the 3280 food items reported by participants, 84% of food items recorded in INTAKE24 either exactly or approximately matched foods recorded in the interviewer-led 24 hour recall. Almost 10% of all recorded foods were omissions and 6% were intrusions (see Table 4.3 in Chapter 4). This is comparable with 82% of matching foods recorded in a comparison study of INTAKE24 undertaken with young people aged 11-24 (Foster *et al.*, 2014a). In agreement with the results from user-testing, the majority of omissions recorded by older adults were fruit and vegetables (21.5%), drinks (19%) and milk added to hot beverages and breakfast cereals (20%, see Table 4.4 in Chapter 4). Of the omissions of milk, 58% of instances were due to the inability of INTAKE24 to add milk to decaffeinated tea or coffee and to herbal drinks. Fifty percent of all intrusions were from duplicated items added to INTAKE24. A technical error within the system, which duplicated breakfast and morning snacks for three participants, contributed to this value.

Estimates of the mean daily total weight of food, and intakes of energy and macronutrients were very similar between those obtained from INTAKE24 and the interviewer-led recalls (see Table 4.5 in Chapter 4) and matched closely with values observed from user-testing (see Table 3.6 in Chapter 3). INTAKE24 over-estimated energy intake (kJ) by just 0.2% (see Table 4.6 in Chapter 4), compared with an under-estimate of 1% by younger participants (Foster *et al.*, 2014a).

When an outlier of extreme energy intake was excluded, Bland-Altman analysis showed no evidence of bias between the methods across the range of estimated mean daily total intakes of energy and the weight of food consumed (see Figure 4.2 and Figure 4.3 in Chapter 4). This indicates that there were no systematic differences in the estimation of energy and food intake between methods. In comparison, no systematic differences were observed in the estimation of macro- and micro-nutrients between the Oxford WebQ online 24 hour recall and the interviewer-led recall reference method (Liu *et al.*, 2011). This suggests that INTAKE24 (and the Oxford WebQ) performs equally well across a wide range of dietary intakes and, therefore, may be suitable for quantifying intakes by the whole target population.

Using an Energy Intake to Basal Metabolic Rate ratio (EI: BMR) cut-off of 1.06 to identify energy under-reporting (Goldberg *et al.*, 1991), 10 participants under-reported energy intake in either one or both recall methods (see Figure 4.4 in Chapter 4). This was equivalent to five participants (17% of the sample) under-reporting when using INTAKE24 and eight participants (27% of the sample) under-reporting in the interviewer-led recalls (see Table 4.7 in Chapter 4). However, in an earlier study, the incidence of under-reporting by young adults aged 17-24 years when using INTAKE24 was higher. The percentage of young males and females who under-reported energy intake at an EI: BMR below 1.0 was 35% and 36% respectively (Foster *et al.*, 2014a).

One explanation for the difference in energy misreporting between the younger and older participants may be due to the way in which they were recruited. The older participants were recruited by the author of this thesis and were in contact with this single researcher only, whereas Ipsos MORI, a leading UK research company (Ipsos MORI, 2015), was responsible for recruiting the majority of 17-24 year olds. The older participants were highly motivated, with an interest in research and all participants who joined the study completed the 4 days of assessment. In contrast, Foster *et al.* (2014a) reported much lower retention and compliance rates (for example, of 411 participants recruited, 159 completed the study). The use of Bland-Altman analysis and the identification of energy misreporters are strengths of the study, as they are not always considered in relative validation studies (Timon *et al.*, 2015).

No significant difference was found in the mean rMED scores between INTAKE24 and the interviewer-led recalls (mean score=7, p=0.86, see Section 4.3.3 of Chapter 4). This suggests that both recall methods performed equally when assessing adherence to the Mediterranean diet using the rMED.

The mean time taken to complete the recalls using INTAKE24 was 21.3 minutes, which was significantly longer than the 17.2 minutes taken to complete the interviewer-led recall (p<0.001, see Table 4.2 in Chapter 4). It should be noted that the mean time taken to complete INTAKE24 in the relative validity study was four minutes shorter than the mean completion time by participants during user-testing (as reported in Chapter 3), despite the mean number of food items reported in both methods remaining the same between the two studies (26 foods). The improvement in mean completion times of INTAKE24 between user-testing and relative validation could be due to the improvement of the system between the studies, the introduction of an instruction booklet (see Appendix W), and/ or the repetition and consequent familiarisation of using the system in the relative validation study (recalls were made on 4 days in the latter study) (Baker *et al.*, 2014).

INTAKE24 was well-received by participants during this study. The mean SUS was 71.7 (see Table 4.8 in Chapter 4), which was slightly lower than the mean score of 73.8 from user-testing (see Table 3.7 in Chapter 3). Whilst 20 out of 30 participants scored the system as above average, a further 4 participants scored the system just half a point below the 68-point cut-off (Sauro, 2011). However, as it was not possible to modify INTAKE24 according to the feedback provided from user-testing, most of the technical errors and difficulties in completing the system arose whilst conducting the relative validation. An instruction booklet was produced for use alongside INTAKE24 (see Appendix W), but this was not used by all of the participants. Those who did read the instructions, did not need as much help from the researcher to use the system.

## 5.3 Strengths and limitations of the study

To date, the FFQ and diet history dietary data from the MEDDINI Study which were used in Chapter 2 have not been analysed (whilst Logan *et al*. (2010) assessed adherence to a MD, this was calculated from a questionnaire-based MDS administered at baseline and follow-up assessments). Comparisons between MDS in respect of their efficacy to measure adherence to the MD diet and/ or associations with health have been investigated previously (Bach-Faig *et al.*, 2006; Knoops *et al.*, 2006; Puchau *et al.*, 2009; Beunza *et al.*, 2010; Toledo *et al.*, 2010; Milà-Villarroel *et al.*, 2011; Lassale *et al.*, 2012). However, all these comparisons were conducted with data from observational studies and no comparisons have used data from intervention studies and, importantly, intervention studies which aimed to improve adherence to the MD. The six MDS used in this thesis have been compared together once before, but only using data from a cross-sectional study of 324 healthy undergraduate students from the University of Barcelona (Milà-Villarroel *et al.*, 2011). In addition, this was the first time that INTAKE24 has been used with an older adult population.

The rMED was selected as the most appropriate MDS to use in future studies with this age group. The rMED was easily applied to dietary data from the MEDDINI study and from the user-testing and relative validation studies of INTAKE24, and it took less time to calculate this score than the MSDPS (which was ranked as the joint second most appropriate MDS to use). This was because the calculation of the MSDPS was not only complex, but each food item consumed by an individual is included in the score (to account for MD and non-MD food consumption). Since almost 3300 food items were recorded in the relative validation study of INTAKE24, had the MSDPS been chosen as the most suitable score, its food groupings assessment method would need to have been applied to over 6000 entries to observe differences between INTAKE24 and the interviewer-led recall methods. In the future, INTAKE24 could be adapted to code foods in the system according to food groups within a MDS and to generate an overall MD score as a routine part of the data output. This would be relatively easy to do for the rMED approach but would be more time consuming to set up for the MSDPS, as every food in the system would need recoding.

Online 24 hour recall tools, such as INTAKE24, offer the benefit of researcher time-efficiency over the traditional, paper-based, interviewer-led 24 hour recall. The dietary recalls can be self-completed at a time and place that is convenient to the user, without the need for an interviewer to be present. This consequently reduces the running costs of studies utilising web-based tools (in addition to saving other costs involved with interviewer-led recalls, such as telephone calls, printing of study materials and posting food photograph atlases to participants). Touvier *et al*. (2011) estimated that the online 24 hour recall used in the NutriNet-Santé study saved €38.14 per participant, when compared with an interviewer-led 24 hour recall administered by telephone.

A strength of the relative validation of INTAKE24 was that the system was tested within the "real world", which is the setting for which online dietary assessment tools are ultimately developed. Additionally, the fact that the INTAKE24 and interviewer-led recalls were conducted on the same day meant that direct comparisons could be made between estimated intakes of foods, energy and macronutrients.

Furthermore, INTAKE24 offers the standardisation of recall procedures in data collection, food coding and the calculation of foods and nutrients intake. This removes possible interviewer-associated variation, as well as the burden and potential errors associated with manual data coding. As INTAKE24 includes the ability to download participant activity and nutrient data from a built-in researcher interface, in the present study, the investigator time saved on data coding, entry and calculation of foods and nutrients intake during the user-testing and relative validation studies was equivalent to 133 hours. Considering that these studies were conducted with relatively small sample sizes of 15 and 30 participants respectively, this further demonstrates that online dietary assessment tools can be used in studies with much greater sample sizes and at lower costs than studies using traditional methods.

One limitation of using data from the MEDDINI study to compare the utility of the six MDS was the relatively small sample size. The MEDDINI study was a pilot study, designed primarily to determine whether coronary heart disease (CHD) patients in a Northern European population would adopt and maintain a MD (Logan *et al.*, 2010). The secondary aim of the MEDDINI Study was to compare the effectiveness of different methodologies aimed at improving compliance with a MD. For this Ph.D. project, 49 participants were included in the analysis at 6 months follow up and 34 in the sub-set follow up at 12 months. As the sample was divided into three interventions, there will have been limited power in detecting between-group differences (and even when comparing both intervention groups vs. the control group). Furthermore, the MEDDINI study design (with a heavy preponderance of men (approximately 80%)) did not allow the present study to determine whether the Mediterranean diet scoring systems worked better for one gender than for the other.

There were also limitations of the INTAKE24 studies. As with any study measuring dietary intake, the participants knew that their diet was under investigation and their recording days were scheduled in advance, and this may have caused them to change their dietary intake. This could have resulted in a reduced ability to measure patterns of true dietary intake (Øverby *et al.*, 2014). It would be very difficult to overcome this problem unless, for example, the dietary assessment was embedded within a larger study which assessed other behaviours or activities and the participants' attention was not drawn specifically to the dietary assessment component of the study. The fact that both dietary intakes, and the comparison between recall methods, yielded very similar results in both the user-testing and relative validation studies, provides some reassurance that the methodology is reproducible.

A limitation of the user-testing study is that only one round of testing was conducted. I had intended to conduct a second round of user testing, following improvements to the INTAKE24 website which were based on participant experiences in the first round. Although I undertook the necessary preparatory work, in the event, this became impossible due to unavailability of the website programmers to undertake this additional work. Had there been some modifications made to the system, the accuracy and precision of INTAKE24 may have been even greater. For example, by incorporating the option to add milk to decaffeinated tea and coffee and herbal tea, 58% of the milk omissions recorded in the relative validation study could have been avoided.

Participants recruited to both studies testing INTAKE24 were not generally representative of the older adult population living in the North East of England. As the participants were highly motivated and the majority were educated to a degree-level and regular internet users, the usability of INTAKE24 by the wider population of older people may have been overestimated (Huybrechts *et al.*, 2011b). Therefore, these results should not be generalised to the general older adult population until further testing has been undertaken.

## 5.4 Future research

Further modification of INTAKE24 is recommended to improve the usability of the system for older adults in future studies. A number of suggestions are proposed in Table 5.1, which are based on the researcher observations and participant feedback obtained during the user-testing and relative validation studies.

The mean daily total intakes of foods, energy and macronutrients of participants in the relative validation study of INTAKE24 were reported during Chapter 4. Further work on these data could be useful e.g. to assess the intra-individual, between-days variation in estimated intakes, as a basis for determining the optimum number of recording days which would be necessary to obtain a reliable estimate of MDS. In addition, exploration of potential differences in dietary intake between weekend and week days, particularly in respect of the MDS, could be useful in the development of future interventions aiming to enhance MD adherence among older people. It is possible that, as participants may have become more accustomed to completing the 24 hour recalls, the degree of variation between recalls may have decreased by the fourth recall and therefore become more accurate (Mennen *et al.*, 2002). Additionally, INTAKE24 could be further validated using the data collected in this study by employing the Bland-Altman method, to analyse the agreement between the recall methods for intakes of key food groups.

The data derived from the MEDDINI study could also be further analysed. The scores from the six MDS used in Chapter 2 could be compared with empirically-derived dietary patterns of the whole diet, to identify whether participants with higher MDS had healthier diets overall. Using k-means cluster analysis, I found previously that three clusters were the most appropriate number of clusters to analyse the dietary patterns of children (Shaw *et al.*, 2013). Comparisons could be made between diets pre- and post-intervention, to identify whether the overall dietary habits of the MEDDINI study participants changed and to assess the ability of the MDS to detect these changes in diet.

The methods and data generated from this Ph.D. project could be used to inform future dietary studies (particularly Mediterranean diet intervention studies). Figure 2.2 describes the range of MDS available, as well as their origins and similarities to each other, which could be referred to and used in conjunction with the set of 10 selection criteria (see Appendix C) to ascertain which MDS are suitable to measure the MD of study participants. Whilst the selection criteria were developed specifically to identify the ability of MDS to measure adherence to a MD within a UK intervention study, these could be tailored to determine applicable MDS for future studies with different research aims, study designs and sample populations. The second set of three selection criteria (described in Section 2.3.4.6) offer a method of calculating which MDS is the most suitable for measuring change in the MD over time, which could be applied to other cohort/ intervention studies.

A recent systematic review and meta-analysis found that Mediterranean dietary interventions among people of retirement age are scarce (Lara *et al.*, 2014), thus highlighting the need for future MD intervention studies involving older adults. The work undertaken during this Ph.D. project indicates that the rMED Mediterranean diet score and INTAKE24 appear to be suitable and cost-efficient tools for analysing the diets of older adults. For future MD intervention studies involving this age group, a system integrating the two tools would be recommended. This would offer researcher time-efficiency, especially if it is employed with a large sample size. However, a number of modifications to INTAKE24 would be required to enable it to calculate the rMED automatically.

Firstly, certain foods within the system would need to be coded according to the food groups used in the calculation of the rMED. The reported intake of foods belonging to each food group would then need to be summed, to calculate their total daily intake. For example, if the user reports that they consumed an apple, the amount consumed would contribute to the total daily amount of the “fruit, nuts and seeds” group of the rMED. Secondly, as the rMED is calculated according to tertiles of food group intakes of the whole sample, it may be unlikely that INTAKE24 could be programmed to produce the total rMED score in the data output for each participant. However, as the total daily intake of each food group could be downloaded, the final calculation would be simple to perform.

Finally, as the rMED calculation includes quantification of olive oil intake, and participants under-reported this food group when using INTAKE24, a modification to INTAKE24 is required to accurately assess olive oil consumption. To resolve this issue, two questions could be added to the system, such as:

1. “Do you use olive oil in cooking or consume it with foods such as salad or bread?”. This question could have a Yes/ No response, which identifies consumers and non-consumers.

2. “How much olive oil do you consume, on average, per day?”. To answer this question, participants could be given the option to record the amount in spoonsful. They would first need to select the size of the spoon and the system could then ask how many of those spoonsful they consume per day, on average. A similar process is currently used by INTAKE24 when ascertaining the consumption of certain foods such as sugar and jam. The responses to this question would be used to calculate the median amount of olive oil consumed daily and then a score of 1 or 2 would be applied to participants consuming below or above this value, respectively.

These suggested modifications to INTAKE24 would also offer the standardisation of food grouping, by minimising potential errors in decision making by the researcher. A modified version of INTAKE24 could be used in future MD intervention studies to assess dietary change between pre- and post-intervention. To identify the usability of the system with participants with different demographic characteristics, the SUS could also be included in data collection.

**Table 5.1 Recommendations for future improvement of INTAKE24 for use with older adults**

| Parts of the system | Recommendations for improvement |
|---|---|
| Instructions | • Alter welcome page instructions to remove school references. Instead of "Were you at school, college, home, work?" use "Were you at home, work, someone else's house, or at a café/ restaurant?"<br>• Add the purpose of the study to the welcome page instructions, including reassurance of anonymity.<br>• Provide an option to make instructions throughout one font size bigger/ bold for those with impaired vision. |
| Entering foods into meals | • Add an extra meal before breakfast. Name this "early morning snack or drink", and rename what was "early morning snack or drink" to "mid-morning snack or drink". |
| Search terms of foods | • Match search term "red bush tea" with tea entries.<br>• Match search term "spread" with low fat and full fat margarines. Also add "margarines" and "butter, margarine, oils" groups to the "Search by food category" section for the search term "spread".<br>• Match search term "crisps" with doritos, quavers, wotsits, monster munch, skips, pringles and tortilla chips.<br>• Match search term "cocoa" with hot chocolate entries.<br>• Match search term "shallots" with onions.<br>• Match search term "chicken tikka" with chicken curry.<br>• Match search term "vegetable stew" with vegetable casserole.<br>• Match search term "beer" with real ales & strong bitters. |

| Parts of the system | Recommendations for improvement |
|---|---|
| Search terms of foods continued | • Match search term "oat cake(s)" with oatcakes.<br>• Match search term "corn" with mini sweetcorn, sweetcorn frozen boiled and sweetcorn tinned.<br>• Match search terms “lettuce”, “salad” and “greens” with rocket leaves.<br>• Match search terms “salad”, “leaves” and “greens” with lettuce.<br>• Match search term "fruit juice" with fruit juices within system. Currently, mixed fruit juices, ice lollies and fruit canned in juice are returned.<br>• Match search term "tea loaf" to fruit cakes. Currently only teas come up as matching foods.<br>• Match search term “rice crackers” with rice cakes.<br>• Change spelling of "bolognaise" to "bolognese" for "spaghetti bolognaise", "bolognaise sauce, homemade" & "bolognaise sauce from a jar". Ensure search terms for all Bolognese foods include both spellings.<br>• Match search term "ovaltine" with Horlicks. |
| Missing foods | • Goat's milk (NDNS code 623)<br>• Reduced fat margarine (NDNS code 10043)<br>• Reduced fat margarine with olive e.g. Bertolli light, Flora pro activ olive (NDNS code 10042)<br>• Vegetarian hot dogs/ frankfurters (NDNS code 9572)<br>• Juice from lemons (NDNS code 2064) and limes (NDNS code 2065)<br>• Spreadable butter (NDNS code 9407) |

| Parts of the system | Recommendations for improvement |
| --- | --- |
| Missing foods continued | • Light spreadable butter (NDNS code 3891)<br>• Vegetarian shepherd's pie (NDNS code 8589)<br>• Rocky road/ Tiffin (NDNS code 10548)<br>• Pork stuffing (NDNS code 8772)<br>• Tabbouleh (NDNS code 5999)<br>• Vegetarian pate (NDNS code 8291)<br>• Kidneys (NDNS code 1176)<br>• Oat bran (NDNS code 8171)<br>• Fruit sugar (NDNS code 9474)<br>• Bacon rashers with fat removed (NDNS code 9464 for unsmoked, 9410 for smoked)<br>• Mixed leaves (NDNS code 8084)<br>• Spring greens cabbage, boiled (NDNS code 1705)<br>• Fish chowder/ fish soup (NDNS code 9128)<br>• Parma ham (NDNS code 8089)<br>• Mustard cress (NDNS code 1782)<br>• Roasted vegetable mix (NDNS code 6602)<br>• Reduced fat chocolate chip biscuits (NDNS code 10065) |

| Parts of the system | Recommendations for improvement |
|---|---|
| Missing foods continued | • Waldorf salad (NDNS code 8113)<br>• Alcohol free lager (NDNS code 8345)<br>• Strawberry tarts, individual (NDNS code 7684)<br>• Vegetable crisps (NDNS code 8075)<br>• Pork tongue (NDNS code 9490)<br>• Greengages raw (NDNS code 2051)<br>• Blue cheese (NDNS code 664)<br>• Prawn toast (NDNS code 6994)<br>• Special fried rice (NDNS code 1334)<br>• Tuna pasta bake (NDNS code 5789)<br>• Bread sauce (NDNS code 2411)<br>• Lamb's liver fried (NDNS code 1195)<br>• Scallops (NDNS code 1576)<br>• Mushroom sauce (NDNS code 8584)<br>• Meat free spaghetti bolognese (NDNS code 6306)<br>• Chicken liver, fried (NDNS code 1189)<br>• Doughnuts fresh cream filled (NDNS code 325) |

| Parts of the system | Recommendations for improvement |
|---|---|
| | • White roll toasted (NDNS code 171)<br>• Garlic (NDNS code 1743) |
| Portion sizes/ pictures | • Add ability to enter more than one glass/ cup/ mug for drinks e.g. hot beverages, alcohol, fruit juice, fizzy drinks, water and energy drinks.<br>• Make the ability to add fractions for countable foods more obvious.<br>• Add sizes of pizza in inches to pictures.<br>• Line up bowls straight as done for mugs, for easier size comparison.<br>• Consider increasing the portion size of cauliflower (when eaten as cauliflower cheese) |
| Prompts | • Add pickles and chutneys to list of matching foods for the prompt for sauces with poppadoms.<br>• Change prompt for sugar/ sauce on porridge to sugar/ honey/ syrup.<br>• Add prompt for milk & sugar in decaf tea and coffee and herbal tea |
| Sidebar | • On the last page when reviewing foods entered in the sidebar, display the quantities or the number of glasses/ countable foods recorded, so if the portion sizes/ quantities are not enough, participants can add more |
| Technical issues | • Set the website to automatically load pages from the top. On laptops, the whole page does not fit on-screen and is loaded in the same position as on the previous page - so when scrolling down to select the portion size, the instructions/ prompts at the top of the next page are not visible.<br>• Start food matching & selecting portion sizes of meals in a chronological order. |

| Parts of the system | Recommendations for improvement |
|---|---|
| Technical issues continued | • Highlight individual chocolate wafer biscuits (unwrapped) when the cursor is moved over them in the guide picture.<br>• Highlight individual bounty chocolate bars when the cursor is moved over them in guide picture.<br>• Highlight individual lion/ toffee crisp/ drifter chocolate bars when the cursor is moved over them in guide picture.<br>• Highlight individual chocolate biscuits with marshmallow when the cursor is moved over them in guide picture and add option to select whole numbers/ fractions consumed.<br>• Check and fix where necessary the technical errors reported in relative validation study:<br>  o Inability to submit completed recall to the server (for 2 participants).<br>  o Repeating of breakfast and early snacks (for 2 participants).<br>  o System crashes during completion (for 2 participants). |

## 5.5 Conclusions

This Ph.D. project aimed to investigate, test and identify age-appropriate dietary assessment tools which are suitable for measuring change in diet (particularly adherence to the MD) as a consequence of lifestyle-based interventions. When six Mediterranean diet scores were applied to dietary data from the MEDDINI intervention study, only one significant difference was found in the Mediterranean Score between the control group and both MD intervention groups at 6 months follow up. Considering that only one of the six MDS observed a significant difference at six not 12 months, this broadly suggests that, in this pilot study which was not powered to detect between-treatment differences, the dietary interventions produced little if any significant improvements in adherence to a Mediterranean diet compared with the control group.

Based on the number of assumptions and modifications that were made to calculate the MDS, the percentage change in diet between intervention groups, and the coefficient of variation from baseline to follow up, the relative Mediterranean diet score (rMED) was identified as the most suitable score to use for testing the efficacy of intervention studies in a UK context.

Whilst computerised and online 24 hour recalls have been used previously with older adults (Mennen *et al.*, 2002; Zoellner *et al.*, 2005; Arab *et al.*, 2011; Huybrechts *et al.*, 2011a; Liu *et al.*, 2011; Touvier *et al.*, 2011; Frankenfeld *et al.*, 2012; Hillier *et al.*, 2012; Kirkpatrick *et al.*, 2014), to the researcher's knowledge, the user-testing of INTAKE24 was the first study to compare the usability of a self-completed 24 hour recall system with a paper-based interviewer-led 24-hour recall with older adults. This project was also the first time that INTAKE24 had been user-tested and relatively validated with an older adult population. INTAKE24 was well-received during both user-testing and relative validation and assessed the diets of older adults very well when compared with a conventional approach. However, future modifications of the

INTAKE24 system (detailed within Table 5.1) may further improve its usability, accuracy and precision, and the system could also be adapted to incorporate a larger range of foods commonly consumed by other English-speaking populations. Finally, the rMED method of scoring adherence to the Mediterranean dietary pattern is compatible with data collected using INTAKE24 and both tools appear to be suitable and cost-efficient for use in future large dietary intervention studies (such as the LiveWell Programme) with UK adults in the retirement transition.

# Appendices

## Appendix A Overview of Mediterranean diet scores

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| Trichopoulou *et al.* (1995) | Mediterranean Diet Score (MDS) | Greece | **Beneficial foods:**<br>1. MUFA:SFA<br>2. Alcohol<br>3. Legumes<br>4. Cereals<br>5. Fruit<br>6. Vegetables<br><br>**Detrimental foods:**<br>1. Meat & meat products<br>2. Milk & dairy products | 1 point for consumption above sex-specific medians (g/day) per beneficial food group; 1 point for consumption below sex-specific medians per detrimental food group | 0-8 | Reflects MD pyramid of the time; quick and easy to use | No details on recommended intakes of food groups, cereals group includes refined grains; does not state whether meat group contains poultry; small range in scale |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| Trichopoulou *et al.* (2003) | Mediterranean Diet Score (MDS) | Greece | **Beneficial foods:**<br>1. MUFA:SFA<br>2. Ethanol (10-50g/day for men, 5-25g/day for women)<br>3. Legumes<br>4. Fish<br>5. Cereals<br>6. Fruit & nuts<br>7. Vegetables<br><br>**Detrimental foods:**<br>1. Meat & poultry<br>2. Dairy products | 1 point for consumption above sex-specific medians per beneficial food group (or if within limits for ethanol); 1 point for consumption below sex-specific medians per detrimental food group | 0-9 | Inclusion of fish group; created for use in a large sample size from a longitudinal study; most commonly used MD score in epidemiological studies | Does not distinguish between refined and whole grains; small range in scale |
| Trichopoulou *et al.* (2005) | Modified Mediterranean Diet Score (Modified MDS) | Denmark, France, Germany, Greece, Italy, The Netherlands Spain, | **Beneficial foods:**<br>1. MUFA + PUFA:SFA<br>2. Ethanol (10-50g/day for men, 5-25g/day for women) | 1 point for consumption above sex-specific medians per beneficial food group (or | 0-9 | PUFA included with MUFA to be applicable to non-Mediterranean populations; developed for a | Does not distinguish between refined and whole grains; small range in scale |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| | | Sweden, UK | 3. Legumes<br>4. Fish<br>5. Cereals<br>6. Fruit<br>7. Vegetables<br><br>**Detrimental foods:**<br>1. Meat & meat products<br>2. Dairy products | if within limits for ethanol); 1 point for consumption below sex-specific medians per detrimental food group | | large cohort study | |
| Fung *et al*. (2005) | Alternate Mediterranean Diet Score (aMED) | USA | **Beneficial foods:**<br>1. MUFA:SFA,<br>2. Ethanol (5-25g/day)<br>3. Legumes<br>4. Fish<br>5. Nuts<br>6. Fruit<br>7. Vegetables<br>8. Whole grains<br><br>**Detrimental** | 1 point for consumption above sex-specific medians per beneficial food group (or if within limits for ethanol); 1 point for consumption below sex- | 0-9 | Inclusion of fish group; developed for a non-Mediterranean population | Cross-sectional study design; alcohol group includes beer & spirits which are not featured in the MD; no dairy products group; small range in scale |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| | | | **foods:**<br>1. Red and processed meats | specific medians per detrimental food group | | | |
| Toledo *et al*. (2010) | Modified Mediterranean Diet Score (MMDS) | Spain | **Beneficial foods:**<br>1. Vegetables<br>2. Legumes<br>3. Fruit<br>4. Cereals<br>5. Fish<br>6. Olive oil<br>7. Red wine (5-<30g/day for men, 2.5-15g/day for women)<br><br>**Detrimental foods:**<br>1. Meat & meat products<br>2. Whole-fat dairy products | 1 point for consumption above sex-specific medians per beneficial food group; 1 point for consumption below sex-specific medians per detrimental food group | 0-9 | Longitudinal study (updated score used to measure change in diet at follow up); Only whole-fat dairy products are considered detrimental (authors previously found low fat dairy is inversely associated with hypertension) | Small range in scale |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| Tognon *et al*. (2011) | Refined modified Mediterranean Diet Score (refined mMDS) | Sweden | **Beneficial foods:**<br>1. Vegetables & potatoes<br>2. Legumes, nuts & seeds<br>3. Fruit & fruit juice<br>4. Wholegrain cereals<br>5. Fish & fish products<br>6. Alcohol<br>7.MUFA+PUFA:SFA<br><br>**Detrimental foods:**<br>1. Meat, meat products & eggs<br>2. Dairy products | 1 point for consumption at or above sex-specific medians per beneficial food group; 1 point for consumption below sex-specific medians per detrimental food group | 0-9 | Intakes of each food group were adjusted to daily energy intakes of 2500kcal (10.5MJ) for men and 2000kcal (8.5MJ) for women; food groups slightly more comprehensive; inclusion of PUFA for non-Mediterranean population | Smaller sample size than other MDS; small range in scale |
| Sánchez-Villegas *et al.* (2006) | Mediterranean Dietary Pattern (MDP) Score_1 | Spain | **Beneficial foods:**<br>1. Cereals<br>2. Vegetables<br>3. Fruit | Positively weighted tertile distribution for | 10-30 | Tertiles of intake used as cut-offs for the scoring system instead | Does not state whether cereals group includes both refined |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| | | | 4. Nuts<br>5. Olive oil<br>6. Red wine (20g/day ethanol for men, 10g/day for women)<br><br>**Detrimental foods:**<br>1. Meat & meat products<br>2. Whole fat dairy products | intakes of beneficial foods and negatively weighted for intakes of detrimental foods. For alcohol, transformation centred at recommended intakes, with progressive lower values given when consumption was lower or higher. Values then categorised into tertiles | | of medians; developed for use in a longitudinal study (change in diet assessed with MDP score_2 at follow up); only whole fat dairy products considered detrimental | grains and wholegrains |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| Buckland *et al*. (2010) | Relative Mediterranean Diet Score (rMED) | UK, France, Denmark, Sweden, Germany, Italy, Spain, The NetherlandsNorway, Greece | **Beneficial foods:**<br>1. Fruit (inc. nuts & seeds)<br>2. Vegetables (exc. potatoes)<br>3. Legumes<br>4. Fish (exc. Fish products & preserved fish)<br>5. Cereals<br>6. Olive oil<br>7. Alcohol<br><br>**Detrimental foods:**<br>1. Total meat<br>2. Dairy products | Positively weighted tertile distribution of the first 5 beneficial foods (scores 0-2). For olive oil, 0 for non-consumption1 point for below median, 2 points for ≥ median. For alcohol, 2 points for ≥5-<25g/day for women and ≥10-<50g/day for men, and 0 for values outside these levels. | 0-18 | Score created for large cohort study; tertiles of intake used as cut-offs for the scoring system which give a greater distribution of subjects with different food intakes | Similar weighting still given to each component and the foods within them, even though their effects on health may be distinct e.g. cereals group includes refined and whole grains, and alcohol includes beer, wine and spirits |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| | | | | Negatively weighted tertile distribution for detrimental foods. | | | |
| Cade *et al*. (2011) | Mediterranean Diet Score | UK | **Beneficial foods:**<br>1. Vegetables<br>2. Legumes<br>3. Fruit and nuts<br>4. Cereals<br>5. Fish<br>6. PUFA:SFA<br>7. Alcohol (5-25g ethanol/day)<br><br>**Detrimental foods:**<br>1. Meat<br>2. Poultry<br>3. Dairy products | 1 point for consumption above sex-specific medians per beneficial food group (or within the alcohol guidelines); 1 point for consumption below sex-specific medians per detrimental food group | 0-10 | Easy and simple to use | Diet measured cross-sectionally; only applied to dietary intake of women |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| Issa *et al*. (2011) | Mediterranean Diet Score (MDS) | Lebanon | **Beneficial foods:**<br>1. Cereals<br>2. Fruit<br>3. Vegetables<br>4. Legumes<br>5. Fish & seafood<br>6. Olive oil:SFA<br><br>**Detrimental foods:**<br>1. Red meat & poultry<br>2. Whole milk & dairy products | 1 point for consumption above median frequency of daily intake per beneficial food group; 1 point for consumption below median frequency of intake per detrimental group | 0-8 | Quick to use as no conversion of food frequency data into g/day | Score designed for a cross-sectional study which had a small sample size; alcohol not included due to religious prohibitions |
| Muñoz *et al*. (2009) | Mediterranean Diet Score (MDS) | Spain | **Beneficial foods:**<br>1. Cereals<br>2. Fruits<br>3. Vegetables<br>4. Fish<br>5. Olive oil<br>6. Nuts<br>7. Legumes<br>8. Red wine | Positively weighted tertile distribution of energy-adjusted intakes for the first 7 beneficial | 10-30 | Energy adjusted dietary intakes (g/day); larger range in scale than other comparable scores. | Score created for a cross-sectional study |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| | | | **Detrimental foods:**<br>1. Meat,<br>2. Dairy products | food groups (scored 1-3 points); negatively weighted tertile distribution for the detrimental food groups. For red wine, ethanol intake up to 20g/day scored 3 points and 0 for excess or no consumption | | | |
| Osler and Schroll (1997) | Mediterranean Diet Score | Denmark | **Beneficial foods:**<br>1. MUFA:SFA<br>2. Alcohol<br>3. Cereals<br>4. Fruit | 1 point for consumption above sex-specific energy | 0-7 | Energy adjusted dietary intakes (g/day) | Small sample size; does not include fish food group; values of moderate alcohol |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| | | | 5. Vegetables & legumes<br><br>**Detrimental foods:**<br>1. Meat<br>2. Milk & dairy products | adjusted medians per beneficial food group; 1 point for consumption below sex-specific medians per detrimental food group | | | intake not provided; score has not been used since; small range in scale |
| Schröder *et al*. (2006) | Mediterranean Diet Score (MDS) | Spain | **Beneficial foods:**<br>1. Cereals<br>2. Fruit<br>3. Legumes<br>4. Vegetables<br>5. Fish<br>6. Olive oil<br>7. Nuts<br>8. Red wine (up to 20g/day ethanol) | Positively weighted tertile distribution of energy-adjusted intakes for the first 7 beneficial food groups (scored 1-3 points); | 10-30 | Dietary data collected by an interviewer-administered FFQ, which may result in more accurate reporting of dietary intake compared to self-reported FFQs. Energy | Score developed for cross-sectional study |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| | | | **Detrimental foods:**<br>1. Meat<br>2. Dairy products | negatively weighted tertile distribution for the detrimental food groups. For red wine, ethanol intake up to 20g/day scored 3 points and 1 for excess or no consumption | | adjusted dietary intakes (g/day); larger range in scale than other comparable scores. | |
| Alberti *et al*. (2009) | Mediterranean Adequacy Index (MAI) | Italy | **Beneficial foods:**<br>1. Wholegrain cereals<br>2. Legumes<br>3. Potatoes<br>4. Vegetables<br>5. Fresh fruit<br>6. Fish | Food variables are expressed as % total daily energy intake (or g/day). The sum of the total daily intake from the beneficial foods is divided by the sum | 0- >100 | Score has been used several times; dietary intake measured by 7 day weighed food diaries; authors | Food variables are expressed as g/day when % total energy intake is unavailable, but they might produce different |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| | | | 7. Wine<br>8. Virgin olive oil<br><br>**Detrimental foods:**<br>1. Milk<br>2. Cheese<br>3. Meat<br>4. Eggs<br>5. Animal fats & margarine<br>6. Sweet beverages<br>7. Cakes, pies & cookies | of the total daily intake from the detrimental foods. The Healthy Reference Italian Mediterranean Diet has a score of 7.2. | | suggest that food variables could be altered to be relevant to modern food consumption e.g. low fat dairy products could be removed from the milk group | values from food group intakes due to differences in energy densities |
| Gerber *et al*. (2000) | Mediterranean Diet Quality Index (M-DQI) | France | 1. SFA (% total energy intake)<br>2. Cholesterol (mg)<br>3. Meats (g)<br>4. Olive oil (ml)<br>5. Fish (g)<br>6. Cereals (g)<br>7. Fruit & vegetables (g) | Consumption of each food variable is scaled into 3 sub-scores, according to recommended guidelines when they exist (e.g. SFA and cholesterol), or by dividing the sample's consumption into | 0-14 | Food portion size estimated using food photographs in interview-administered FFQ than details of standard portions; score validated using | Doesn't specify which food groups were derived from nutritional guidelines or from tertiles of sample's consumption; poultry and alcohol not |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| | | | | tertiles (e.g. meat, fish) | | biomarkers; although a Mediterranean diet score, several food groups scored using US recommendati ons | included in the score; refined and whole grains not separated; small scale |
| Goulet *et al*. (2003) | Mediterranean Score | Canada | 1. Whole grains<br>2. Vegetables<br>3. Fruit<br>4. Legumes, nuts & seeds<br>5. Olive oil, olives & olive margarine 6. Milk & dairy products<br>7. Fish & seafood (not breaded)<br>8. Poultry (not breaded)<br>9. Eggs, | Each food group scored 0-4, depending on frequency of daily or weekly consumption. Foods placed higher up in the MD pyramid score higher points if consumed less frequently and vice versa | 0-44 | Based on the MD pyramid; detailed information provided on portion sizes and food groups; created for an intervention study; score has been used since | Some standard portion sizes are given in cups, which will need converting to grams if used in other populations |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| | | | 10. Sweets<br>11. Red meat/ processed meat | | | | |
| Panagiotakos *et al*. (2006b) | MedDietScore | Greece | **Beneficial foods:**<br>1. Cereals<br>2. Potatoes<br>3. Fruit<br>4. Vegetables<br>5. Legumes<br>6. Fish<br>7. Use of olive oil in cooking<br>8. Alcohol<br><br>**Detrimental foods:**<br>1. Red meat & products<br>2. Poultry<br>3. Full fat dairy products | Each food group scored 0-5 depending on frequency of daily/ weekly/ monthly intake. Higher points are awarded for higher frequencies of consumption for beneficial food and vice versa for detrimental foods. For alcohol, 5 points are awarded for intakes of <300ml/day, 4 points for 300ml/day, 3 points for 400-500ml/day, 2 points for | 0-55 | Based on MD pyramid; has been used extensively by the authors | Created for a cross-sectional study |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| | | | | 600ml/day, 1 points for 700ml/day and 0 for no intake or >700ml/day | | | |
| Panagiotakos *et al*. (2009) | Modified MedDietScore | Greece | **Foods to be consumed daily:**<br>1. Whole grains<br>2. Fruit<br>3. Vegetables<br>4. Legumes<br>5. Use of olive oil in cooking<br>6. Alcohol<br><br>**Foods to be consumed weekly:**<br>1. Potatoes<br>2. Fish<br>3. Full fat dairy products<br><br>**Foods to be consumed** | Each food group scored 0-5 depending on frequency of daily/ weekly/ monthly intake. Five points are awarded for frequencies of consumption meeting recommendations for foods to be consumed daily, with lesser points awarded to lesser or no intakes (except alcohol) and vice versa for foods to be consumed monthly. | 0-130 | Based on MD pyramid; weighting given according to recommendations on the frequency of food groups to be eaten; larger scale score which could detect extremes in food intakes | Created for a cross-sectional study with a small sample size |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| | | | **monthly:**<br>1. Poultry<br>2. Red meat & products | Alcohol scored as above. Scores for foods to be consumed daily are multiplied by 3 and scores for foods to be consumed weekly are multiplied by 2. | | | |
| Estruch *et al*. (2006) | MEDAS | Spain | 1. Olive oil as the main culinary fat<br>2. ≥4tbsp olive oil consumed/day<br>3. ≥2 servings vegetables/day<br>4. ≥3 servings fruit/day<br>5. <1 serving/day butter, 6 <1 serving/ day red & processed meat | One point allocated to positive responses; no points for negative responses. | 0-14 | Score developed for an intervention study; rapid measure of MD compliance; has been used several times since; provides recommended serving sizes | Relatively small sample size; does not include all foods in the MD pyramid |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| | | | 7. <1/day sweet/ carbonated beverage<br>8. ≥3 glasses/day water, 9. ≥3 servings/week legumes<br>10. ≥3 servings/ week fish & shellfish<br>11. <3 servings/ week sweets & pastries<br>12. ≥ 1 serving/ week nuts<br>13. Preferential consumption of chicken, turkey & rabbit over veal & processed pork<br>14. ≥2 servings/ week solfrito (tomato, onion & | | | | |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| | | | olive oil sauce) | | | | |
| Martínez-Gonzalez *et al*. (2004) | Short MD questionnaire | Spain | 1. ≥ 1 spoon/day olive oil<br>2. ≥1 serving/day fruit<br>3. ≥1 serving/day vegetables/salad<br>4. ≥1 serving/day fruit *and* ≥1 serving/day vegetables<br>5. ≥2 servings/week legumes<br>6. ≥3 servings/ week fish<br>7. ≥1 glass/day wine<br>8. ≤1 serving/day meat<br>9. <1 serving/day white bread and <1 | One point allocated to positive responses; no points for negative responses. | 0-9 | Rapid measure of MD adherence and can provide immediate feedback | Based on MD pyramid, but does not incorporate the recommended intakes from the pyramid; developed for use in a small sample size with diet measured cross-sectionally |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| | | | serving/ week rice *or* >5 servings/ week wholegrain bread | | | | |
| Mozaffarian *et al*. (2007) | Mediterranean diet score | Italy | Questions on usual consumption of cooked & raw vegetables, fruit, fish, olive oil & other oils, butter, cheese, wine and coffee. | Each food item scored 1-3 points depending on frequency of consumption | 0-15 | Rapid measure of MD adherence | Questionnaire does not assess other components of the MD e.g. cereals, nuts or legumes; no clear demonstration of the score including possible responses and how many points are awarded to each answer; score has not been used since |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| Rumawas *et al*. (2009) | Mediterranean-Style Dietary Pattern Score (MSDPS) | USA | 1. Whole grains<br>2. Fruit<br>3. Vegetables<br>4. Dairy<br>5. Wine<br>6. Fish & other seafood<br>7. Poultry<br>8. Olives, legumes & nuts<br>9. Potatoes & other starchy roots<br>10. Eggs<br>11. Sweets<br>12. Meat<br>13. Olive oil | Except for olive oil, each food group scored from 0-10 depending on the degree of conformity to recommended intakes. For olive oil 10 points are assigned if it is exclusively used as the source of added fat, 5 points if it is used in occurrence with other vegetable oils, and no points if it is not used at all. For overconsumption of each food group, 1 point is subtracted per serving consumed in excess. If overconsumption of | 0-100 | Based on MD pyramid components; includes a weighting factor to account for energy intake derived from non-MD foods; large scale implying more accuracy; uses a continuous scale to remove necessity of applying cut-off points to dietary components | Most complex score to use; diet measured cross-sectionally |

| Author, Year | Name of Score | Country | Food Components | Scoring System | Range | Advantages | Disadvantages |
|---|---|---|---|---|---|---|---|
| | | | | a food group exceeds 100%, score is defaulted at 0. Points standardised to a sum of 100. To account for non-MD foods, a weighting factor on a continuous scale of 0-1, reflecting 0-100% of energy derived from MD foods is multiplied to the standardised score. | | | |

## Appendix B Quality assessment form for Mediterranean diet scores

| | |
|---|---|
| **Dietary Score:** | |
| **Paper reference:** | |
| ***1. Where was the score developed and in which populations?*** | |
| | |
| ***2. Was it intended for measuring change in diet or cross-sectionally?*** | |
| | |
| ***3. What values of dietary intake are used to calculate the score e.g. mean, median, g/day*** | |
| | |
| ***4. How was dietary intake collected?*** | |
| | |
| ***5. How is the score calculated? Include positive & negative scorings of food groups*** | |
| | |
| ***6. What is the range of scores?*** | |
| | |
| ***7. Has the score been widely used in other studies?*** | |
| | |

| ***8. Any advantages/ disadvantages?*** |
| --- |
| |

# Appendix C Criteria for selecting Mediterranean diet scores to test

| | |
|---|---|
| **Dietary Score:** | |
| **Paper reference:** | |

1. ***Does the score consider all "beneficial" food groups of the MD pyramid (foods to be consumed ≥ 2 times/week, according to Bach-Faig, 2011)?***
   **i.e. fruit, vegetables (and potatoes), olive oil (will consider lipid ratio as substitute), cereals (preferably wholegrain), olives/nuts/seeds, dairy products (preferably low fat), eggs, legumes, fish/seafood, white meat, alcohol**

☐ 1 point — Excludes ≥ 3 food groups

☐ 2 points — Excludes 1-2 food groups

☐ 3 points — Includes all recommended food groups

Food groups missing:

_______________________________________________

_______________________________________________

2. ***Does the score consider non-Mediterranean foods or those to be consumed less frequently?***

☐ 1 point — Only red meat and/or (full fat) dairy groups

☐ 2 points — Red meat and/or (full fat) dairy products plus other food groups e.g. sweets, carbonated drinks

☐ 3 points — Negative weighting factor of non-Mediterranean foods

Notes:

_______________________________________________

| |
|---|
| ***3. Does the score provide enough information to be able to reproduce the score?*** |
| ☐ 0 points — No<br>☐ 1 point — Some information missing e.g. recommended levels of intakes used for awarding points<br>☐ 2 points — Sufficient information provided, but needs some work to apply to a different population e.g. conversion of portion sizes from cups to grams<br>☐ 3 points — Yes |
| ***4. What is the score's maximum number of points?*** |
| ☐ 1 point — 0-10 points<br>☐ 2 points — 11-30 points<br>☐ 3 points — 31+ points |
| ***5. What is the method of assigning points?*** |
| ☐ 1 point — Dichotomising e.g. above or below median/mean intakes<br>☐ 2 points — Tertiles/ quintiles<br>☐ 3 points — More complex methods e.g. ratio, continuous scale, percentage |
| ***6. What is the study design in which the score was developed?*** |
| ☐ 1 point — Cross-sectional<br>☐ 2 points — Cohort (longitudinal)<br>☐ 3 points — Intervention |

| ***7. Has the score been used in a non-Mediterranean population?*** | | |
|---|---|---|
| ☐ | 1 point | No |
| ☐ | 2 points | Both Mediterranean and non-Mediterranean populations |
| ☐ | 3 points | Only in non-Mediterranean populations |

| ***8. What was the dietary assessment method used in developing the score?*** | | |
|---|---|---|
| ☐ | 1 point | Food frequency e.g. FFQ |
| ☐ | 2 points | Semi-quantitative e.g. estimated weight food diaries, 24hr recall |
| ☐ | 3 points | Quantitative e.g. weighed food diaries |

Notes:

___

___

| ***9. Has the score been applied to other datasets since its development?*** | | |
|---|---|---|
| ☐ | 0 points | Not been used since |
| ☐ | 1 points | Only been used by authors/in the same population |
| ☐ | 2 points | Used in 1-5 papers |
| ☐ | 3 points | Used in 6+ papers |

Notes:

___

___

| *10. Has the score been tested in a review paper and if so, how did it fare in comparison to other scores?* | |
|---|---|
| ☐ 0 points — Not tested in a review paper<br>☐ 1 point — Featured in a paper but scored low compared to other scores/not associated with the health outcome of interest<br>☐ 2 points — Scored moderately in comparison with other scores/with the health outcome<br>☐ 3 points — Most favourable score compared to others/highest associations with the health outcome<br><br>Notes: ______________________________<br>______________________________ | |
| **Total points:** | /30 |

# Appendix D Rationale for selection criteria of Mediterranean diet scores to test

1. ***Does the score consider all "beneficial" food groups of the MD pyramid (foods to be consumed ≥ 2 times/week, according to Bach-Faig, 2011)?***

   Ideally, the most suitable Mediterranean diet score to test will be one which incorporates all the "Mediterranean" food components described in the most recent version of the Mediterranean diet pyramid.

   Reference:

   Bach-Faig, A., et al. (2011) Mediterranean diet pyramid today. Science and cultural updates. *Public Health Nutrition*. **14**(12 A): p. 2274-2284.

2. ***Does the score consider non-Mediterranean foods or those to be consumed less frequently?***

   This question incorporated foods which were not considered to be Mediterranean. For the majority of Trichopoulou-like scores, they only included meat and/or dairy products. However, dairy is actually considered a beneficial component in Bach-Faig's MD pyramid and non-Mediterranean foods should include red meat, processed meat and sweets. Scores that incorporated a negative weighting factor of Mediterranean: non-Mediterranean food consumption (such as that employed by Rumawas *et al.*'s Mediterranean-Style Dietary Pattern Score) were scored higher due to their greater relevance in a non-Mediterranean population.

3. ***Does the score provide enough information to be able to reproduce the score?***

   In order to test a Mediterranean diet score, it firstly must be assessed for whether there is sufficient information provided in the paper to replicate the score. In this criterion, point allocation was graded according to how much information was missing. For those scores which were awarded one and two points, they may be usable if they could be modified for use in the intended population (e.g. ascertain RNIs for those scores based on national recommended intakes of foods/nutrients or convert portion sizes into appropriate measures used in the UK).

4. ***What is the score's maximum number of points?***

Scores containing smaller ranges in points may be less able to detect small changes in diet. Point allocation of this criterion was based on the range in points of the scores found from a literature search. Scores based on Trichopoulou *et al.*'s Mediterranean Diet Score (which are the simplest and dichotomise median food intakes to assign points) range from 0-10 points and were allocated 1 point. Slightly less simple scores (e.g. scores which used tertiles/quintiles of mean dietary intakes to assign points) fell in the range of 11-30 points and were allocated 2 points in the criterion, whilst the most complex MDS which have greater ranges of points were allocated the maximum three points.

5. ***What is the method of assigning points?***

This criterion is similar to the last criterion, where those scores with greater complexity to their calculation were allocated greater points.

6. ***What is the study design in which the score was developed?***

Ideally, a diet score developed for an intervention study would be the most applicable to the LiveWell programme and were therefore awarded three points. Conversely, scores developed for a cross-sectional study may be less able to detect changes in diet over time were awarded one point.

7. ***Has the score been used in a non-Mediterranean population?***

Since the LiveWell Programme is based in the UK, it would be favourable to use an MDS which is known to work sufficiently well in a non-Mediterranean population. Therefore, scores which have only been tested in Mediterranean countries (either by the MDS' authors or subsequently in a different population by a different research group) were awarded one point.

***8. What was the dietary assessment method used in developing the score?***

This criterion was based on the accuracy of the dietary assessment method which was used to record dietary data in the development of the MDS. Weighed food diaries are considered the Gold standard of dietary assessment and were allocated three points in this criterion. Food frequency questionnaires were allocated the lowest points value, due to them being based on the recall of dietary habits over the previous year.

***9. Has the score been applied to other datasets since its development?***

This criterion tests how popular the Mediterranean diet scores are. Papers describing the development of an MDS were searched for in a literature database and the citations checked for how many times and in what study population the MDS have been used. Scopus database was used for this purpose, as it is the largest medical sciences literature database which overlaps with other medical databases. If an MDS was reported to have been used in several papers, but using the data from the study population in which the score was developed, then only one point was awarded in this criterion. It is important to note that this criterion was based on the number of datasets that the MDS were applied to, not the number of papers which cited their use. Therefore, even if an MDS was applied to a large dataset (e.g. EPIC) and its relationship with differing outcomes reported in several papers, it still only counted as one study population (unless each paper reported on a different sub-sample of the study population). A note was made of the references which utilised the MDS. Whilst it is recognised that this criterion has placed an unfair disadvantage on the more recently developed MDS, older scores may not have been utilised in more recent times, and there are nine other criteria in which the MDS are assessed on.

***10. Has the score been tested in a review paper and if so, how did it fare in comparison to other scores?***

Six papers were identified which reviewed the correlations and/or associations with health outcomes between the adherence to two or more MDS. For those

MDS which featured in these review papers, the point allocation of this criterion was based on how well the MDS in question fared in relation to other MDS. For those scores which were described as being poorly correlated with other MDS or health outcomes, one point was awarded. For those scores which were the most comparable to other MDS or provided the highest associations with a health outcome, three points were awarded. For those scores in between which fared moderately, two points were awarded. Scores which were not tested in the review papers were not assigned any points.

Review paper references:

Lassale, C. *et al.* (2012) Association between dietary scores and 13-year weight change and obesity risk in a French prospective cohort. *International Journal of Obesity*: 1-8.

Mila-Villarroel, R., *et al*. (2011) Comparison and evaluation of the reliability of indexes of adherence to the Mediterranean diet. *Public Health Nutrition*. **14**(12A): p. 2338-2345.

Beunza, J. J., *et al*. (2010) Adherence to the Mediterranean diet, long-term weight change, and incident overweight or obesity: the Seguimiento Universidad de Navarra (SUN) cohort. *American Journal of Clinical Nutrition*. **92**: p. 1484-93.

Toledo, E., *et al*. (2009) Hypothesis-oriented food patterns and incidence of hypertension: 6-year follow up of the SUN (Seguimiento Universidad de Navarra) prospective cohort. *Public Health Nutrition*. **13**(3): p. 338-349.

Puchau, B., *et al*. (2009) Dietary total antioxidant capacity: A novel indicator of diet quality in healthy young adults. *Journal of the American College of Nutrition*. **28**(6): p. 648-656.

Knoops, K. T. B., *et al*. (2006) Comparison of three different dietary scores in relation to 10-year mortality in elderly European subjects: the HALE project. *European Journal of Clinical Nutrition*. **60**: p. 746-755.

# Appendix E Calculation of the six chosen Mediterranean diet scores

## Mediterranean Adequacy Index (MAI)

The MAI is calculated by dividing the sum of the percentage of total energy intake from typical Mediterranean food groups (bread, cereals, legumes, vegetables, fresh fruit, nuts, fish, wine and vegetable oils) by the sum of the percentage of total energy intake from non-typical Mediterranean food groups (milk, cheese, meat, eggs, animal fats and margarines, sweet beverages, cakes pies and cookies and sugar). Although the MAI was classified as a parent score, some food groupings have been slightly revised since its development, whilst still maintaining its original name and method of calculation. The 2004 version was chosen for testing, due to its inclusion of the MAI value assigned to a healthy reference Italian Mediterranean diet (the median MAI is between 4.0 and 8.5), which offers scope for comparison (Fidanza *et al.*, 2004). The score ranges from 0 to over 100 points.

## Relative Mediterranean Diet Score (rMED)

Each food component of the rMED (Buckland *et al.*, 2010) (except alcohol) is calculated as g/1000kcal/day and then divided into tertiles of intake. The score ranges between 0 and 18 points, with higher scores indicating greater adherence to the Mediterranean diet. Calculation of the rMED is described below.

**Calculation of the Relative Mediterranean Diet Score**

| | Points | | |
|---|---|---|---|
| Food group | Tertile 1 | Tertile 2 | Tertile 3 |
| Fruit (inc. nuts & seeds) | 0 | 1 | 2 |
| Vegetables (exc. potatoes) | 0 | 1 | 2 |
| Legumes | 0 | 1 | 2 |
| Fish (fresh or frozen, exc. fish products & preserved fish) | 0 | 1 | 2 |
| Cereals | 0 | 1 | 2 |
| Total meat | 2 | 1 | 0 |
| Dairy products | 2 | 1 | 0 |
| Olive oil | 0 = non consumers | 1 = < median of olive oil consumers | 2 = ≥median of consumers |
| Alcohol | 0 = above or below 5-25g g/d women & 10-50g/d men | | 2 = 5-25g/d women and 10-50g/d men |

**Mediterranean Score**

Each food group within the Mediterranean Score (Goulet *et al.*, 2003) is divided into five frequencies based on daily and weekly consumption, which are awarded between zero and four points (see below). Unlike the other five MDS selected for testing, the Mediterranean Score does not include alcohol as a food group. The score ranges from 0-44 points, with higher scores indicating greater adherence to a Mediterranean diet.

## Calculation of the Mediterranean Score

| Score<br>Food Group | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Whole grains | <1 portion/ day | 1-2 portions/ day | 3-4 portions/ day | 5-6 portions/ day | ≥7 portions/ day |
| Vegetables | <1 portion/ day | 1 portion/ day | 2 portions/ day | 3 portions/ day | ≥4 portions/ day |
| Fruit | <1 portion/ day | 1 portion/ day | 2 portions/ day | 3 portions/ day | ≥4 portions/ day |
| Legumes, nuts & seeds | <0.5 portions/ day | 0.5 portions/ day | 1 portion/ day | 2 portions/ day | >2 portions/ day |
| Olive oil, olives & olive oil margarines | <1 time/ day | 1 time/day | 2 times/day | 3 times/day | ≥4 times/ day |
| Milk & dairy products | <1 portion/ day or > 4 portions/ day | 4 portions/ day | Not awarded | 1 portion/ day | 2-3 portions/ day |
| Fish & seafood (not breaded) | Never | <1 portion/ week | 1 portion/ week | 2 portions/ week | ≥3 portions/ week |
| Poultry (not breaded) | Never | <1 portion/ week | 1 portion/ week or ≥4 portions/ week | 2 portions/ week | 3 portions/ week |
| Eggs | ≥7/week | Not awarded | 5-6/week | Not awarded | 0-4/week |
| Sweets | ≥7 times/ week | 5-6 times/ week | 3-4 times/ week | 1-2 times/ week | <1 time/ week |
| Red meat/ processed meat | ≥7 portions/ week | 5-6 portions/ week | 3-4 portions/ week | 1-2 portions/ week | <1 portion/ week |

**Mediterranean-Style Dietary Pattern Score (MSDPS)**

The MSDPS (Rumawas *et al.*, 2009) is the most complex of all Mediterranean diet scores found in the literature and is calculated in three stages. Firstly, consumption of each of the food components is compared with the recommended daily or weekly number of servings defined by a Mediterranean food pyramid (Ministry of Health and Welfare Supreme Scientific Health Council of Greece, 1999). With the exception of olive oil, each group is scored proportionally from 0 to 10, depending on the degree of adherence to the recommendations (e.g. consuming 50% of the recommended servings would result in a score of 5). Overconsumption of these foods is also incorporated into the score. This incurs a penalty by subtracting one point proportionally to the number of servings consumed that exceed the recommended intake for that group (e.g. exceeding the recommendation by 40% would result in a score of 6). Due to this "overconsumption penalty," the score of a food group can be negative if the recommendations are exceeded by 100%. In this instance, the negative score is defaulted to zero. The scoring of olive oil is categorical, based on its exclusive use (10 points), the use of olive oil in addition to other vegetable oils (5 points), or no use of olive oil (0 points). The calculation of food group intakes according to recommendations is explained in the table below.

Secondly, the 13 food group scores are summed and the total standardised to a 0–100 scale by dividing the calculated sum by the theoretical maximum sum of 130 and multiplying by 100. Thirdly, considering that the 13 food groups are part of the Mediterranean diet pyramid and this score was developed for use within a non-Mediterranean population, the standardized sum of the 13 components is weighted by the proportion of energy intake derived from foods consumed as part of the Mediterranean diet pyramid. This weighting factor, which reflects a 0–100% energy intake attributed to the consumption of Mediterranean foods, is a continuous factor ranging from 0–1. For example, if a person consumes 25% of energy from non-Mediterranean foods, the calculated weighting factor is 0.75. This weighting factor is then multiplied by the standardised total of consumption of the 13 food groups, to give a MSDPS score ranging between 0-100 where higher scores indicate greater adherence to the Mediterranean diet.

## Calculation of the Mediterranean-Style Dietary Pattern Score

| Food group | Criteria for max score of 10 | Score (points/serving) |
|---|---|---|
| | (servings/day) | |
| Whole grains | 8 | 1.25 |
| Fruits | 3 | 3.33 |
| Vegetables | 6 | 1.67 |
| Dairy | 2 | 5 |
| Wine -men | 3 | 3.33 |
| Wine - women | 1.5 | 6.67 |
| | (servings/week) | |
| Fish & other seafood | 6 | 1.67 |
| Poultry | 4 | 2.5 |
| Olives, legumes & nuts | 4 | 2.5 |
| Potatoes & other starchy roots | 3 | 3.33 |
| Eggs | 3 | 3.33 |
| Sweets | 3 | 3.33 |
| Meat | 1 | 10 |
| Olive oil | Use only olive oil | 0 (for no use) |
| | | 5 (for use + other veg oils) |

### Mediterranean Diet Adherence Screener Score (MEDAS)

In contrast to the previous scores selected for further testing, MEDAS (Estruch *et al.*, 2006) fulfils the roles of both an FFQ and a Mediterranean diet score, as it was designed as a short questionnaire which provides rapid assessment of adherence to the MD. This score is an extension of a nine-point score developed by Martínez-González et al. (2004). Each of the 14 items is scored zero or one, which are then summed. Higher scores indicate greater compliance to the MD. The questionnaire and criteria for scoring points are described below.

## Calculation of the Mediterranean Diet Adherence Screener Score

| Foods and frequency of consumption | Criteria for 1 point* |
|---|---|
| Do you use olive oil as main culinary fat? | Yes |
| How much olive oil do you consume in a given day (inc. oil used for frying, salads, out-of-house meals etc.?) | ≥4 tbsp or 54g<br>(1tbsp = 13.5g) |
| How many vegetable servings do you consume per day? (1 serving = 200g. Consider side dishes as half a serving/ half a point) | ≥2 (≥1 portion raw or as salad) |
| How many fruit units (inc. natural fruit juices) do you consume per day? | ≥3 |
| How many servings of red meat, hamburger, or meat products (ham, sausage etc.) do you consume per day? (1 serving = 100-150g) | <1 |
| How many servings of butter, margarine, or cream, do you consume per day? (1 serving = 12g) | <1 |
| How many sweet or carbonated beverages do you drink per day? | <1 |
| How much wine do you drink per week? | ≥3 glasses |
| How many servings of legumes do you consume per week? (1 serving = 150g) | ≥3 |
| How many servings of fish or shellfish do you consume per week? (1 serving = 100-150g fish/ 4-5 units/ 200g shellfish) | ≥3 |
| How many times per week do you consume commercial sweets or pastries (not homemade) e.g. cakes, cookies, biscuits or custard? | <3 |
| How many servings of nuts (including peanuts) do you consume per week? (1 serving = 30g) | ≥1 |
| Do you preferentially consume chicken, turkey, or rabbit meat instead of veal, pork, hamburger or sausage? | Yes |
| How many times per week do you consume vegetables, pasta, rice, or other dishes seasoned with sofrito (sauce made with tomato and onion, leek, or garlic and simmered with olive oil)? | ≥2 |

* 0 points if these criteria are not met

**MedDietScore**

The MedDietScore (Panagiotakos *et al.*, 2006b) was developed according to recommendations for the same MD pyramid as the MSDPS (Ministry of Health and Welfare Supreme Scientific Health Council of Greece, 1999). Monotonic functions are used (except for alcohol) to score the frequency of monthly food group intakes between 0-5 points. This score ranges from 0-55 points, with higher values signifying greater adherence to the MD. Similarly to MEDAS, this score can either be applied to dietary data or used as a questionnaire in itself, with the aid of the MedDietScore computer programme (Panagiotakos *et al.*, 2006a).

**Calculation of the MedDietScore**

| | Frequency of consumption (servings/month) | | | | | |
|---|---|---|---|---|---|---|
| Foods | Never | 1-4 | 5-8 | 9-12 | 13-18 | >18 |
| Non-refined cereals | 0 | 1 | 2 | 3 | 4 | 5 |
| Potatoes | 0 | 1 | 2 | 3 | 4 | 5 |
| Fruits | 0 | 1 | 2 | 3 | 4 | 5 |
| Vegetables | 0 | 1 | 2 | 3 | 4 | 5 |
| Legumes | 0 | 1 | 2 | 3 | 4 | 5 |
| Fish | 0 | 1 | 2 | 3 | 4 | 5 |
| Red meat and products | 5 | 4 | 3 | 2 | 1 | 0 |
| Poultry | 5 | 4 | 3 | 2 | 1 | 0 |
| Full fat dairy products (cheese, yoghurt & milk) | 5 | 4 | 3 | 2 | 1 | 0 |
| Use of olive oil in cooking (times/week) | Never | Rare | <1 | 1-3 | 3-5 | Daily |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| Alcoholic beverages (ml/day, 100ml = 12g ethanol) | <300 | 300 | 400 | 500 | 600 | >700 or 0 |
| | 5 | 4 | 3 | 2 | 1 | 0 |

## Appendix FSources of nutrient compositions and average portion sizes of foods added to the FFQ database

| Food Group | Food Name | Source of Nutrient Composition | Source of Average Portion Size (APS) |
|---|---|---|---|
| Meat & Fish | Fish roe, taramasalata | Mean calculated from caviar/roe in NDNS Nutrient Databank | Frequency of consumption and mean APS calculated from consumers of caviar and fish roe in NDNS. |
| Bread & Savoury Biscuits | Crispbread, e.g. Ryvita | Mean calculated from crispbreads in NDNS Nutrient Databank | Mean of individual crispbread weights in FSA food portion sizes book |
| Cereals | Breakfast cereal such as cornflakes, muesli etc. | Calculated mean from sugar coated cereals; non-sugar coated cereals; all bran; WG cereals pre-existing in database | Merged sugar coated cereals; non-sugar coated cereals; all bran; WG cereals cereal items pre-existing in database and recalculated mean APS |
| The following on bread or vegetables | Monounsaturated reduced fat spread, e.g. Bertolli | “Reduced fat spread, not PUFA, with olive oil”; from NDNS Nutrient Databank | Frequency of consumption and mean APS from “Fat spread (60% fat), with olive oil” consumers in NDNS |
| The following on bread or vegetables | Monounsaturated low fat spread, e.g. Golden Olive | “Low fat spread, not PUFA, olive” from NDNS Nutrient Databank | Frequency of consumption and mean APS calculated from consumers of corresponding low fat olive-based spreads in NDNS |
| The following on bread or vegetables | Very low fat spread (tub), e.g. Flora pro activ extra light | Mean calculated from flora pro activ light and very low fat spread in NDNS Nutrient Databank | Consumers of “Fat spread (20-25% fat), not polyunsaturated” in NDNS |
| Sweets & Snacks | Home-made cakes e.g. fruit, sponge | Copied from pre-existing "cakes" in database | Copied from pre-existing "cakes" in database |
| Sweets & Snacks | Ready-made cakes, e.g. fruit, sponge | Copied from pre-existing "cakes" in database | Copied from pre-existing "cakes" in database |

| Food Group | Food Name | Source of Nutrient Composition | Source of Average Portion Size (APS) |
|---|---|---|---|
| Sweets & Snacks | Home baked buns/pastries e.g. scones, flapjacks | Copied from pre-existing "sweet buns/pastries" in database | Copied from pre-existing "sweet buns/pastries" in database |
| Sweets & Snacks | Ready-made buns/pastries e.g. croissants, doughnuts | Copied from pre-existing "sweet buns/pastries" in database | Copied from pre-existing "sweet buns/pastries" in database |
| Sweets & Snacks | Home baked fruit pies, tarts, crumbles | Copied from pre-existing "fruit pies, tarts, crumbles" in database | Copied from pre-existing "fruit pies, tarts, crumbles" in database |
| Sweets & Snacks | Ready-made fruit pies, tarts, crumbles | Copied from pre-existing "fruit pies, tarts, crumbles" in database | Copied from pre-existing "fruit pies, tarts, crumbles" in database |
| Sweets & Snacks | Home baked sponge puddings | Mean calculated from chocolate and plain/fruit/syrup sponge puddings in NDNS Nutrient Databank | Frequency of consumption and mean APS calculated from consumers of sponge puddings in NDNS |
| Sweets & Snacks | Ready-made sponge puddings | Mean calculated from chocolate and plain/fruit/syrup sponge puddings in NDNS Nutrient Databank | Frequency of consumption and mean APS calculated from consumers of sponge puddings in NDNS |
| Drinks | Coffee, decaffeinated | Copied from pre-existing "Coffee, instant or ground" in database | Copied from pre-existing "Coffee, instant or ground" in database |
| Milk | Whole milk | Mean of summer and winter whole milk in NDNS Nutrient Databank | Tick box in FFQ. Pints converted to grams. Daily consumption of more than one pint calculated from mean portion size of consumers over 568g in NDNS |
| Milk | Semi-skimmed milk | Mean of summer and winter semi-skimmed milk in NDNS Nutrient Databank | Tick box in FFQ. Pints converted to grams. Daily consumption of more than one pint calculated from mean portion size of consumers over 568g in NDNS |
| Milk | Skimmed milk | Mean of summer and winter skimmed milk in | Tick box in FFQ. Pints converted to grams. Daily |

| Food Group | Food Name | Source of Nutrient Composition | Source of Average Portion Size (APS) |
|---|---|---|---|
| | | NDNS Nutrient Databank | consumption of more than one pint calculated from mean portion size of consumers over 568g in NDNS |
| Milk | Soya milk | Mean of sweetened and unsweetened soya milk in NDNS Nutrient Databank | Tick box in FFQ. Pints converted to grams. Daily consumption of more than one pint calculated from mean portion size of consumers over 568g in NDNS |
| Milk | Oat milk | Mean of fortified and unfortified oat milk in NDNS Nutrient Databank | Tick box in FFQ. Pints converted to grams. Daily consumption of more than one pint calculated from mean portion size of consumers over 568g in NDNS |
| Milk | Rice milk | Mean of fortified and unfortified rice milk in NDNS Nutrient Databank | Tick box in FFQ. Pints converted to grams. Daily consumption of more than one pint calculated from mean portion size of consumers over 568g in NDNS |

# Appendix G Clustered boxplots of Mediterranean diet scores by intervention group and time point

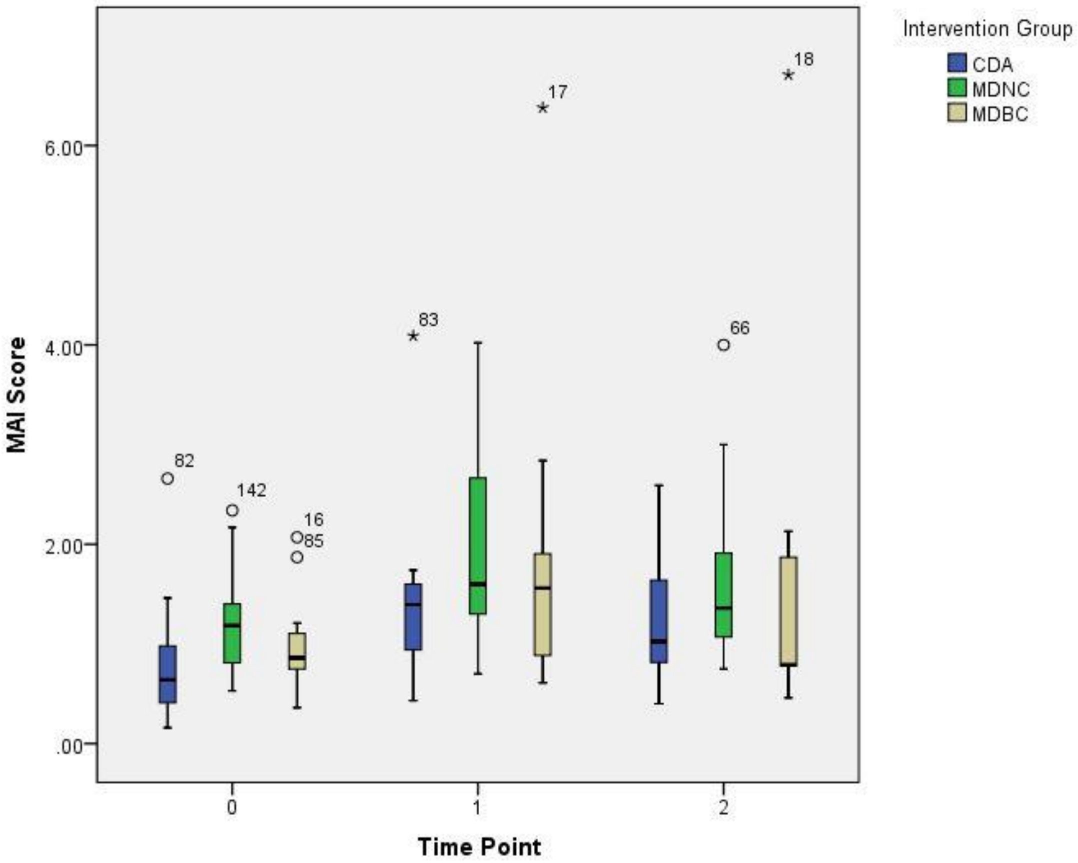



**Figure G.1 Clustered boxplot of MAI by intervention and time point**

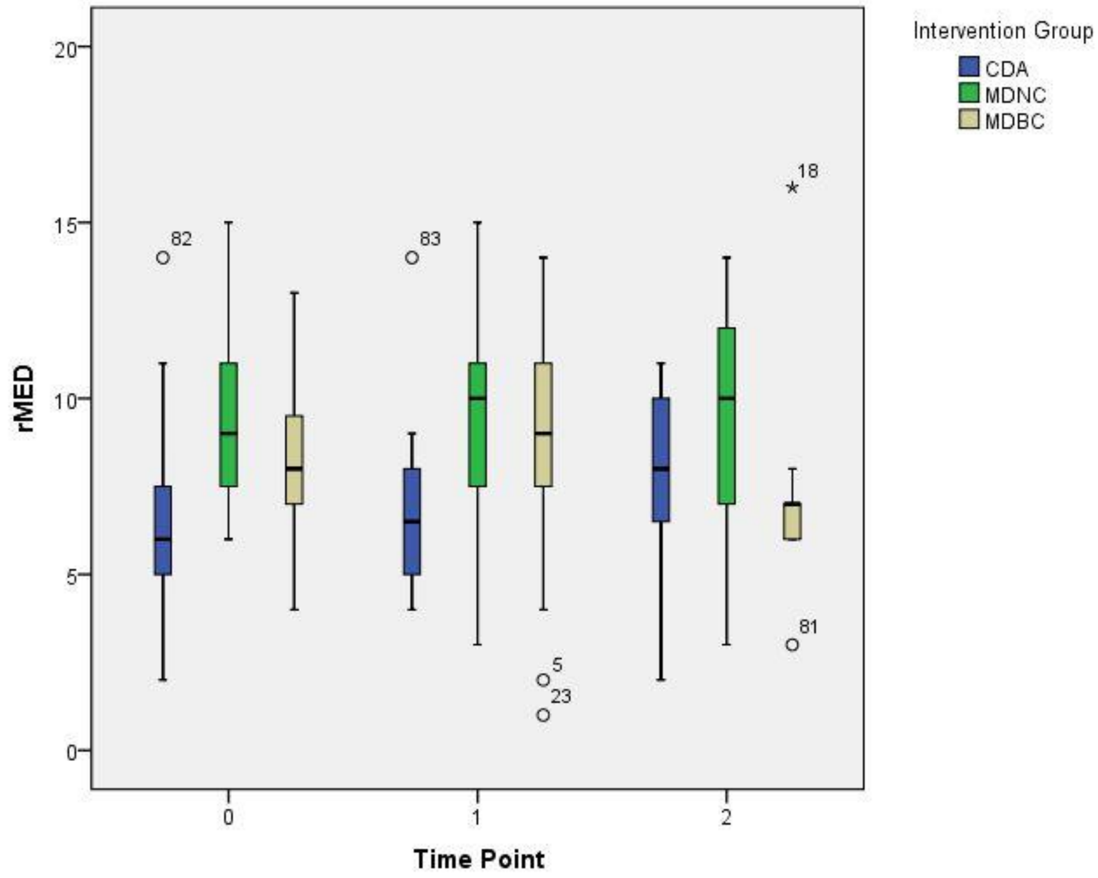



**Figure G.2 Clustered boxplot of rMED by intervention and time point**

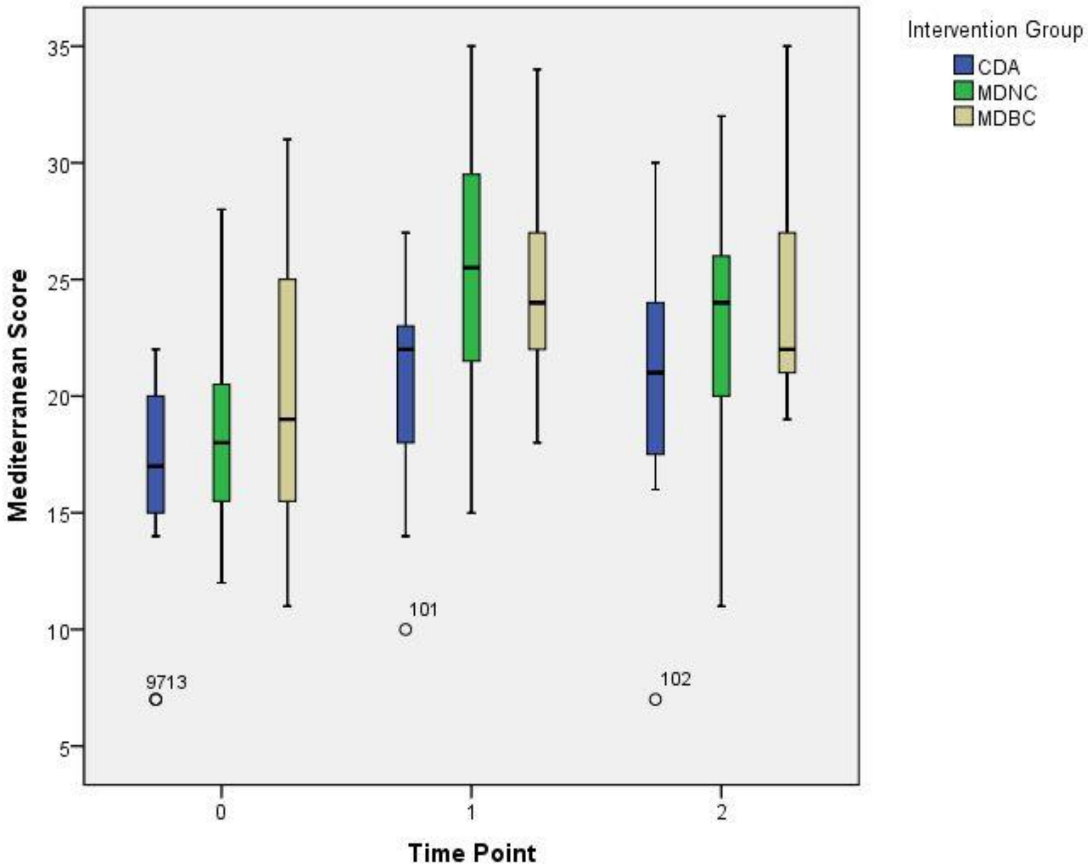



**Figure G.3 Clustered boxplot of Mediterranean Score by intervention and time point**

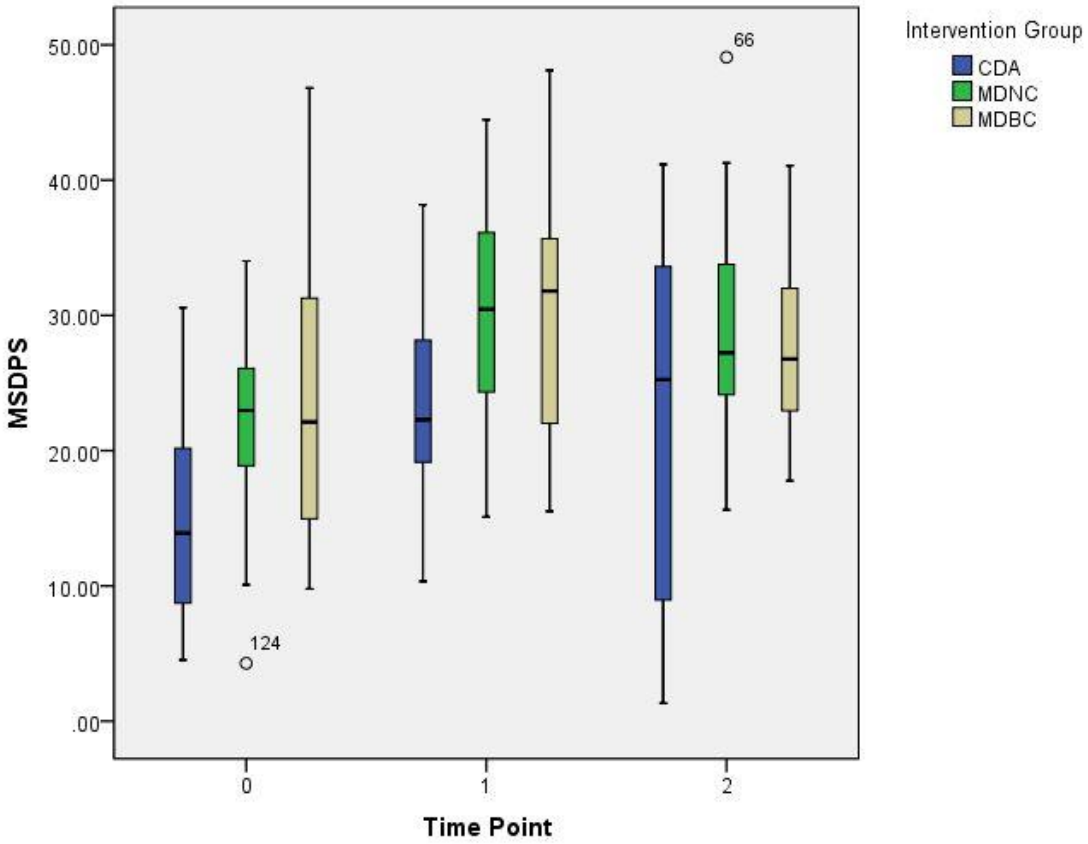



**Figure G.4 Clustered boxplot of MSDPS by intervention and time point**

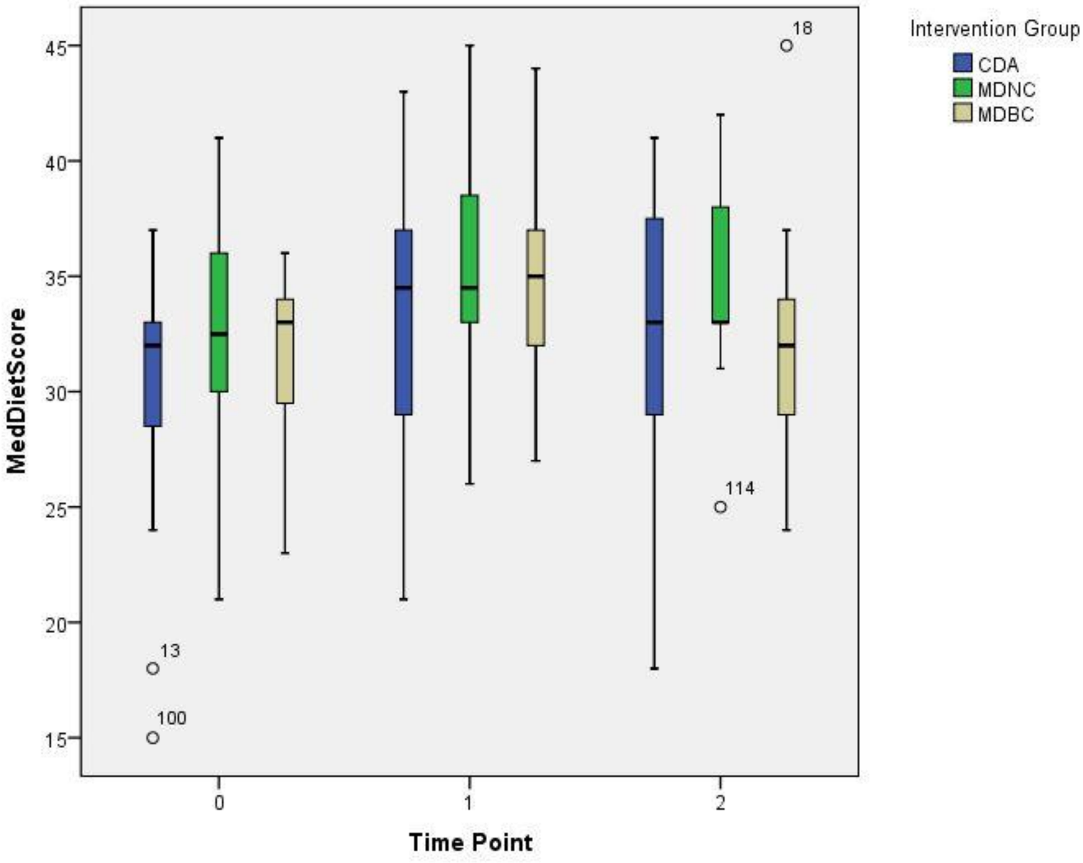



**Figure G.5 Clustered boxplot of MedDietScore by intervention and time point**

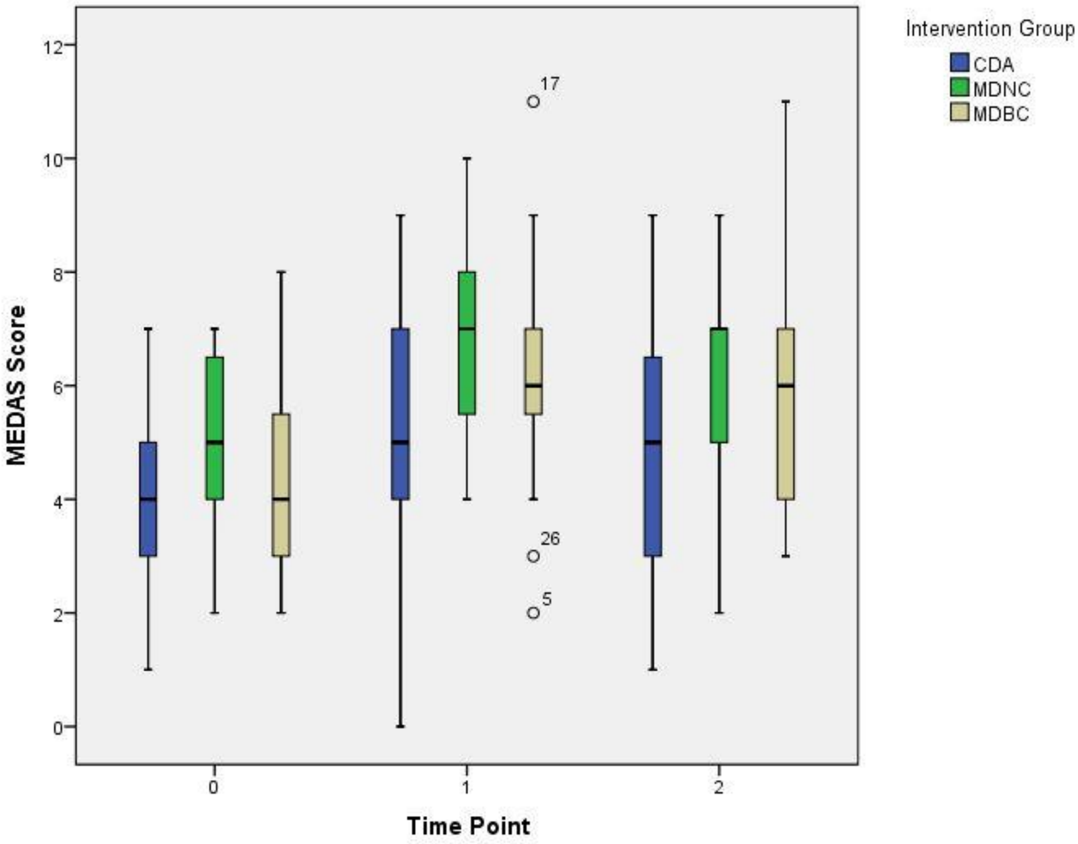



**Figure G.6 Clustered boxplot of MEDAS by intervention and time point**

# Appendix H Scatterplots of Mediterranean diet scores at baseline, 6 month and 12 month follow up

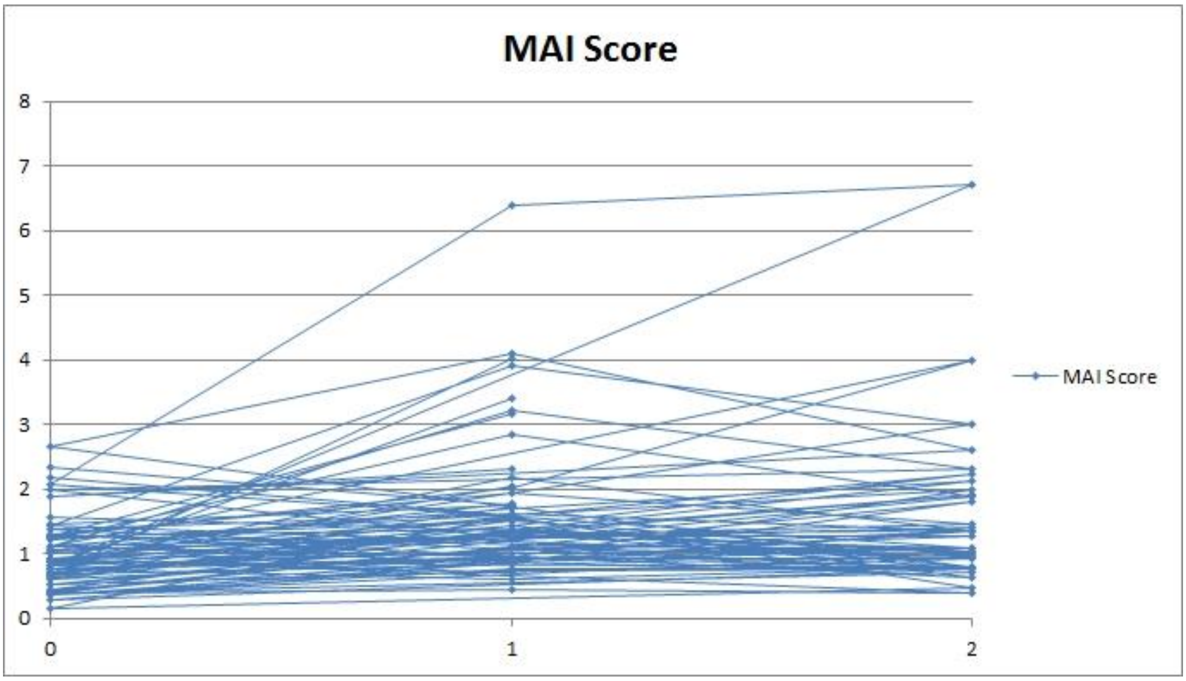



**Figure H.1 Scatterplot of individual MAI scores at baseline, 6 and 12 month follow up**

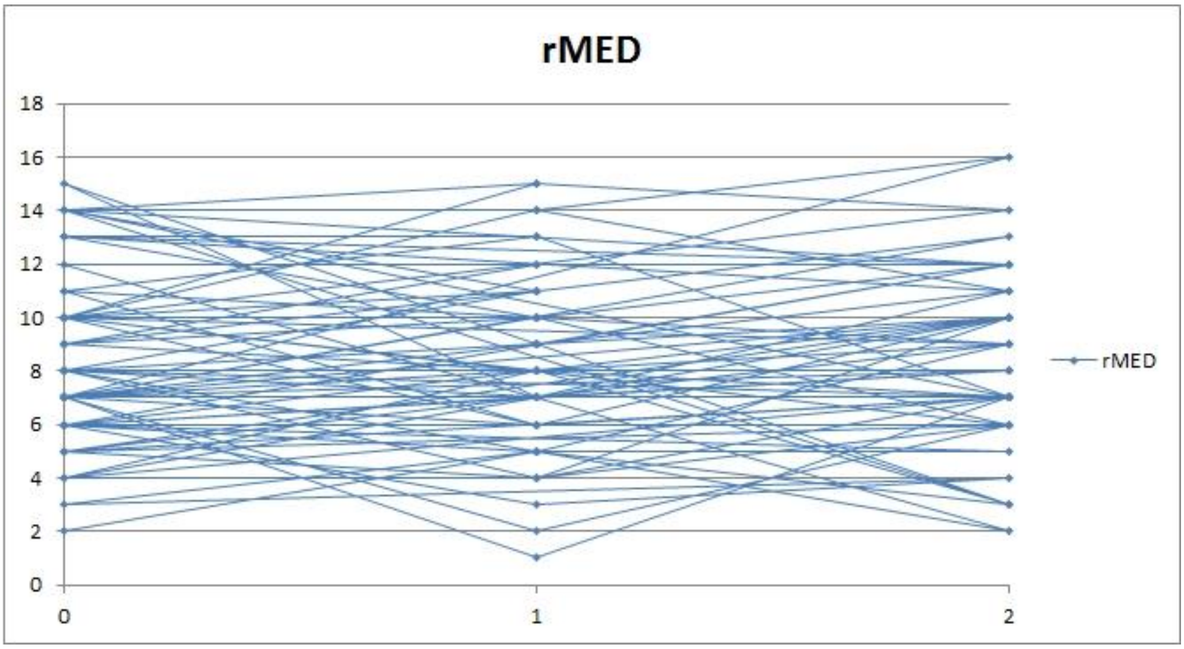



**Figure H.2 Scatterplot of individual rMED scores at baseline, 6 and 12 month follow up**

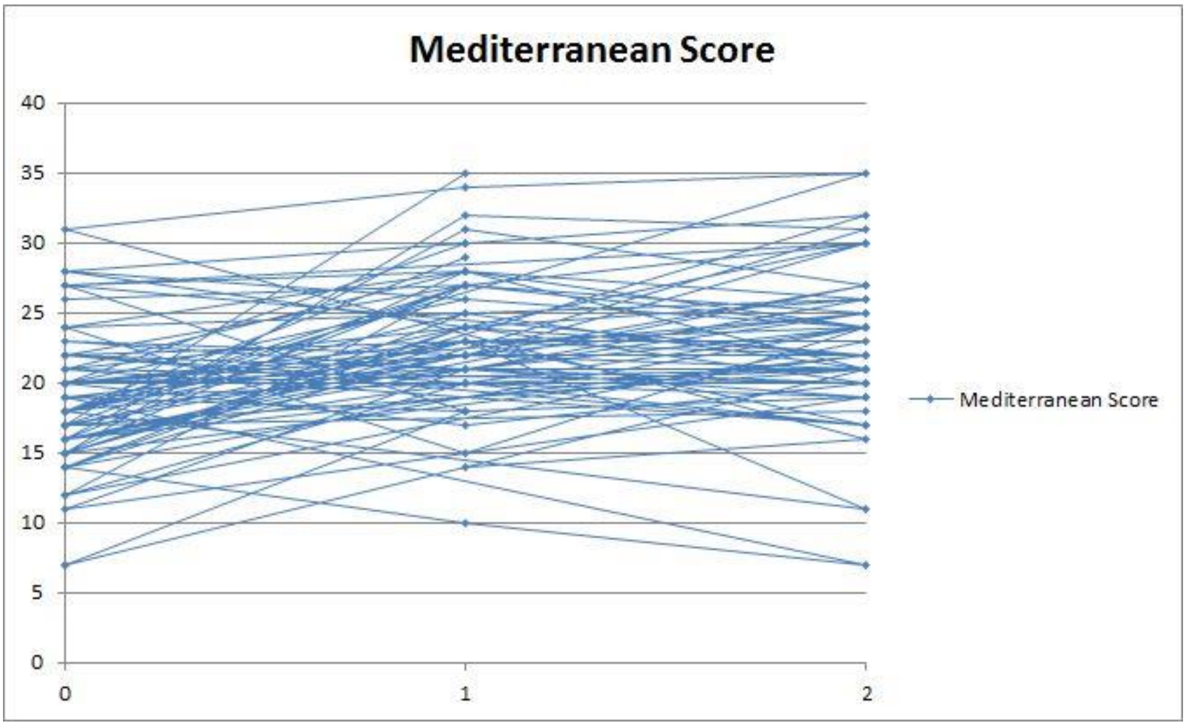



**Figure H.3 Scatterplot of individual Mediterranean Scores at baseline, 6 and 12 month follow up**

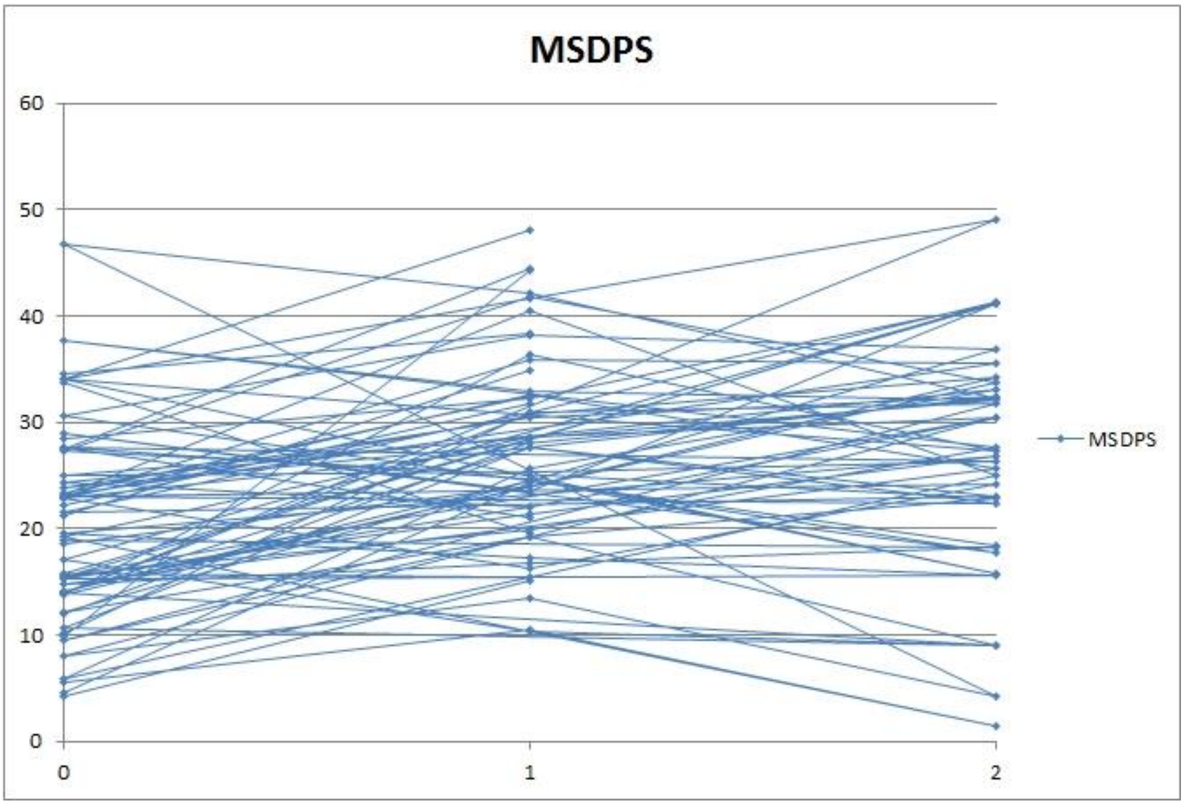



**Figure H.4 Scatterplot of individual MSDPS scores at baseline, 6 and 12 month follow up**

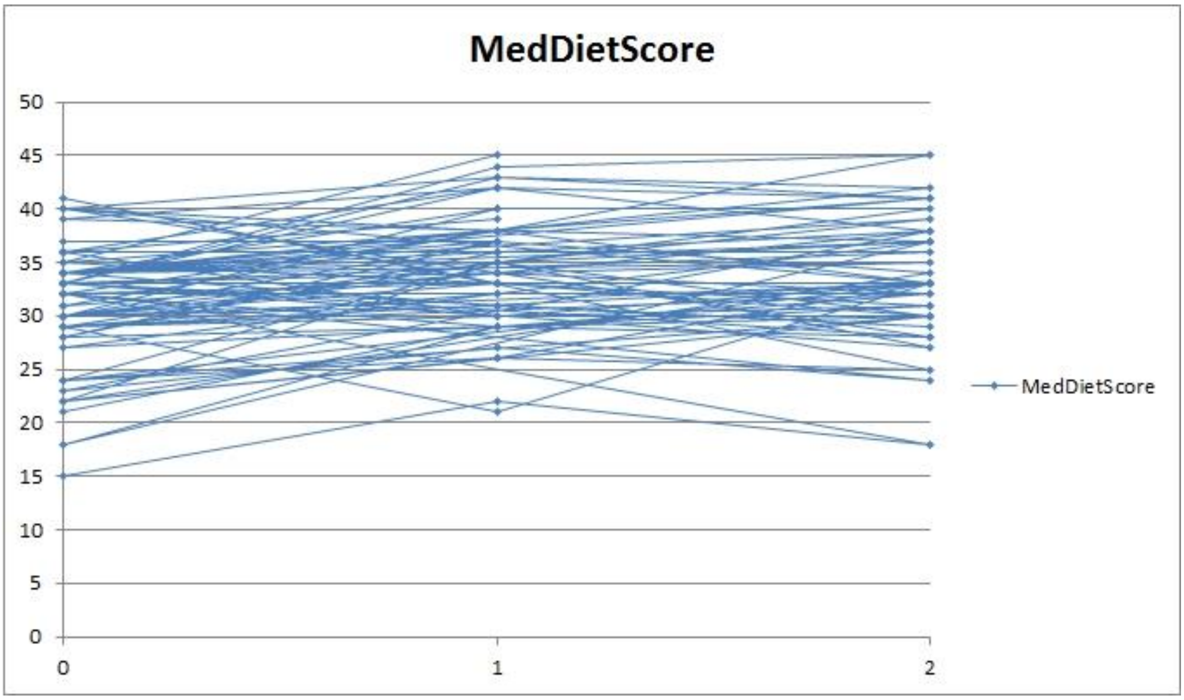



**Figure H.5 Scatterplot of individual MedDietScores at baseline, 6 and 12 month follow up**

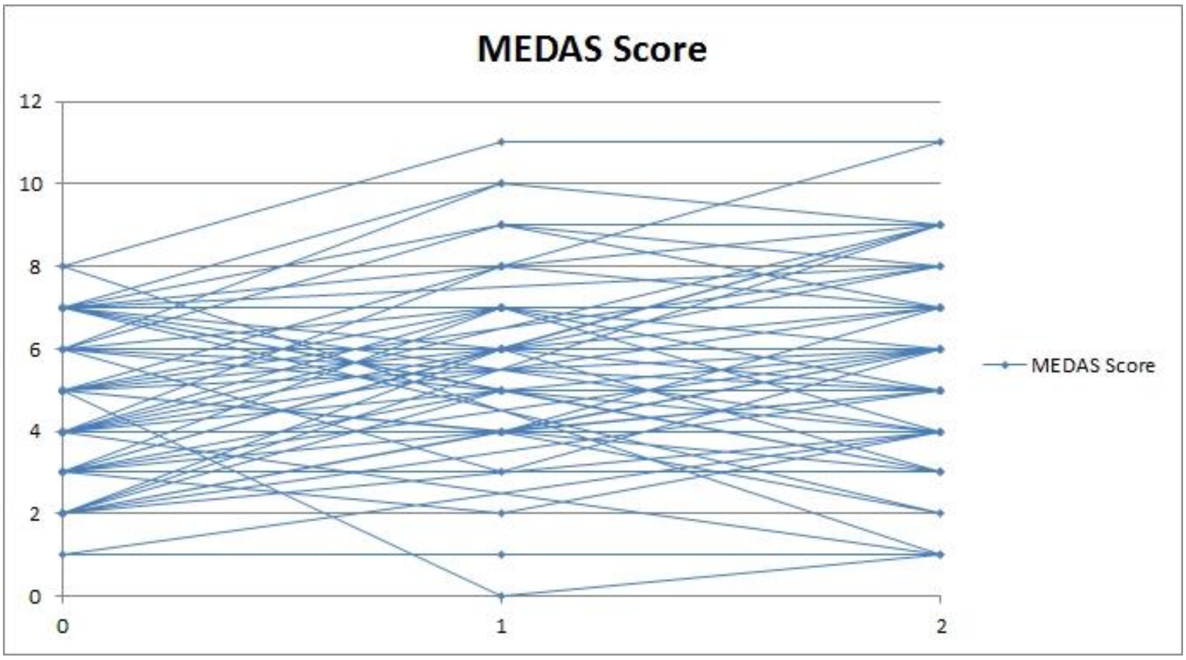



**Figure H.6 Scatterplot of individual MEDAS scores at baseline, 6 and 12 month follow up**

# Appendix I Discrepancies in the range of portion sizes of commonly consumed foods between INTAKE24 and the NDNS

| NDNS Food Name | INTAKE24 Food Name | NDNS Mean portion size (g) | NDNS Range in portion size (g) | INTAKE24 Range in portion size inc. leftovers (g) |
|---|---|---|---|---|
| Broccoli spears calabrese fresh boiled | Broccoli boiled/ steamed/ microwaved | 83.2 | 5-251 | 2-132.2 |
| Carrots old fresh boiled | Carrots boiled/ steamed/ microwaved; Baby carrots, boiled/steamed/microwaved | 68.22 | 4-280 | 2-122 |
| Cauliflower fresh boiled | Cauliflower | 100.5 | 9.6-350 | 2-123.2 |
| Cheese Cheddar any other or for recipes | Cheddar cheese; Cheddar/Cheshire cheese low fat; Cheddar cheese, reduced fat | 46.26 | 5-167 | 1-91 |
| Cheese Cheddar English | Cheddar cheese; Cheddar/Cheshire cheese low fat; Cheddar cheese, reduced fat | 46.05 | 3-200 | 1-91 |
| Chicken roast light meat only | Chicken slices; Chicken/turkey slices, without skin; Chicken/turkey slices, with skin; Chicken breast fillet; Chicken breast slices; chicken/turkey breast, without skin; chicken/turkey fillets, with skin | 100.25 | 15-290 | 5-204.2 |
| Chicken roast meat only | Chicken slices; Chicken/turkey slices, without skin; Chicken/turkey slices, with skin; Chicken breast fillet; Chicken breast slices; chicken/turkey breast, without skin; chicken/turkey fillets, with skin; Chicken/turkey | 122.49 | 30-290 | 5-204.2 |

| NDNS Food Name | INTAKE24 Food Name | NDNS Mean portion size (g) | NDNS Range in portion size (g) | INTAKE24 Range in portion size inc. leftovers (g) |
|---|---|---|---|---|
| | drumsticks/wings, with skin; Chicken/turkey wing/drumstick, without skin; Chicken wings, marinated (soaked in sauce/juice before cooking) | | | |
| Cod in batter fried in commercial oil | Fish in batter, from takeaway; Cod in batter, fried | 172.35 | 86-255 | 106-169 |
| Cornflakes Kellogg's only | Cornflakes | 46.71 | 11.7-231 | 1-72 |
| Crunchy/ crispy muesli type cereal | Strawberry crunch cereal; chocolate crunch cereal; maple and pecan crunch cereal | 57.47 | 13-120 | 2-98 |
| Cucumber raw | Cucumber | 28.59 | 2-221 | 1-64 |
| Egg fried rice inc. takeaway | Egg fried rice | 211.34 | 75-376 | 5-359.4 |
| Fruit and fibre Kellogg's only | Fruit 'n' fibre | 58.07 | 21-101 | 1-72 |
| Fruit and fibre own brand not Kellogg's | Fruit 'n' fibre | 65.86 | 20-148 | 1-72 |
| Grapes white raw flesh & skin not pips | White grapes | 76.1 | 5-300 | 2-190.5 |
| Gravy thickened no fat | Gravy homemade; Gravy, made from granules; Gravy granules, reduced salt, made up | 80.12 | 1-403 | 1-174 |
| Lettuce unspecified raw | Lettuce | 34.27 | 2-266 | 1-60 |
| Lettuce iceberg raw | Lettuce | 38.76 | 3-114 | 1-60 |
| Pasta spaghetti boiled white | Spaghetti | 190.97 | 5-539 | 5-350 |
| Peas frozen boiled | Peas, boiled/ steamed/ microwaved | 66.07 | 8-272.7 | 2-111.9 |
| Potato chips oven ready baked | Oven chips; Oven chips, reduced fat | 157.32 | 41-481 | 5-334 |

| NDNS Food Name | INTAKE24 Food Name | NDNS Mean portion size (g) | NDNS Range in portion size (g) | INTAKE24 Range in portion size inc. leftovers (g) |
|---|---|---|---|---|
| Potatoes new boiled skins eaten | New potatoes, skins eaten, boiled/ steamed/ microwaved | 162.29 | 15-400 | 5-276.9 |
| Potatoes new boiled without skins | New potatoes, without skins, boiled/steamed/microwaved | 165.84 | 16-385 | 5-276.9 |
| Potatoes old baked flesh & skin | Baked potato/jacket potato, skin eaten; Baked potato/jacket potato, no skin eaten; McCains baked potato/jacket potato, skin eaten; McCains baked potato/jacket potato, no skin eaten | 214.65 | 49-578 | 71-406 |
| Potatoes old boiled | Potatoes, boiled/steamed/microwaved | 171.08 | 15-500 | 5-299.7 |
| Potatoes old roast in blended vegetable oil | Roast potatoes | 163.9 | 27-340 | 5-248 |
| Rice basmati boiled | Basmati rice | 198.02 | 26-462 | 5-359.4 |
| Rice white long polished boiled | White rice | 178.59 | 11-376 | 5-359.4 |
| Salmon grilled | Salmon, steamed | 154.67 | 40-350 | 28-188 |
| Strawberries raw | Strawberries | 95.9 | 5-286 | 2-150 |

## Appendix J User-testing of INTAKE24 recruitment email sent to VOICENorth members

### Computerised Dietary Recall System

**Aim of Research**

This research is being done to help develop a computerised dietary tool which will eventually be used in the LiveWell Programme. Researchers would like to work with members of VOICENorth to modify the system so that it is as user-friendly as possible.

**Volunteer Criteria**

- Aged 55 - 70 (this is the target 'peri-retirement' audience of the LiveWell Programme)

**What will I be asked to do?**

You will be asked to attend a 1-2 hour session at the Biomedical Research Building on the Campus for Ageing & Vitality on a date convenient to you to work with researchers to test the system. You will be asked questions about your diet and your height and weight will be measured.

**Will I get anything for taking part?**

Volunteers who complete this study will be given a £10 Eldon Square voucher as a token of appreciation. Participants will also be provided with feedback about the study results.

**How can I be involved?**

Contact researcher Caroline Shaw at c.a.shaw@ncl.ac.uk for more information or to register to take part.

Sent on behalf of VOICENorth

VOICENorth@ncl.ac.uk

0191 208 1144

## Appendix K User-testing of INTAKE24 recruitment poster

# Newcastle University

# Food Study

**Are you between 55-70 years old?**

Can you help us to test a computerised system to recall dietary intake?

*We would like you to use the computer system to recall and record all the food and drink you consumed the previous day, as well as record this on paper. We will also measure your height and weight.*

*In exchange we will give you a*

**£10 Eldon Square gift voucher**

**For more information please contact Caroline Shaw on:**

0191 248 1141

c.a.shaw@ncl.ac.uk

## Appendix LUser-testing of INTAKE24 consent form

# NEWCASTLE UNIVERSITY - COMPUTERISED DIETARY RECALL SYSTEM CONSENT FORM

I have read the recruitment letter, understand what is required of me and would be happy to take part in the study.

**Name:** ..........................................................................................

**Address:** ..........................................................................................

..........................................................................................

..........................................................................................

**Postcode:** ..........................................................................................

**Date of birth:** ..........................................................................................

**Home telephone number:** ..........................................................................................

**Mobile telephone number:** ..........................................................................................

**Email address:**

..........................................................................................

**Signature:** ..........................................................................................

**Date:**

..........................................................................................

☐ **Please tick if you would like to be considered for future testing of the computerised dietary recall system.**

***Thank you***

# Appendix M User-testing of INTAKE24 participant information sheet

Human Nutrition Research Centre
Biomedical Research Building
Campus for Ageing and Vitality
Newcastle University
Newcastle upon Tyne, NE4 5PL

## NEWCASTLE UNIVERSITY FOOD STUDY

## ONLINE SYSTEM TO MEASURE WHAT WE EAT


### WHAT'S IT ALL ABOUT?


We are developing an online system to measure what we eat, which would be suitable for people aged 55-70 years old. The system, called INTAKE24 will help users to remember and record all the foods and drinks they consumed the previous day, because a good understanding of what we eat can help us to identify the links with our health. We are recruiting 55-70 year old volunteers to help us by using the system and giving us feedback on how well the system operates. This should take approximately 1 to 2 hours to complete.

### WHAT WOULD BE INVOLVED?

- We would like to invite you to the Campus for Ageing and Vitality at Newcastle University, where you will use the computer system to recall and record all the food and drink you consumed the previous day.

- We will use a range of methods to see how easy the system is to use. These include:
  - With your consent, we would like to audio record you "thinking aloud" while using the system. This will help us to identify where people have difficulties in using the system.
  - Direct observation

  Once you have completed the recall, we would like to conduct a short interview to discuss how easy or difficult the system was to use and possible areas for improvement.

- We would also like you to repeat the process of remembering everything you ate and drank yesterday with our researcher on paper, as an alternative way to using the system to measure what you eat. We would also like to measure your height and weight so that we can calculate your energy and nutrient needs.

***As a thank-you for taking part you will receive a £10 Eldon Square gift voucher***

**There is of course no obligation to take part and you can withdraw from the study at any time. All information will remain confidential, as individuals will not be identified. Audio**

**and visual recordings will only be used by the researcher, and will be securely stored and erased when not required.**

If you would like to take part please:

- Complete the enclosed consent form and questionnaire
- Return them in the envelope provided

Thank you very much for taking the time to read this.

Yours sincerely,

Caroline Shaw

Nutritionist – Project co-ordinator

Tel: 0191 248 1141 Email: c.a.shaw@ncl.ac.uk

# Appendix N User-testing of INTAKE24 appointment protocol

## Set-up checklist

1. Ensure all the items are present from the equipment checklist.
2. Log on to the computer/ laptop and place audio recorder nearby.
3. Ensure there is a set of user IDs and passwords on paper to use, that have already been registered to the software.
4. Set up the Leicester height measure and Tanita weighing scales in a different area of the room.

## Pre-task

With the user:

1. Give the participant a copy of the information sheet to read through again.
2. Make sure participants have signed the consent form and completed the demographic questionnaire (they should do this before the visit, but bring spares if not).
3. Reassure the participant that their computer skills or the quality of their diets are being judged, but making sure that the system is suitable and easy to use for them and other people of a similar age.
4. Reaffirm their right to withdraw and that all information will be kept confidential.
5. Remind the user to wear their glasses if they require them for reading/ computer work.
6. Give the user a piece of paper with their user ID and password on.
7. Ask the participant to follow the “think-aloud protocol” during the interaction to describe and explain their thought processes and onscreen movements.

At the computer:

1. Ask the user to sit at the computer.
2. Instruct them to position the chair so that they are at a comfortable distance from the keyboard, mouse and screen.
3. Remind participant to recall all foods & drinks consumed the previous day from midnight to midnight, including water and alcohol.
4. Make a note of the participant’s user ID, date, and exact time of day of the recording to ensure the recording can be later cross-referenced.

5. Load up the INTAKE24 website: http://workcraft.org/intake24/surveys/livewell/login
6. Start the audio recorder, **stating the user ID and date**.
7. Ask the user to enter their user ID and password and begin a survey.
8. **Start the stopwatch** when the participant begins the survey (as a relative time reference for any researcher notes made and to time the process duration).

**During task**

1. The participant should follow the "think-aloud" protocol during the interaction to describe and explain their interactions.
2. If the user remains silent, prompt with, e.g. "What are you doing now?", "What made you <perform that action>?", or "And now you are…?"
3. Make a note of any specific interaction issues which appear e.g. long hesitations, if participant misunderstands or gets frustrated, any errors/glitches on the website.
4. If the user asks for help, encourage them to try to solve it themselves. If they cannot proceed, make a note of this and give them hints.
5. Make a note of the participants' food choices as a starting point for identifying any missed food items within the interview.
6. Stop the stopwatch once the participant has completed their recall and make a note of the time it took to complete.

**Post-task interview**

1. **Whilst still voice recording**, ask participant a fixed set of questions about the interface/interaction from the interview schedule.
2. Ask any specific questions from notes made during the session.
3. **Stop the audio recorder.**
4. Ask them to fill in the system usability scale.

**Interviewer-led 24hr recall**

1. When the participant is ready to start the paper-based interviewer-led recall, **start the stopwatch** (to compare the duration of each method).
2. Follow instructions given in the Low Income Diet and Nutrition Survey (start with a quick list of food items, then identify exact foods, time of day and portion sizes using the young person's food atlas etc.).
3. Prompt for any missed foods e.g. drinks, butter on bread, condiments etc.

4. Stop the stopwatch once the interview has finished and note how long it took to complete.

**After the interview**

1. Measure their height and weight (Ask participants to remove their shoes, outdoor clothing and any heavy objects in their pockets first).
2. Give the gift voucher to the participant and ask them to provide their signature to confirm it.

# Appendix O INTAKE24 demographics and lifestyle questionnaire

Participant ID: ______ Date: ___ / ___ / ___

## Newcastle University Computerised Dietary Recall System Study
## Demographics & Lifestyle Questionnaire

**PLEASE FILL IN YOUR DETAILS BELOW**

First Name [ ]

Date of Birth _____ / _____ / ________

**HOW TO FILL IN THIS QUESTIONNAIRE**

Please complete the following questions by:

Ticking a box like this ☑

Or writing a number/word in a box like this [ 65 ]

Sometimes you will find an instruction telling you which questions to answer next like this:

Yes ☑

No ☑ -> Go to question 5

**HOW TO RETURN THIS QUESTIONNAIRE**

Please return the completed questionnaire with your completed consent form in the pre-paid envelope as soon as you possibly can.

**PLEASE START THE QUESTIONNAIRE AT QUESTION 1 ON THE NEXT PAGE.**
Thank you for your help

| 1. | What is your current marital status? (Tick one box) |
|---|---|

- ☐ Single
- ☐ Cohabiting
- ☐ Married (first and only marriage)
- ☐ Remarried (second or later marriage)
- ☐ A civil partner in a legally-recognised Civil Partnership
- ☐ Legally separated
- ☐ Divorced
- ☐ Widowed

| 2. | Which ethnic group listed below do you consider yourself to belong to (Tick one box)? |
|---|---|

- ☐ White
- ☐ Black – Caribbean
- ☐ Black – African
- ☐ Black – Other
- ☐ Indian
- ☐ Pakistani
- ☐ Bangladeshi
- ☐ Chinese
- ☐ None of these

If you ticked "Black – Other" or "None of these", how would you describe the ethnic group that you belong to?

| 3. | Do you have any of the following qualifications (Tick all that apply)? |
| --- | --- |

- ☐ O-Level passes or CSE Grade 1
- ☐ CSE Grade 2-5
- ☐ School leaving or matriculation certificate
- ☐ A-level passes
- ☐ Clerical or commercial qualifications
- ☐ Apprenticeships
- ☐ Degree (or degree level qualification)
- ☐ Teaching qualification
- ☐ HNC/HND, BEC/TEC Higher
- ☐ City & Guilds Full Technological Certificate
- ☐ Nursing qualification SRN, RGN, RNMS, RHV, MIDWIFE
- ☐ Membership of professional institutions
- ☐ Other professional education or vocational qualification
- ☐ Postgraduate degree
- ☐ Other qualifications (please specify)

| 4. | What is your current occupational status? (Tick one box) |
|---|---|

- ☐ Working for an employer full time (more than 30 hours a week)
- ☐ Working for an employer part time (1 hour or more a week)
- ☐ Self-employed, employing other people
- ☐ Waiting to start a job you have already accepted
- ☐ Unemployed and looking for a job
- ☐ In full time education
- ☐ Unable to work because of long term sickness or disability
- ☐ Retired from paid work
- ☐ Looking after the home or family

| 5. | Have you already retired? |
|---|---|

- ☐ Yes
- ☐ No

If NO (you are not retired)…

At what age would you like to retire (write in years)?

☐ → Go to question 6

If YES (you are retired)…

i. At what age did you retire (write age in years)?

☐

ii. What were your reasons for retiring (tick all that apply)?

- ☐ Reached retirement age
- ☐ Long term health problems
- ☐ Ill health of a relative/friend
- ☐ Made redundant/dismissed/had no choice
- ☐ Offered reasonable financial terms to retire early or take voluntary redundancy
- ☐ Could not find another job
- ☐ To spend more time with partner/family
- ☐ To enjoy life while still young and fit enough
- ☐ Fed up with job and wanted a change
- ☐ To retire at the same time as husband/wife/partner
- ☐ To retire at a different time to husband/wife/partner
- ☐ To give the younger generation a chance
- ☐ None of these
- ☐ Other reason (please specify)

| 6. | On average, how often do you use the Internet or email (tick one box)? |
|---|---|

- ☐ Every day, or almost every day
- ☐ At least once a week (but not every day)
- ☐ At least once a month (but not every week)
- ☐ At least once every 3 months
- ☐ Less than every 3 months
- ☐ Never

| 7. | On which of the following devices do you access the Internet (tick all that apply)? |
|---|---|

- ☐ Desktop computer
- ☐ Laptop computer
- ☐ Tablet computer (e.g. iPad, Samsung Galaxy Tab)
- ☐ Smartphone (e.g. iPhone, Blackberry)
- ☐ TV (e.g. games console, set top box or smart TV)
- ☐ Other mobile devices
- ☐ Don’t know
- ☐ Do not access Internet

| 8. | In which of the following places have you used the Internet or email in the last 3 months (tick all that apply)? |
|---|---|

- ☐ At home
- ☐ At places of work (other than home)
- ☐ At another person's home
- ☐ On the move
- ☐ Other place (library, Internet café)

**THANK YOU FOR COMPLETING THIS QUESTIONNAIRE**

# Appendix P Interviewer-led recall used in INTAKE24 studies

| Quick List | Time (24 hour) | Description of food or drink (as much detail as possible) | Homemade / retail (H, R, NA) If H: Prompt for recipes | Cooking method<br>Oven = O<br>Fried = F<br>Grilled = G<br>Boiled = B<br>Steamed = S<br>Not applic. = NA | Brand | Amount served<br>Preface with W. Weight P. Photo H. Household | Leftover<br>Preface with W. Weight P. Photo H. Household | To be completed by nutritionist: Food code | Weight |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

# Appendix Q INTAKE24 system usability interview schedule

1. How did you find the system overall? (e.g. how easy was it to use)

2. Are there any parts that you liked or disliked in particular?

3. Were there enough instructions on screen and did they provide enough information for you to be able to complete INTAKE24? What do you think about having the option of viewing a set of instructions or instruction video before you use INTAKE24?

4. Were the instructions clear enough for you to know that you have to enter one food item at a time instead of a whole meal e.g. for a pasta dish, enter the pasta and sauce separately?

5. Were the pop-up prompts (e.g. for drinks, butter on bread) easy to understand and were there enough of them to help you remember any foods or drinks which you might have forgotten?

6. What did you think about the font size of the text onscreen? Are the buttons that you have to press on screen large or obvious enough?

7. What did you think about the colours used and what colours would you like to see?

8. Is the system appealing or engaging to use?

9. How did you find searching for new foods? E.g. spelling mistakes, brand names, searching through food categories, any items missing from the system

10. Did you find the right portion size pictures for the amounts of food and drinks that you ate?

11. If you made any mistakes, how did you find the process to delete or rectify them?

12. What did you think about selecting the whole number and fractions of countable foods when using the guide photos for items such as crisps, biscuits, and pieces of fruit?

13. Did you find any technical errors with the system?

14. Are there any improvements that you would like us to make to the system?

# Appendix R System usability scale

## System Usability Scale

**Instructions:** For each of the following statements, mark <u>one</u> box that best describes your reactions to the system *today*.

| | | Strongly Disagree | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1. | I think that I would like to use this system frequently. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 2. | I found this system unnecessarily complex. | | | | | |
| 3. | I thought this system was easy to use. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 4. | I think that I would need assistance to be able to use this system. | | | | | |
| 5. | I found the various functions in this system were well integrated. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 6. | I thought there was too much inconsistency in this system. | | | | | |
| 7. | I would imagine that most people would learn to use this system very quickly. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 8. | I found this system to be very cumbersome/awkward to use. | | | | | |
| 9. | I felt very confident using this system. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 10. | I needed to learn a lot of things before I could get going with this system. | | | | | |

What do you think about the messages that remind you of forgotten items?

Please provide any further comments about this system:

## Appendix S Participant responses to the semi-structured interview used during INTAKE24 user-testing

| Interview question | Participant responses |
|---|---|
| 1. How did you find the system overall? | • It was good. Initially I had to read it a couple of times to get used to it, but once I entered a couple of foods, I got into the rhythm of it and how it worked.<br>• Very easy to use and very logical.<br>• Overall I thought it was fine and it was very easy to use. With any computer programme it depends on your experience and any time you go onto a new programme, there's always something that throws you a bit. When I kept asking you (the researcher) questions, it wasn’t because I had lots of problems, it's because I wasn’t quite sure what it was asking me to do.<br>• Because I'd never used it before, it was knowing exactly where to click and inputting the foods I had with what’s in the system. It was easy to use and to go back and correct, as sometimes you'd forget things.<br>• It was easy to use. The only problem I had was it didn’t have enough foods in it for what I was eating and I think most people using it would search for the exact thing, like Tunnock's tea cakes.<br>• It was easy for me. I work with computers quite a lot.<br>• Once you get used to it, it gets easier, but I think it needs to tell you how to do it. It will also get easier with practice.<br>• For a bit at the start it was a bit slow, but once I found out how it goes, it was easy. It was progressive, it took you through it, which I liked. It didn’t leave you feeling "what do I do now?”.<br>• I didn’t like it very much, partly because I'm used to an Apple Mac and partly because it didn’t fit the size of the computer screen. |

| Interview question | Participant responses |
|---|---|
| 2. Are there any parts that you liked or disliked? | • It didn't cope with homemade mushroom sauce well. There wasn't a similar sauce to choose from.<br>• I think you had to remember it was going to ask you extra things like “did you eat it all?”, so you had to be ready to scroll back up to read it. It was the scrolling up and down to make sure you'd answered all the questions it wanted that was a bit tricky.<br>• I didn’t like the 24 hour clock.<br>• It was helpful having the pictures of the food for the amount of butter spread on, or the size of banana or piece of grilled bacon - that was helpful to give you an estimate.<br>• I liked putting things in and then it asking further questions about how much, because I was wondering whether to do that at first. And then it asked nice prompt questions.<br>• If you had to do it a lot, it would be time consuming to separate out into little bits like salad.<br>• I liked how the system remembers the mugs of tea. The whole thing was quite enjoyable to do.<br>• The bowl sizes were a bit confusing, with two very similar. Maybe it would have been better if they were lined up together like the glasses are.<br>• I didn’t quite get the amounts from the pictures - the size of glasses and the size of pizza. If it said how big pizzas are in inches that would help, as that's how they’re usually measured. |
| 3. Were there enough instructions? | • Yes, apart from at the very beginning. Once I'd scrolled down, it then missed the top of the screen where the instructions were. Once you realise where it was then you could just scroll back to the top.<br>• It wouldn't help me to have an instruction video at the start, but it would for some people depending on their age and how savvy they are with computers. I think some people would be terrified. |

| Interview question | Participant responses |
| --- | --- |
| | • At first I thought “what do I do next?”. Once I got over the first couple of minutes, it started to flow better.<br>• It would probably help if there was a worked example of what to do.<br>• It might help to watch an instruction video first because it might remove nervousness and stop you thinking "Am I going to get this right?”. I preferred you asking me the questions (on the interviewer-led recall) because I like the human interaction, but if you weren't doing that then an example video would be very helpful.<br>• The first time I came across the "Was it this much?" or “Was it less?” for portion sizes, it wasn’t obvious that you had to click on one of those to get to the next page. So maybe a bit of text to say "Select one of these" would help.<br>• If people were doing it at home alone, there would have to be some sort of help. |
| 4. Were instructions clear enough to know that you have to enter one item at a time instead of a whole meal? | • No, I was hesitant about that. That bit wasn’t that simple to grasp. Maybe if that bit was in a video that you had to watch first then that would be sensible.<br>• Not at first, I had to ask you what to do.<br>• Not at first, because I tried to put everything that I had for breakfast in one go.<br>• That was a bit confusing until I got used to it. I think it would come in very helpful in a worked example. When you think of the foods you eat, you think of it as a whole meal and not individual foods.<br>• Yes. |
| 5. Were prompts easy to understand/ help remember forgotten foods? | • The prompt was good for rice and chutney with curry, as I'd forgotten that at first.<br>• Yes, it even asked about putting butter on the potatoes which I had forgotten about.<br>• Sometimes it was annoying if it kept asking me the same questions when I've already answered them.<br>• It was good that when I had a cup of tea it asked us “Was that the same cup?”, because normally it would be the same. |

| Interview question | Participant responses |
|---|---|
| | • Yes. I had forgotten the margarine.<br>• Yes I think you need those because you would just put down tea, you wouldn’t necessarily put down tea with milk and sugar. |
| 6. Was the font size large enough/ buttons obvious enough? | • Was right size for me, but if it was for an older person, they would prefer a larger font.<br>• The buttons were obvious enough.<br>• I think it could be a bit bigger, perhaps bold on the instructions.<br>• Maybe the buttons could be a different colour or bolder to make the page look a bit less bland.<br>• I think the buttons could have been clearer, they could have used colour to help navigate that, such as if you consistently use green to move forward on the screen. You're trying to scan the screen backwards and forwards as well as up and down, which is not easy if you're new to the system. |
| 7. What did you think about the colours? | • I’m quite happy with the colours.<br>• I didn’t really take much notice of the colour. My focus was just on remembering what I had and filling it out so the colours were unimportant to me.<br>• They were all fine. The pictures that were brought up were clear as day too.<br>• The colours were quite good. You didn’t have anything where you were straining to read. I think sometimes when its yellows and greens it can be quite awkward to read.<br>• I would like to see the instructions in a different colour, a bigger font, or bold to make them stand out a bit more, because immediately my eyes went straight to the pictures and I had to make myself go back to the instructions. |

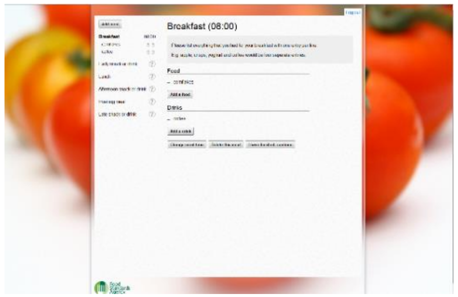
| Interview question | Participant responses |
| --- | --- |
| | • The generality is fine, grey is neither here nor there, but in terms of navigating onto the next screen, green would be good to say you've completed it successfully.<br>• You want neutral, you don't want something glaring at you. You want to be looking at the typing and the pictures, but not the overall picture. If it was bright pink it would distract you. |
| 8. Is the system appealing and engaging to use? | • I would use it again if I was asked to.<br>• I was quite interested and engaged. It pulls you along, which is good.<br>• I think it's about the right length. Perhaps if someone ate a lot they might get a bit fed up doing it! I think you wouldn't want it to be taking more than half an hour.<br>• I didn't find it too onerous.<br>• I think having to itemise each single food could get a bit tedious. If someone was having to fit this into a busy lifestyle it would be difficult. It would be better suited for someone who was at home all day or retired. I think it's very bitty, there are so many little questions, but I think you have to ask those questions, but when you ask is it useable, after a while it may become difficult.<br>• Yes, I'd be quite happy to use it. Although it's not quick, because it goes into such detail. |
| 9. How did you find searching for foods? | • Once you realised it was going to come up with alternatives for foods you had that weren't in the system, then it was OK.<br>• It took me a while to find Double Gloucester but it was there. And avocado was there which is good. It didn't have green salad, given it had things like Greek salad which has got more things in than green salad is quite strange, even bean salad it had. |

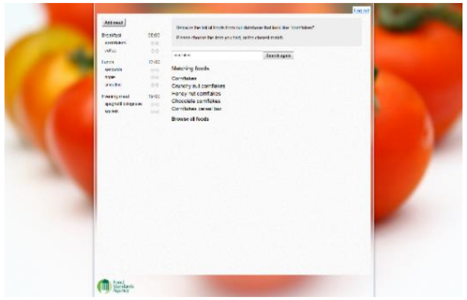
| Interview question | Participant responses |
| --- | --- |
| | • That was easy. In fact when it came up for brand names for the carrot cake, I thought it was impressive that it had Sainsbury's Taste the Difference, which is what I had!<br>• I think it's quite a comprehensive list but it's difficult to get everything in that everyone ate. It didn't have goat's milk in so I pressed on semi-skimmed milk. It was easy to search through food groups too if something wasn't in the list - I was amazed at how many cheeses there were!<br>• It was a bit difficult because it didn't have a lot of what I had. I had to adjust it to find something similar.<br>• You needed to tell me how to put in orange juice instead of fruit juice, so I wouldn't have found orange juice otherwise, so maybe it needs an interim step what type of juice, or maybe orange juice in the list of matching foods<br>• At first I was thinking there were bits of foods missing, but then I realised you can't put everything in there, it'd be like a supermarket shopping list and that would be silly. All the basics were there, that's the main thing. The others were just varieties. I mean orange juice is orange juice. |
| 10. Did you find the right portion size pictures for the amounts you ate? | • Yes there was a good selection<br>• No I thought that was difficult. I think I was erring on the side of caution and thinking "Was I a piggy and eating that much?". It's very difficult to tell unless I had my own bowl in front of me and shown the amounts in that. I found the pictures easier to tell using this than with the atlas pictures (for the interviewer-led recall).<br>• On the whole yes, apart from the liquids, I found them difficult to estimate. Also I ate more cauliflower cheese than what was in the picture.<br>• Yes, I didn't eat any more than there was there. |

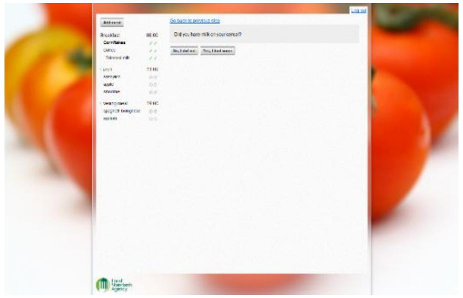
| Interview question | Participant responses |
| --- | --- |
| | • It's good doing it by portion size on a plate rather than by grams because you don't know how much you eat unless you're on a diet. I find asking the weight of how much you ate totally inappropriate. |
| 11. If you made any mistakes, were they easy to rectify? | • Yes it was easy to go back.<br>• It would let you delete things, it would let you move about in the side column and go back and suddenly remember something or delete something. I think I would have worked out how to do it if you weren't there. Some people like to have a written out sheet in front of them that they can refer to. But it is really reading the screen and paying attention. The trouble is sometimes you don't see some things that are there in front of you because you're panicking.<br>• It was easy to keep going back to check. It was confusing when I'd already put jam in with bread and then it asked me if I had any jam.<br>• I made mistakes, but I needed help to correct them.<br>• I would have struggled to correct some without help. You could put it in some instructions to say if you make a mistake, you can click on the bar on the left and change it in there. Recalling yesterday's food intake is not easy to do and not something you're in the habit of doing, so inevitably you will think of things you forgot as you go through it. |
| 12. How did you find using the number and fractions of countable foods? | • It was easy enough (although the researcher observed they needed help with entering whole numbers/ fractions at first).<br>• It said how many did you have and I thought it said how many crisps. I thought it could have said how many packets.<br>• Fine – I just entered a half for avocado as 1/3 is not an option in fractions<br>• It wasn't obvious that it was asking about whole numbers and fractions.<br>• I didn't get the fractions until you pointed it out |

| Interview question | Participant responses |
|---|---|
| | • I never spotted the fractions button, but that was easy |
| 13. Did you find any technical errors? | • Just the scrolling up and down. I was trying to work out why it did that.<br>• It asked about the late night snack first instead of in chronological order.<br>• I was asked about portion sizes twice for breakfast.<br>• Portion sizes started asking about late night snack first. And there wasn't an option for entering coffee first before breakfast<br>• It wouldn't let me select a chocolate biscuit (in the guide picture).<br>• It was asking me about butter on toast again even though I'd already entered it. |
| 14. Are there any improvements to make to the system? | • Offer a person a little trial to show them what happens. Because they might think they're under pressure otherwise.<br>• Make the font size bigger and bold.<br>• If it could instigate to some people that milk in drinks shouldn't be put separately. I guess the same would apply to sugar if they add that in drinks too. It depends how logical they think what a separate food is. You would think butter is separate from bread so you'd put that as a separate food, so it's hard to know really.<br>• It would be helpful to have an option for a snack before breakfast<br>• It's a fairly faceless system, especially if people aren't going to be given "This is how you do it". You would want to know that what you're adding there is going through to a human at the end of it. It's not just the data side of it, it's the relationship with a person too and if you haven't got that, then it would be very easy just to stop halfway through.<br>• Just the scrolling issue |

## Appendix TResearcher observations and thinking aloud by participants user-testing INTAKE24

| Parts of the system | Researcher observations/ Thinking aloud |
|---|---|
| Entering the time of meals and adding/deleting meals  | • Two participants who had more than one snack between two meals were unsure of where to put these.<br>• The option to add new meals wasn't obvious: As the "early snack or drink" meal is situated between breakfast and lunch, four participants who ate before breakfast were unsure of where to add those items.<br>• Two participants who did not consume foods within a specified meal time needed to ask the researcher how to delete the meal.<br>• Three participants did not realise that they needed to press the "Around that time" button to finish setting the meal time before the system moved on to entering food items for that meal. |
| Adding foods to a meal   | • Instructions not read or understood properly: More than one or all items within a meal were written on one line by seven participants.<br>• Two participants added estimated quantities to the foods they entered, as they did not realise that they would be asked to quantify portion sizes at a later stage.<br>• Two participants entered milk in hot drinks as separate items – the system recognised this as milk drunk on its own in a glass. Participants needed showing by the researcher how to delete these foods. |

| Parts of the system | Researcher observations/ Thinking aloud |
|---|---|
| Finding matching foods/drinks<br> | • Some search terms did not produce matches with some items within the system, e.g. searching for "salad" did not result in lettuce or other salad items appearing in the food list.<br>• Fourteen participants required guidance on selecting similar items if the exact matching food was not present in the system e.g. by choosing the nearest item in the list, or by using a different search term to return more similar results.<br>• Two participants needing showing how to delete an item from a meal in the sidebar when no similar alternatives were present in the system e.g. juice from a lemon. |
| Selecting portion sizes<br> | • Unlike for bottles/cartons/cans, the system did not ask how many glasses/cups were consumed of the same drinks within a meal. The second glass of wine or hot beverage was omitted from the system on four occasions for three participants.<br>• The option to select whole numbers/fractions for countable foods was not well understood.<br>• Two participants were shown how to click on the "go back to previous step" button when they made a mistake on selecting the correct portion size.<br>• Some confusion when presented with the option of two ways to assess portion sizes (e.g. whether to click on mugs or takeaway cups for hot drinks).<br>• Five participants expressed difficulties in choosing between cup or cereal bowl sizes.<br>• Two participants were unsure of what to do when presented with guide pictures of plates/trays of different biscuit and bread types and sizes. |

| Parts of the system | Researcher observations/ Thinking aloud |
|---|---|
| Prompts<br> | • Prompts still appeared for foods commonly consumed with other items (e.g. toast with poached eggs), despite already being entered. This confused participants and resulted in some items being doubly entered.<br>• Helped to remember many forgotten foods, including milk added to hot drinks, sugar with strawberries, jam and butter on toast, and rice with curry.<br>• Prompts for foods eaten between meals also helped participants to remember snack items.<br>• No prompts for milk in decaffeinated drinks or herbal teas lead to their omissions.<br>• Chutneys not included in list of foods when prompted for sauces with poppadoms. |
| Final review<br> | • Prompted three participants to add missing foods.<br>• Not all of the participants read the final instructions or reviewed foods entered in the sidebar before pressing submit. |
| Technical difficulties with the system | • The whole webpage did not fit on a laptop screen and loaded at the same position on each page, which obscured instructions and portion size pictures from view. Nine participants were shown how to scroll up and down to view the whole page. |

| Parts of the system | Researcher observations/ Thinking aloud |
|---|---|
| Technical difficulties with the system | • The picture did not load for spoons when participants were given the option to select portion size of jam as on bread or in spoonsful.<br>• When foods were added to the “late snack or drink” meal, the chronological order of matching foods and their portion sizes started with this meal first before breakfast etc.<br>• Two participants were asked to select matching foods and portion sizes of breakfast twice. |

**Appendix U Relative validation of INTAKE24 recruitment poster**

# Newcastle University

# Food Study

## Are you between 55-70 years old?

Can you help us to test a computerised system to recall dietary intake?

*We would like you to use the computer system to recall and record all the food and drink you consumed the previous day on 4 days in 4 weeks, as well as record this on paper. We will also measure your height and weight.*

*In exchange we will give you a*

## £10 Eldon Square gift voucher

**For more information please contact Caroline Shaw on:**


0191 248 1141


c.a.shaw@ncl.ac.uk

# Appendix V Relative validation of INTAKE24 participant information sheet

Human Nutrition Research Centre
Biomedical Research Building
Campus for Ageing and Vitality
Newcastle University
Newcastle upon Tyne, NE4 5PL

## NEWCASTLE UNIVERSITY FOOD STUDY

## ONLINE SYSTEM TO MEASURE WHAT WE EAT


### WHAT'S IT ALL ABOUT?


We are developing an online system to measure what we eat, which would be suitable for people aged 55-70 years old. The system, called INTAKE24 will help users to remember and record all the foods and drinks they consumed the previous day, because a good understanding of what we eat can help us to identify the links with our health. We are recruiting 55-70 year old volunteers to help us by recording what you ate and drank on the previous day into INTAKE24 and again on paper with the help of a researcher (an interviewer-led recall), to see how well the system works in practice and how well it compares to an interview with a researcher.

### WHAT WOULD BE INVOLVED?

- We would like volunteers to complete 2 food surveys (INTAKE24 and an interviewer-led recall) on the same day, on 4 separate occasions, over the course of 1 month. It takes no longer than 1 hour to complete both surveys on each day. Both surveys ask you to recall and record everything you ate and drank the previous day.

- INTAKE24 is an online survey which can be accessed on a computer, laptop or iPad/tablet at home, work, or wherever is convenient for you.

- On the first recall day, we would invite you to the Campus for Ageing and Vitality at Newcastle University, to carry out the first interviewer-led recall with you. The recall process will be similar to the online survey, however it will be a paper-based exercise and the researcher will be present. You will also be asked to enter everything you ate and drank on the previous day into INTAKE24 either before or after the paper-based exercise. We would also like to measure your height and weight on this occasion, so that we can calculate your energy and nutrient needs.

- The remaining 3 interviewer-led recalls will be carried out over the telephone at a time convenient to you. The researcher will provide you with a book containing food photographs that will help during the telephone surveys. We will provide you with a stamped addressed envelope to return the book to us once the 4 recall days are complete.

- You will need to complete the remaining 3 INTAKE24 surveys on the same days as the interviewer-led recalls at a time that is convenient for you, however, you must complete both recalls in the same order as you did at your visit to the University. You will be provided with the INTAKE24 website address and login details.

***As a thank-you for taking part you will receive a £10 Eldon Square gift voucher***

**There is of course no obligation to take part and you can withdraw from the study at any time. All information will remain confidential, as individuals will not be identified.**

If you would like to take part please:

- Complete the enclosed consent form and questionnaire
- Return them in the envelope provided

Thank you very much for taking the time to read this.

Yours sincerely,

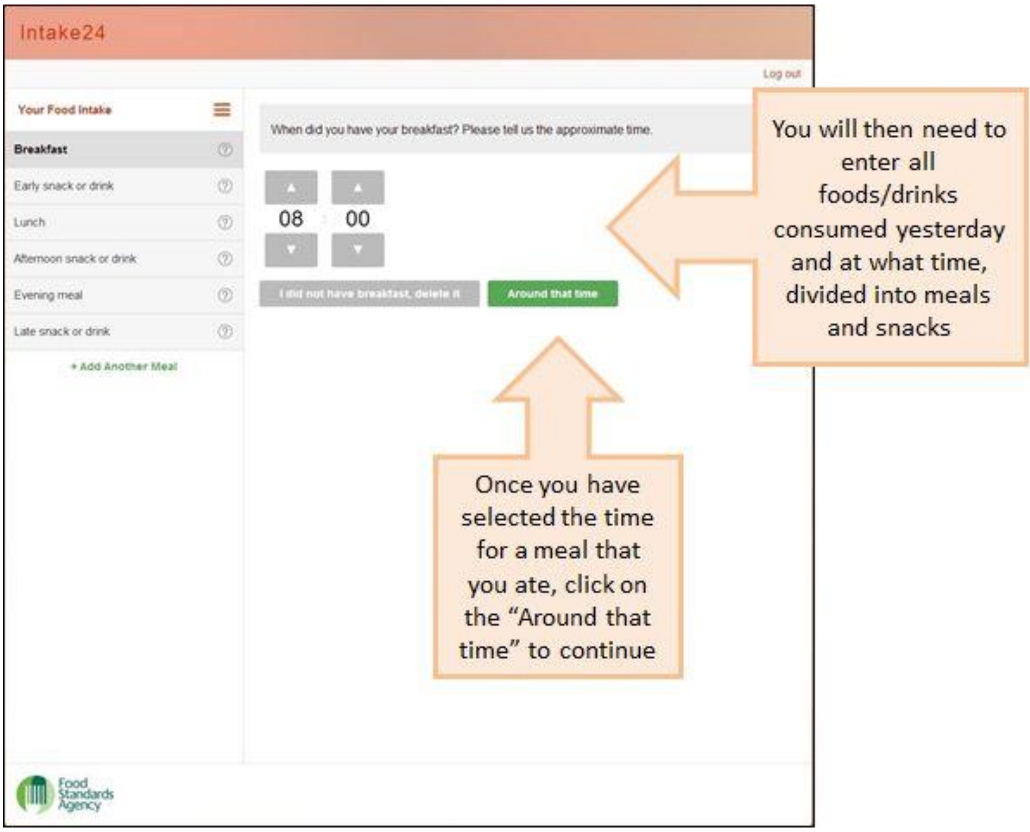
Caroline Shaw

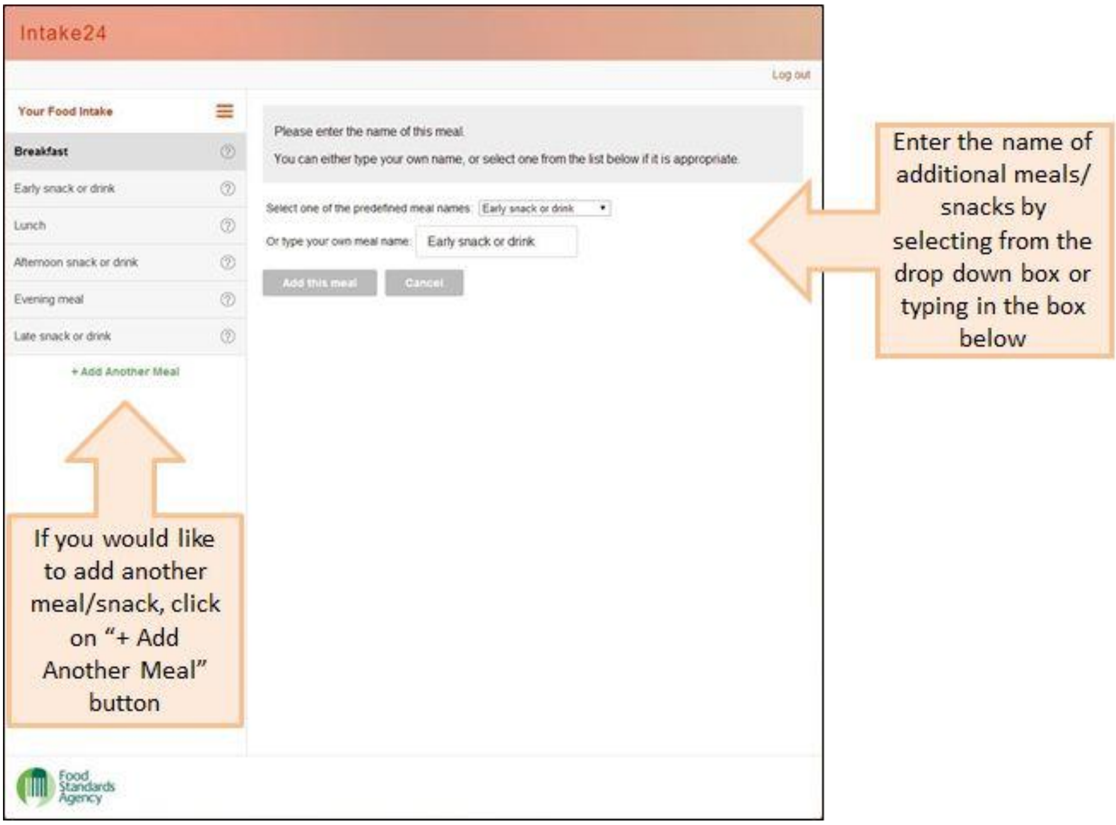
Nutritionist – Project co-ordinator

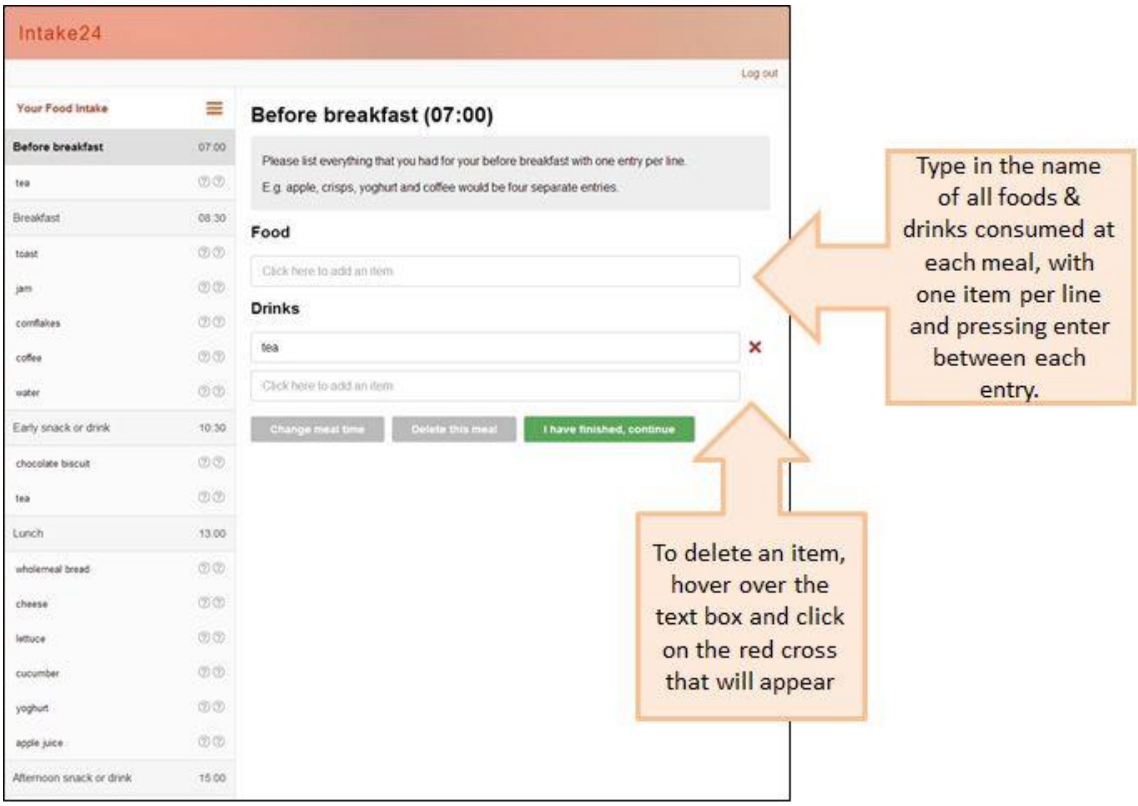
Tel: 0191 248 1141    Email: c.a.shaw@ncl.ac.uk

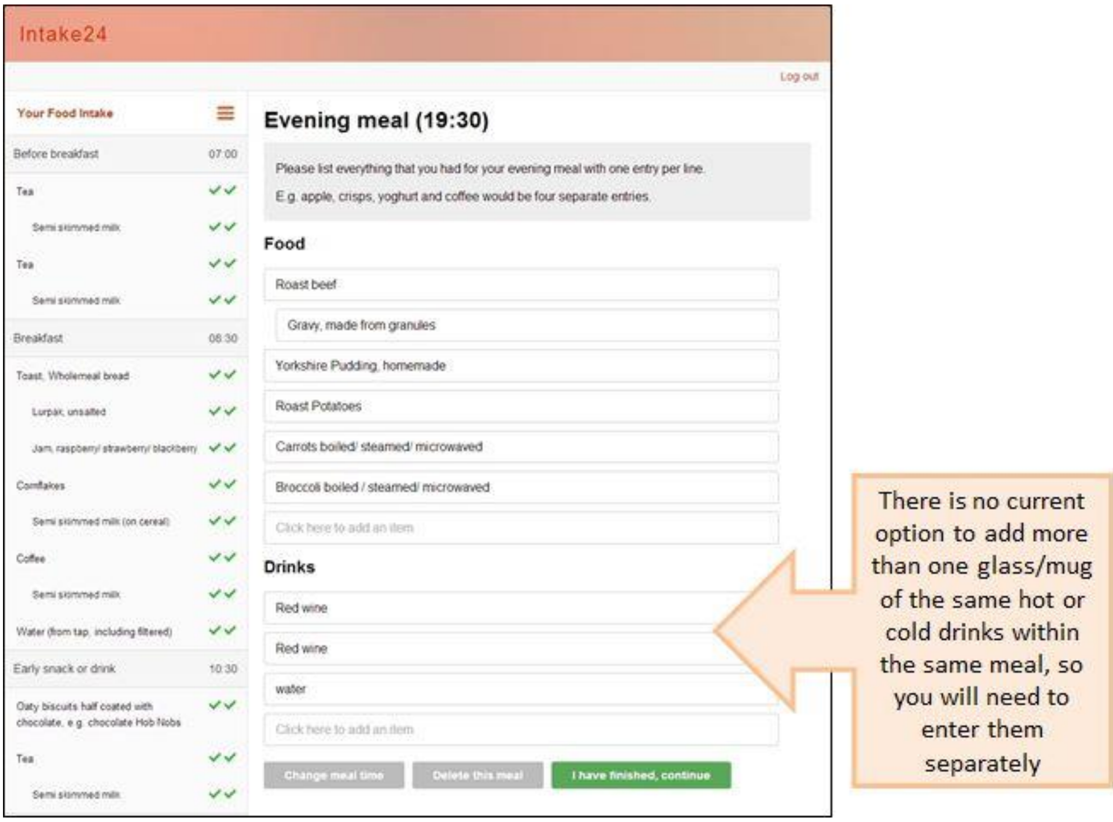
# Appendix W Instructions for completing INTAKE24 on PC's and laptops

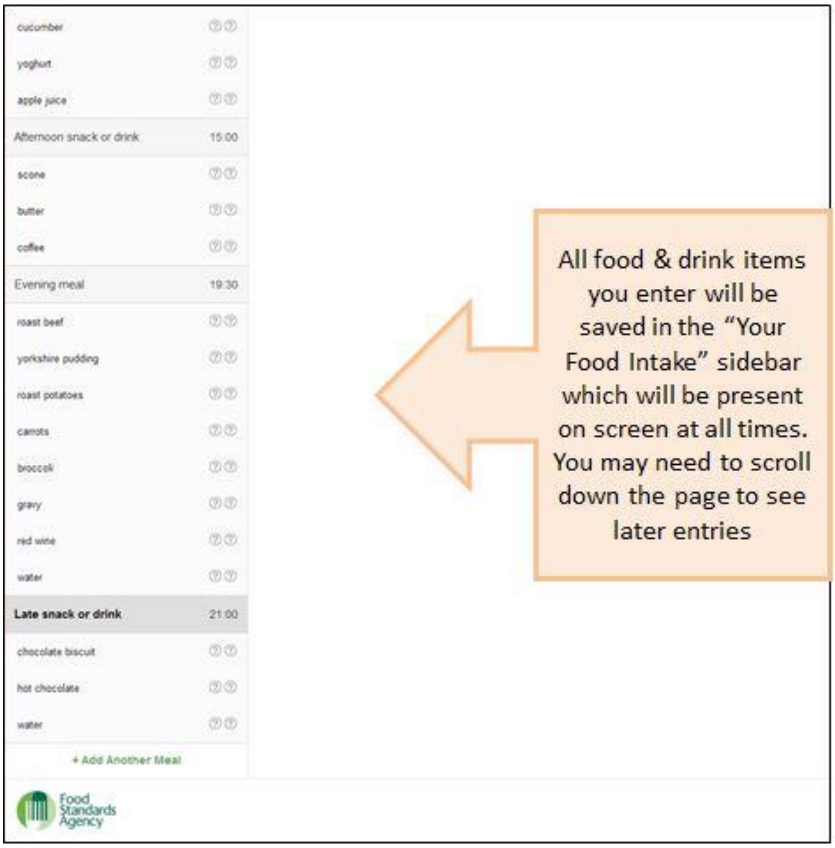
Visit the INTAKE24 website at: https://intake24.co.uk/surveys/livewell

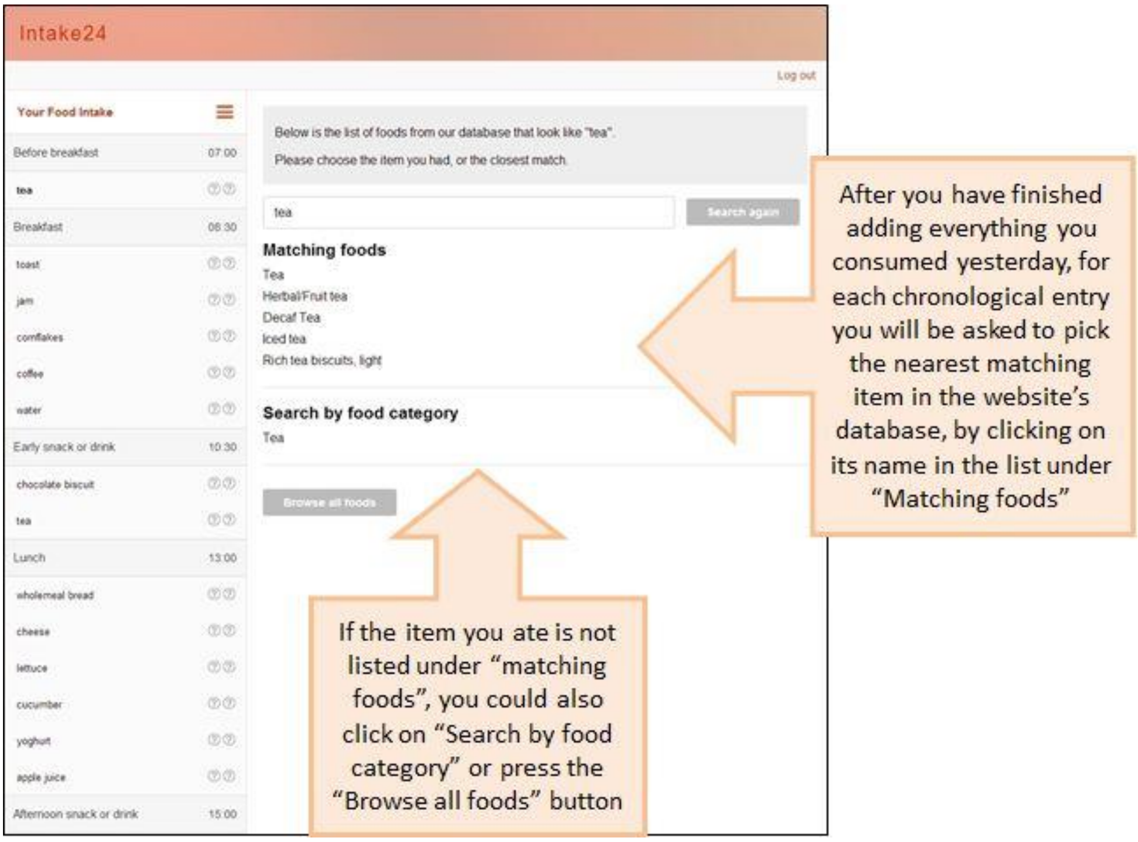



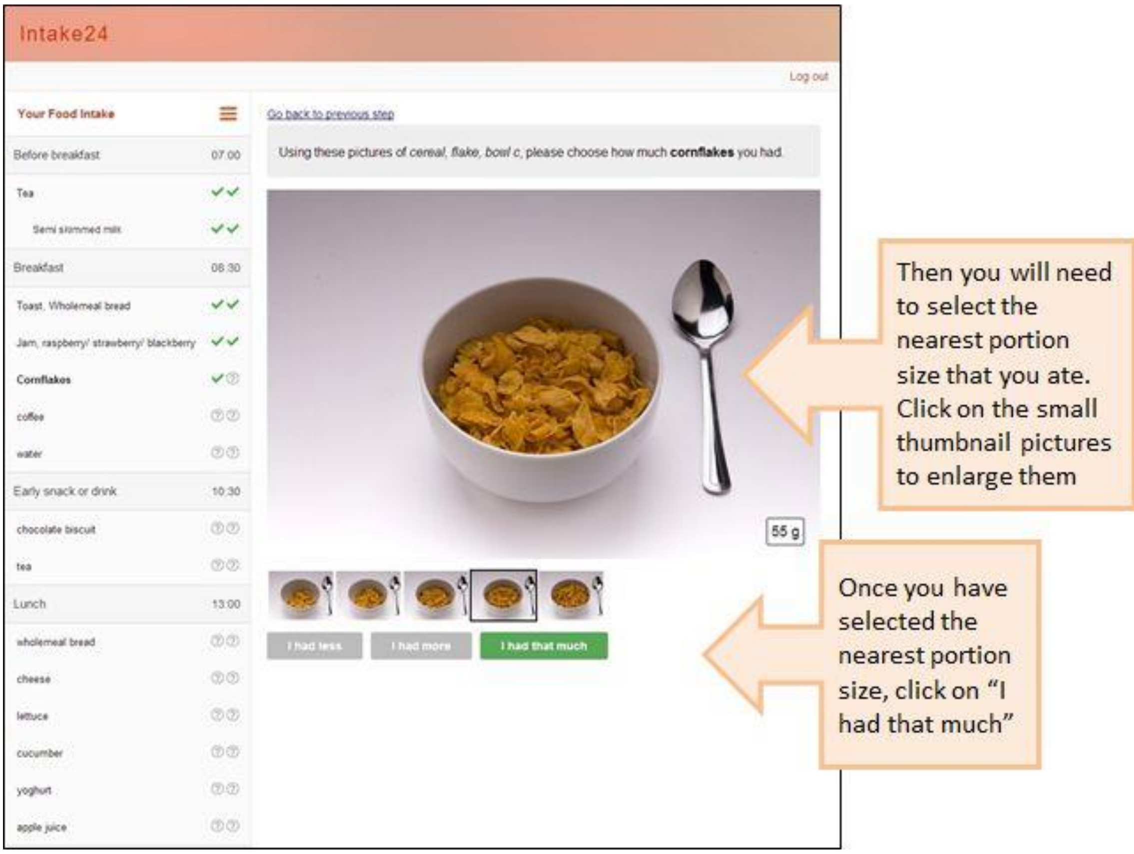

Intake24
Log out
Your Food Intake
Breakfast
Early snack or drink
Lunch
Afternoon snack or drink
Evening meal
Late snack or drink
+ Add Another Meal
Please enter the name of this meal.
You can either type your own name, or select one from the list below if it is appropriate.
Select one of the predefined meal names: Early snack or drink
Or type your own meal name: Early snack or drink
Add this meal
Cancel
Enter the name of additional meals/ snacks by selecting from the drop down box or typing in the box below
If you would like to add another meal/snack, click on "+ Add Another Meal" button
Food Standards Agency


Intake24
Log out
Your Food Intake
Before breakfast 07:00
tea
Breakfast 08:30
toast
jam
cornflakes
coffee
water
Early snack or drink 10:30
chocolate biscuit
tea
Lunch 13:00
wholemeal bread
cheese
lettuce
cucumber
yoghurt
apple juice
Afternoon snack or drink 15:00
Before breakfast (07:00)
Please list everything that you had for your before breakfast with one entry per line.
E.g. apple, crisps, yoghurt and coffee would be four separate entries.
Food
Click here to add an item
Drinks
tea
Click here to add an item
Change meal time
Delete this meal
I have finished, continue
Type in the name of all foods & drinks consumed at each meal, with one item per line and pressing enter between each entry.
To delete an item, hover over the text box and click on the red cross that will appear

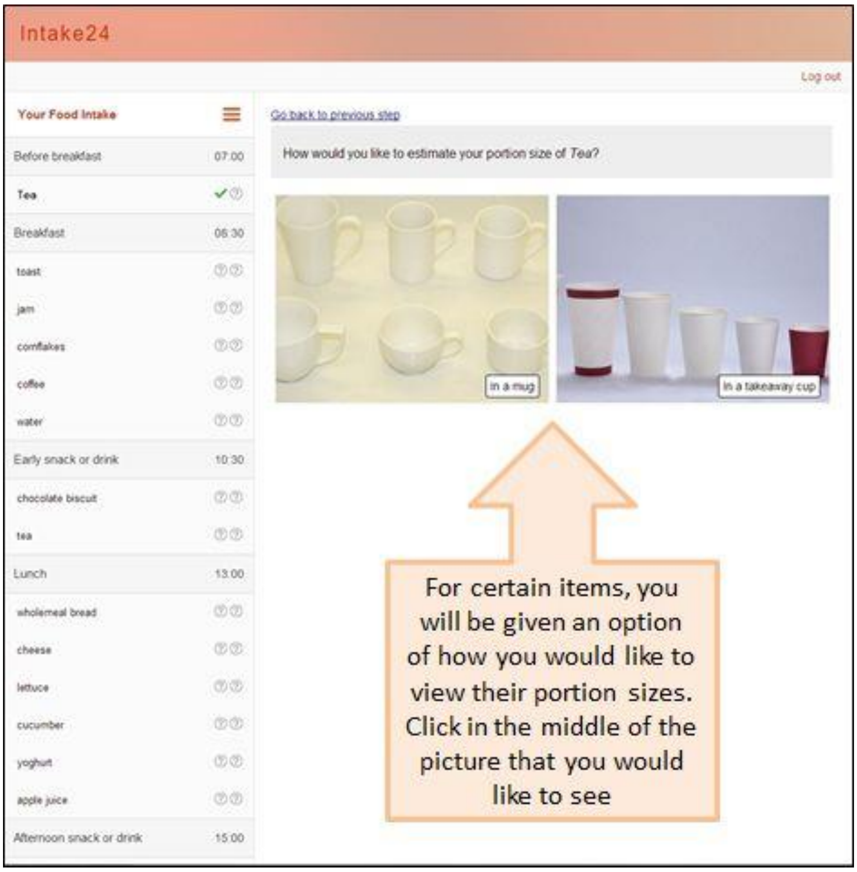

Intake24
Log out
Your Food Intake
Before breakfast 07:00
Tea
Semi skimmed milk
Tea
Semi skimmed milk
Breakfast 08:30
Toast, Wholemeal bread
Lurpak, unsalted
Jam, raspberry/ strawberry/ blackberry
Cornflakes
Semi skimmed milk (on cereal)
Coffee
Semi skimmed milk
Water (from tap, including filtered)
Early snack or drink 10:30
Oaty biscuits half coated with chocolate, e.g. chocolate Hob Nobs
Tea
Semi skimmed milk
Evening meal (19:30)
Please list everything that you had for your evening meal with one entry per line.
E.g. apple, crisps, yoghurt and coffee would be four separate entries.
Food
Roast beef
Gravy, made from granules
Yorkshire Pudding, homemade
Roast Potatoes
Carrots boiled/ steamed/ microwaved
Broccoli boiled / steamed/ microwaved
Click here to add an item
Drinks
Red wine
Red wine
water
Click here to add an item
Change meal time
Delete this meal
I have finished, continue
There is no current option to add more than one glass/mug of the same hot or cold drinks within the same meal, so you will need to enter them separately

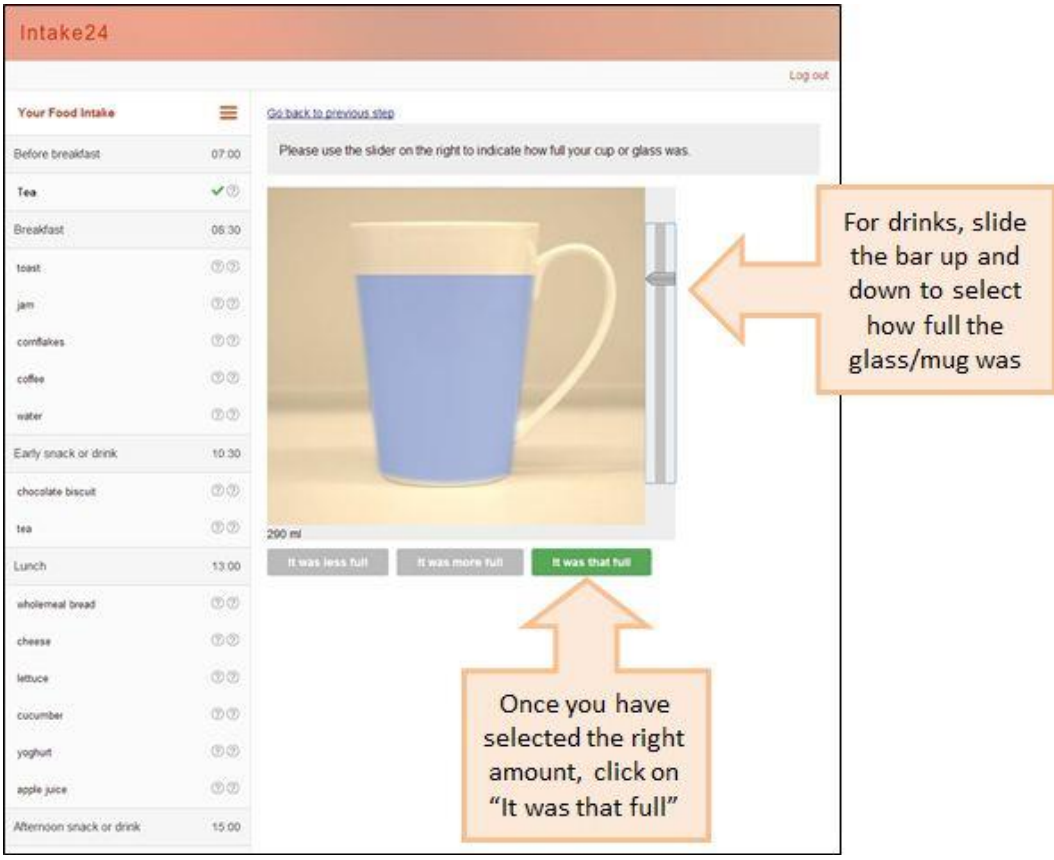

cucumber
yoghurt
apple juice
Afternoon snack or drink 15:00
scone
butter
coffee
Evening meal 19:30
roast beef
yorkshire pudding
roast potatoes
carrots
broccoli
gravy
red wine
water
Late snack or drink 21:00
chocolate biscuit
hot chocolate
water
+ Add Another Meal
Food Standards Agency
All food & drink items you enter will be saved in the "Your Food Intake" sidebar which will be present on screen at all times. You may need to scroll down the page to see later entries

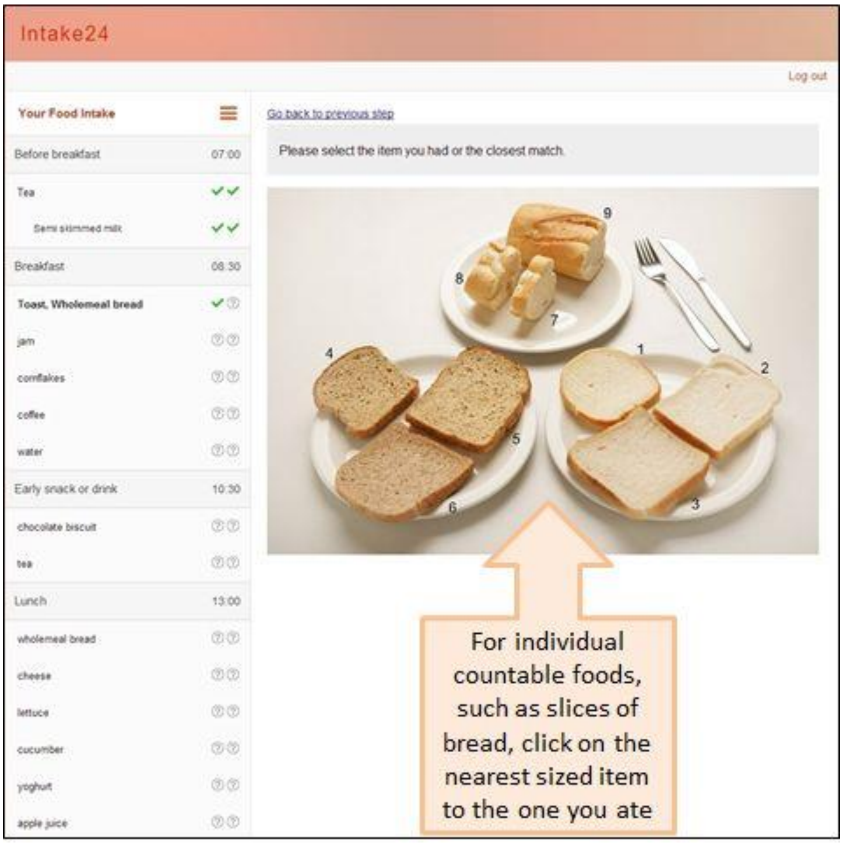

Intake24
Log out
Your Food Intake
Before breakfast 07:00
tea
Breakfast 08:30
toast
jam
cornflakes
coffee
water
Early snack or drink 10:30
chocolate biscuit
tea
Lunch 13:00
wholemeal bread
cheese
lettuce
cucumber
yoghurt
apple juice
Afternoon snack or drink 15:00
Below is the list of foods from our database that look like "tea".
Please choose the item you had, or the closest match.
tea
Search again
Matching foods
Tea
Herbal/Fruit tea
Decaf Tea
Iced tea
Rich tea biscuits, light
Search by food category
Tea
Browse all foods
After you have finished adding everything you consumed yesterday, for each chronological entry you will be asked to pick the nearest matching item in the website's database, by clicking on its name in the list under "Matching foods"
If the item you ate is not listed under "matching foods", you could also click on "Search by food category" or press the "Browse all foods" button

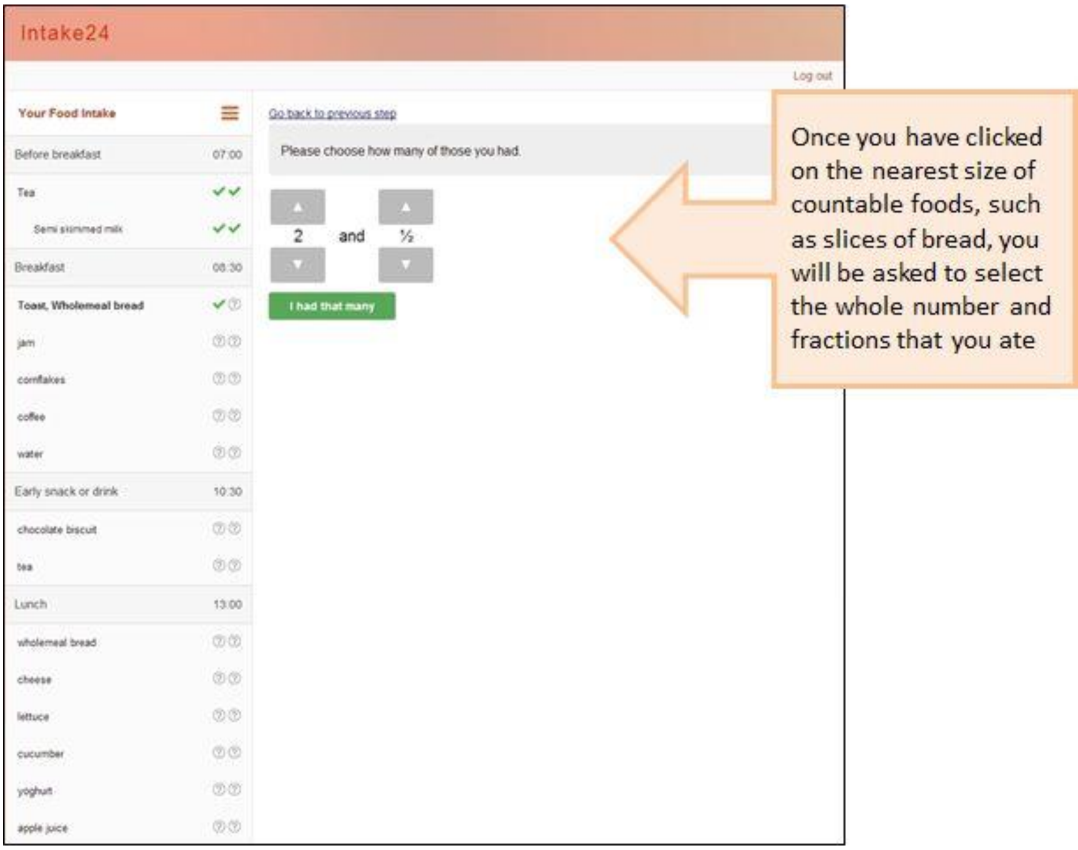

Intake24
Log out
Your Food Intake
Go back to previous step
Before breakfast 07:00
Tea
Semi skimmed milk
Breakfast 08:30
Toast, Wholemeal bread
Jam, raspberry/ strawberry/ blackberry
Cornflakes
coffee
water
Early snack or drink 10:30
chocolate biscuit
tea
Lunch 13:00
wholemeal bread
cheese
lettuce
cucumber
yoghurt
apple juice
Using these pictures of cereal, flake, bowl c, please choose how much cornflakes you had.
55 g
I had less
I had more
I had that much
Then you will need to select the nearest portion size that you ate. Click on the small thumbnail pictures to enlarge them
Once you have selected the nearest portion size, click on "I had that much"

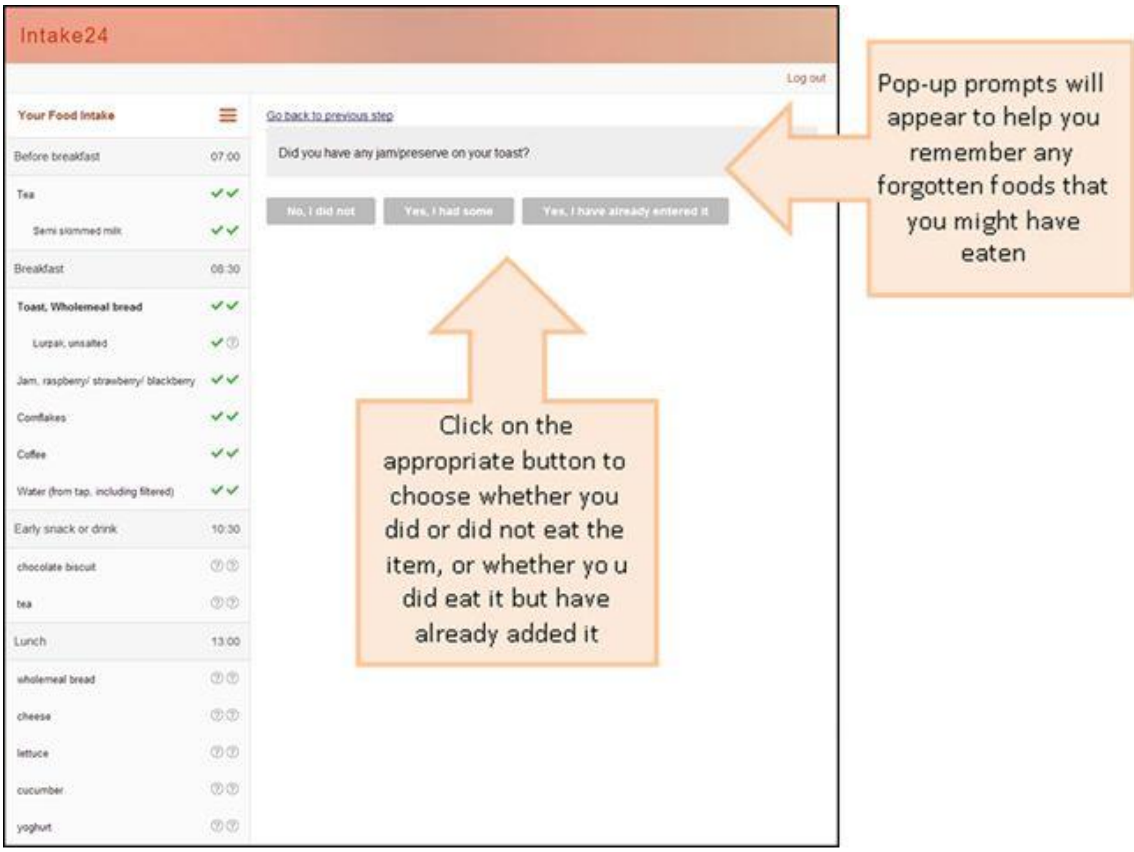

Intake24
Log out
Your Food Intake
Go back to previous step
Using these pictures of cereal, flake, bowl c, leftovers, please choose how much cornflakes you left.
Before breakfast 07:00
Tea
Semi skimmed milk
Tea
Semi skimmed milk
Breakfast 08:30
Toast, Wholemeal bread
Lurpak, unsalted
Jam, raspberry/ strawberry/ blackberry
Cornflakes
Coffee
Semi skimmed milk
Water (from tap, including filtered)
Early snack or drink 10:30
Oaty biscuits half coated with chocolate, e.g. chocolate Hob Nobs
Tea
Semi skimmed milk
Lunch 13:00
6 g
I left less
I left more
I left that much
After selecting the portion size, there will be the option to add any leftovers that you did not eat
Once you have selected the nearest portion size, click on "I left that much"

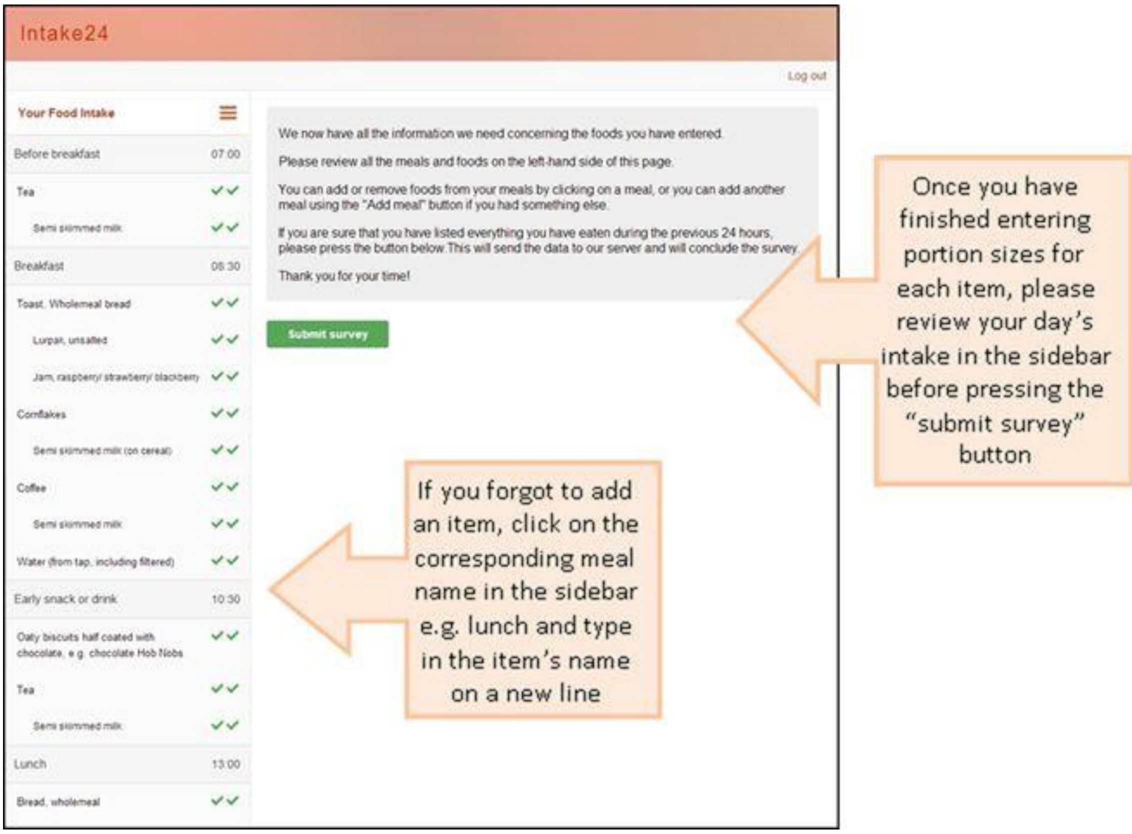

Intake24
Log out
Your Food Intake
Go back to previous step
How would you like to estimate your portion size of Tea?
Before breakfast 07:00
Tea
Breakfast 08:30
toast
jam
cornflakes
coffee
water
Early snack or drink 10:30
chocolate biscuit
tea
Lunch 13:00
wholemeal bread
cheese
lettuce
cucumber
yoghurt
apple juice
Afternoon snack or drink 15:00
In a mug
In a takeaway cup
For certain items, you will be given an option of how you would like to view their portion sizes. Click in the middle of the picture that you would like to see


Intake24
Log out
Your Food Intake
Go back to previous step
Please use the slider on the right to indicate how full your cup or glass was.
Before breakfast 07:00
Tea
Breakfast 08:30
toast
jam
cornflakes
coffee
water
Early snack or drink 10:30
chocolate biscuit
tea
Lunch 13:00
wholemeal bread
cheese
lettuce
cucumber
yoghurt
apple juice
Afternoon snack or drink 15:00
290 ml
It was less full
It was more full
It was that full
For drinks, slide the bar up and down to select how full the glass/mug was
Once you have selected the right amount, click on "It was that full"


Intake24
Log out
Your Food Intake
Go back to previous step
Please select the item you had or the closest match.
Before breakfast 07:00
Tea
Semi skimmed milk
Breakfast 08:30
Toast, Wholemeal bread
jam
cornflakes
coffee
water
Early snack or drink 10:30
chocolate biscuit
tea
Lunch 13:00
wholemeal bread
cheese
lettuce
cucumber
yoghurt
apple juice
1
2
3
4
5
6
7
8
9
For individual countable foods, such as slices of bread, click on the nearest sized item to the one you ate


Intake24
Log out
Your Food Intake
Go back to previous step
Please choose how many of those you had.
2 and ½
I had that many
Before breakfast 07:00
Tea
Semi skimmed milk
Breakfast 08:30
Toast, Wholemeal bread
jam
cornflakes
coffee
water
Early snack or drink 10:30
chocolate biscuit
tea
Lunch 13:00
wholemeal bread
cheese
lettuce
cucumber
yoghurt
apple juice
Once you have clicked on the nearest size of countable foods, such as slices of bread, you will be asked to select the whole number and fractions that you ate


Intake24
Log out
Your Food Intake
Go back to previous step
Did you have any jam/preserve on your toast?
No, I did not
Yes, I had some
Yes, I have already entered it
Before breakfast 07:00
Tea
Semi skimmed milk
Breakfast 08:30
Toast, Wholemeal bread
Lurpak, unsalted
Jam, raspberry/ strawberry/ blackberry
Cornflakes
Coffee
Water (from tap, including filtered)
Early snack or drink 10:30
chocolate biscuit
tea
Lunch 13:00
wholemeal bread
cheese
lettuce
cucumber
yoghurt
Pop-up prompts will appear to help you remember any forgotten foods that you might have eaten
Click on the appropriate button to choose whether you did or did not eat the item, or whether yo u did eat it but have already added it


Intake24
Log out
Your Food Intake
Before breakfast 07:00
Tea
Semi skimmed milk
Breakfast 08:30
Toast, Wholemeal bread
Lurpak, unsalted
Jam, raspberry/ strawberry/ blackberry
Cornflakes
Semi skimmed milk (on cereal)
Coffee
Semi skimmed milk
Water (from tap, including filtered)
Early snack or drink 10:30
Oaty biscuits half coated with chocolate, e.g. chocolate Hob Nobs
Tea
Semi skimmed milk
Lunch 13:00
Bread, wholemeal
We now have all the information we need concerning the foods you have entered.
Please review all the meals and foods on the left-hand side of this page.
You can add or remove foods from your meals by clicking on a meal, or you can add another meal using the "Add meal" button if you had something else.
If you are sure that you have listed everything you have eaten during the previous 24 hours, please press the button below. This will send the data to our server and will conclude the survey.
Thank you for your time!
Submit survey
Once you have finished entering portion sizes for each item, please review your day's intake in the sidebar before pressing the "submit survey" button
If you forgot to add an item, click on the corresponding meal name in the sidebar e.g. lunch and type in the item's name on a new line

# Appendix X Relative validation of INTAKE24 user details and recording days letter

Human Nutrition Research Centre
Biomedical Research Building
Campus for Ageing and Vitality
Newcastle University
Newcastle upon Tyne, NE4 5PL

## NEWCASTLE UNIVERSITY FOOD STUDY
## ONLINE SYSTEM TO MEASURE WHAT WE EAT

Dear [NAME]

Many thanks for taking part in this study and for completing your first recording day.

For your next three diet recording days over the coming weeks, I would like you to complete the INTAKE24 online tool, where you will recall and record everything that you ate and drank on the previous day from midnight to midnight. This can be completed whenever and wherever is convenient to you, but it must be done **BEFORE** our telephone interviews. This should take no longer than 30 minutes.

To access the INTAKE24 website, please follow the link and enter the username and password below. If you can't find the foods/drinks you require in the system, please select the closest match. If you experience any difficulties or you need to change your appointments please email me on c.a.shaw@ncl.ac.uk or you can contact me on 0191 248 1141 or 07894 861540.

https://intake24.co.uk/surveys/livewell

- Username: **test[ID]**
- Password: **food**

On the same recording days, I will also telephone you to ask what you ate and drank on the previous day (after you have completed INTAKE24). Using the food photograph book that I gave you on your visit, I will ask you to describe the portion sizes that you ate. This should take no longer than 30 minutes.

The following days are the dates of your 3 other recording days. I will send you a reminder email on the day before your appointments.

**Recording Day 2: [DAY DATE MONTH]**
**Complete INTAKE24 FIRST**
**Telephone interview time: [TIME]**

**Recording Day 3: [DAY DATE MONTH]**
**Complete INTAKE24 FIRST**
**Telephone interview time: [TIME]**

**Recording Day 4: [DAY DATE MONTH]**
**Complete INTAKE24 FIRST**
**Telephone interview time: [TIME]**

Yours sincerely,

Caroline Shaw
Email: c.a.shaw@ncl.ac.uk
Tel: 0191 248 1141

# Appendix Y Relative validation of INTAKE24 appointment protocol

**Participants who are completing INTAKE24 first:**

1. The first appointment is arranged with participant.

2. The participant visits the researcher at Newcastle University and INTAKE24 is carried out, whilst being timed on a stopwatch and if they prefer, using the instructions as a guide. PROVIDE PARTICIPANT WITH LOG-IN DETAILS, WEBSITE ADDRESS AND INSTRUCTIONS.

3. The INTERVIEWER-LED RECALL is then carried out, whilst being timed on a stopwatch.

4. The food atlas is left with the participant and a brief description of how to use it is given (indicate served and leftover images. Researcher will say "please turn to page xx" during telephone interview). MAKE A NOTE OF ATLAS NUMBER ON INSIDE COVER AND PROVIDE SAE BAG TO RETURN IT.

5. The researcher will explain that there will be three more recalls carried out over the next three weeks over the phone and the order of completing the tools will remain the same. ARRANGE FOLLOWING 3 RECORDING DAYS AND BEST TIME TO CALL. ANY PROBLEMS?

6. Measure the participant's height and weight.

**Participants who are completing INTERVIEWER-LED RECALL first:**

1. The first appointment is arranged with participant.

2. The participant visits the researcher at Newcastle University and the INTERVIEWER-LED RECALL is carried out, whilst being timed on a stopwatch.

3. The participant is then advised to complete INTAKE24 afterwards at the visit, whilst being timed and if they prefer, using the instructions as a guide. PROVIDE PARTICIPANT WITH LOG-IN DETAILS, WEBSITE ADDRESS AND INSTRUCTIONS.

4. The food atlas is left with the participant and a brief description of how to use it is given (indicate served and leftover images. Researcher will say "please turn to page xx" during telephone interview). MAKE A NOTE OF ATLAS NUMBER ON INSIDE COVER AND PROVIDE SAE BAG TO RETURN IT.

5. The researcher will explain that there will be three more recalls carried out over the next three weeks over the phone and the order of completing the tools will remain the same. ARRANGE FOLLOWING 3 RECORDING DAYS AND BEST TIME TO CALL. ANY PROBLEMS?

6. Measure the participant's height and weight.

# Appendix Z Relative validation of INTAKE24 study participant's internet usage

| Characteristic (n=30) | Category | N | % Participants |
|---|---|---|---|
| Frequency of internet use | Every day/ Almost every day | 28 | 93.3 |
| | At least once a week | 2 | 6.7 |
| No. of devices internet accessed | 1 | 11 | 36.7 |
| | 2 | 10 | 33.3 |
| | 3 | 4 | 13.3 |
| | 4 | 5 | 16.7 |
| Places internet is accessed | At home | 8 | 26.7 |
| | At home & outside the home | 22 | 73.3 |

# References

Adamson, A.J., Collerton, J., Davies, K., Foster, E., Jagger, C., Stamp, E., Mathers, J.C. and Kirkwood, T. (2009) 'Nutrition in advanced age: Dietary assessment in the Newcastle 85 + study', *European Journal of Clinical Nutrition*, 63(SUPPL. 1), pp. S6-S18.

Alberti-Fidanza, A. and Fidanza, F. (2004) 'Mediterranean Adequacy Index of Italian diets', *Public health nutrition*, 7(7), pp. 937-941.

Alberti-Fidanza, A., Fidanza, F., Chiuchiù, M.P., Verducci, G. and Fruttini, D. (1999) 'Dietary studies on two rural Italian population groups of the Seven Countries Study. 3. Trend of food and nutrient intake from 1960 to 1991', *European Journal of Clinical Nutrition*, 53(11), pp. 854-860.

Alberti, A., Fruttini, D. and Fidanza, F. (2009) 'The Mediterranean Adequacy Index: Further confirming results of validity', *Nutrition, Metabolism and Cardiovascular Diseases*, 19(1), pp. 61-66.

Antonogeorgos, G., Panagiotakos, D.B., Grigoropoulou, D., Papadimitriou, A., Anthracopoulos, M., Nicolaidou, P. and Priftis, K.N. (2013) 'The mediating effect of parents' educational status on the association between adherence to the Mediterranean diet and childhood obesity: The PANACEA study', *International Journal of Public Health*, 58(3), pp. 401-408.

Arab, L., Tseng, C.H., Ang, A. and Jardack, P. (2011) 'Validity of a Multipass, Web-based, 24-Hour Self-Administered Recall for Assessment of Total Energy Intake in Blacks and Whites', *American Journal of Epidemiology*, 174(11), pp. 1256-1265.

Argo, C.K. and Caldwell, S.H. (2009) 'Epidemiology and Natural History of Non-Alcoholic Steatohepatitis', *Clinics in Liver Disease*, 13(4), pp. 511-531.

Bach-Faig, A., Berry, E.M., Lairon, D., Reguant, J., Trichopoulou, A., Dernini, S., Medina, F.X., Battino, M., Belahsen, R., Miranda, G., Serra-Majem, L. and Mediterranean Diet Foundation Expert, G. (2011) 'Mediterranean diet pyramid today. Science and cultural updates', *Public Health Nutrition*, 14(12 A), pp. 2274-2284.

Bach-Faig, A., Geleva, D., Carrasco, J.L., Ribas-Barba, L. and Serra-Majem, L. (2006) 'Evaluating associations between Mediterranean diet adherence indexes and biomarkers of diet and disease', *Public health nutrition*, 9(8 A), pp. 1110-1117.

Bach, A., Serra-Majem, L., Carrasco, J.L., Roman, B., Ngo, J., Bertomeu, I. and Obrador, B. (2006) 'The use of indexes evaluating the adherence to the Mediterranean diet in epidemiological studies: a review', *Public health nutrition.*, 9(1 A), pp. 132-146.

Baker, L.B., Heaton, L.E., Stein, K.W., Nuccio, R.P. and Jeukendrup, A.E. (2014) 'Validity and relative validity of a novel digital approach for 24-h dietary recall in athletes', *Nutrition Journal*, 13(1).

Baranowski, T., Islam, N., Baranowski, J., Cullen, K.W., Myres, D., Marsh, T. and De Moor, C. (2002) 'The Food Intake Recording Software System is valid among fourth-grade children', *Journal of the American Dietetic Association*, 102(3), pp. 380-385.

Barrera, F. and George, J. (2014) 'The role of diet and nutritional intervention for the management of patients with NAFLD', *Clinics in Liver Disease*, 18(1), pp. 91-112.

Basiotis, P.P., Welsh, S.O., Cronin, F.J., Kelsay, J.L. and Mertz, W. (1987) 'Number of days of food intake records required to estimate individual and group nutrient intakes with defined confidence', *Journal of Nutrition*, 117(9), pp. 1638-1641.

Bates, B., Lennox, A. and Swan, G. (2010) *National Diet and Nutrition Survey: Headline Results from Years 1 and 2 (combined) of the Rolling Programme 2008-9 - 2009-10*. [Online]. Available at: https://www.gov.uk/government/publications/national-diet-and-nutrition-survey-headline-results-from-years-1-and-2-combined-of-the-rolling-programme-2008-9-2009-10.

Baxter, S.D., Thompson, W.O., Davis, H.C. and Johnson, M.H. (1997) ''How do you remember you ate.. .?': A Delphi technique study to identify retrieval categories from fourth-grade children', *Journal of the American Dietetic Association*, 97(1), pp. 31-36.

Benetou, V., Orfanos, P., Pettersson-Kymmer, U., Bergström, U., Svensson, O., Johansson, I., Berrino, F., Tumino, R., Borch, K.B., Lund, E., Peeters, P.H.M., Grote, V., Li, K., Altzibar, J.M., Key, T., Boeing, H., Von Ruesten, A., Norat, T., Wark, P.A., Riboli, E. and Trichopoulou, A. (2013) 'Mediterranean diet and incidence of hip fractures in a European cohort', *Osteoporosis International*, 24(5), pp. 1587-1598.

Benetou, V., Trichopoulou, A., Orfanos, P., Naska, A., Lagiou, P., Boffetta, P. and Trichopoulos, D. (2008) 'Conformity to traditional Mediterranean diet and cancer incidence: The Greek EPIC cohort', *British Journal of Cancer*, 99(1), pp. 191-195.

Benítez-Arciniega, A.A., Mendez, M.A., Baena-Díez, J.M., Rovira Martori, M.A., Soler, C., Marrugat, J., Covas, M.I., Sanz, H., Llopis, A. and Schröder, H. (2011) 'Concurrent and construct validity of Mediterranean diet scores as assessed by an FFQ', *Public Health Nutrition*, 14(11), pp. 2015-2021.

Bere, E. and Brug, J. (2010) 'Short communication: Is the term Mediterranean diet a misnomer?', *Public health nutrition*, 13(12), pp. 2127-2129.

Beunza, J.J., Toledo, E., Hu, F.B., Bes-Rastrollo, M., Serrano-Martínez, M., Sánchez-Villegas, A., Martínez, J.A. and Martínez-González, M.A. (2010) 'Adherence to the Mediterranean diet, long-term weight change, and incident overweight or obesity: The Seguimiento Universidad de Navarra (SUN) cohort', *American Journal of Clinical Nutrition*, 92(6), pp. 1484-1493.

Bingham, S.A., Welch, A.A., McTaggart, A., Mulligan, A.A., Runswick, S.A., Luben, R., Oakes, S., Khaw, K.T., Wareham, N. and Day, N.E. (2001) 'Nutritional methods in the European prospective investigation of cancer in Norfolk', *Public Health Nutrition*, 4(3), pp. 847-858.

Bland, J.M. and Altman, D.G. (1986) 'Statistical methods for assessing agreement between two methods of clinical measurement', *Lancet*, 1(8476), pp. 307-310.

Blanton, C.A., Moshfegh, A.J., Baer, D.J. and Kretsch, M.J. (2006) 'The USDA Automated Multiple-Pass Method accurately estimates group total energy and nutrient intake', *Journal of Nutrition*, 136(10), pp. 2594-9.

Brooke, J. (1996) 'SUS: A "quick and dirty" usability scale', in Jordan, P.W., Thomas, B., McClelland, I.L. and Weerdmeester, B. (eds.) *Usability Evaluation In Industry*. CRC Press.

Brustad, M., Skeie, G., Braaten, T., Slimani, N. and Lund, E. (2003) 'Comparison of telephone vs face-to-face interviews in the assessment of dietary intake by the 24 h recall EPIC SOFT program - The Norwegian calibration study', *European Journal of Clinical Nutrition*, 57(1), pp. 107-113.

Buckland, G., Agudo, A., Luján, L., Jakszyn, P., Bas Bueno-de-Mesquita, H., Palli, D., Boeing, H., Carneiro, F., Krogh, V., Sacerdote, C., Tumino, R., Panico, S., Nesi, G., Manjer, J., Regnér, S., Johansson, I., Stenling, R., Sanchez, M.J., Dorronsoro, M., Barricarte, A., Navarro, C., Quirós, J.R., Allen, N.E., Key, T.J., Bingham, S., Kaaks, R., Overvad, K., Jensen, M., Olsen, A., Tjønneland, A., Peeters, P.H.M., Numans, M.E., Ocké, M.C., Clavel-Chapelon, F., Morois, S., Boutron-Ruault, M.C., Trichopoulou, A., Lagiou, P., Trichopoulos, D., Lund, E., Couto, E., Boffeta, P., Jenab, M., Riboli, E., Romaguera, D., Mouw, T. and González, C.A. (2010) 'Adherence to a Mediterranean diet and risk of gastric adenocarcinoma within the European Prospective Investigation into Cancer and Nutrition (EPIC) cohort study', *American Journal of Clinical Nutrition*, 91(2), pp. 381-390.

Buckland, G., Agudo, A., Travier, N., María Huerta, J., Cirera, L., Tormo, M.J., Navarro, C., Dolores Chirlaque, M., Moreno-Iribas, C., Ardanaz, E., Barricarte, A., Etxeberria, J., Marin, P., Ramón Quirós, J., Redondo, M.L., Larrañaga, N., Amiano, P., Dorronsoro, M., Arriola, L., Basterretxea, M., Sanchez, M.J., Molina, E. and González, C.A. (2011) 'Adherence to the Mediterranean diet reduces mortality in the Spanish cohort of the European Prospective

Investigation into Cancer and Nutrition (EPIC-Spain)', *British Journal of Nutrition*, 106(10), pp. 1581-1591.

Buckland, G., Ros, M.M., Roswall, N., Bueno-de-Mesquita, H.B., Travier, N., Tjonneland, A., Kiemeney, L.A., Sacerdote, C., Tumino, R., Ljungberg, B., Gram, I.T., Weiderpass, E., Skeie, G., Malm, J., Ehrnström, R., Chang-Claude, J., Mattiello, A., Agnoli, C., Peeters, P.H., Boutron-Ruault, M.C., Fagherazzi, G., Clavel-Chapelon, F., Nilsson, L.M., Amiano, P., Trichopoulou, A., Oikonomou, E., Tsiotas, K., Sánchez, M.J., Overvad, K., Quirós, J.R., Chirlaque, M.D., Barricarte, A., Key, T.J., Allen, N.E., Khaw, K.T., Wareham, N., Riboli, E., Kaaks, R., Boeing, H., Palli, D., Romieu, I., Romaguera, D. and Gonzalez, C.A. (2013) 'Adherence to the Mediterranean diet and risk of bladder cancer in the EPIC cohort study', *International Journal of Cancer*, 134(10), pp. 2504-2511.

Cade, J.E., Taylor, E.F., Burley, V.J. and Greenwood, D.C. (2011) 'Does the Mediterranean dietary pattern or the Healthy Diet Index influence the risk of breast cancer in a large British cohort of women?', *European Journal of Clinical Nutrition*, 65(8), pp. 920-928.

Cole, G.M., Ma, Q.L. and Frautschy, S.A. (2010) 'Dietary fatty acids and the aging brain', *Nutrition Reviews*, 68(SUPPL. 2), pp. s102-s111.

Conway, J.M., Ingwersen, L.A., Vinyard, B.T. and Moshfegh, A.J. (2003) 'Effectiveness of the US Department of Agriculture 5-step multiple-pass method in assessing food intake in obese and nonobese women', *American Journal of Clinical Nutrition*, 77(5), pp. 1171-1178.

Cooper, C., Campion, G. and Melton Iii, L.J. (1992) 'Hip fractures in the elderly: A world-wide projection', *Osteoporosis International*, 2(6), pp. 285-289.

Crispim, S.P., Geelen, A., Souverein, O.W., Hulshof, P.J.M., Ruprich, J., Dofkova, M., Huybrechts, I., De Keyzer, W., Lillegaard, I.T., Andersen, L.F., Lafay, L., Rousseau, A.S., Ocké, M.C., Slimani, N., Van'T Veer, P. and De Vries, J.H. (2011) 'Biomarker-based evaluation of two 24-h recalls for comparing usual fish, fruit and vegetable intakes across European centers in the EFCOVAL Study', *European Journal of Clinical Nutrition*, 65(SUPPL. 1), pp. S38-S47.

Curtis, P.J., Adamson, A.J. and Mathers, J.C. (2012) 'Effects on nutrient intake of a family-based intervention to promote increased consumption of low-fat starchy foods through education, cooking skills and personalised goal setting: The Family Food and Health Project', *British Journal of Nutrition*, 107(12), pp. 1833-1844.

Da Costa, F.F., Schmoelz, C.P., Davies, V.F., Di Pietro, P.F., Kupek, E. and De Assis, M.A.A. (2013) 'Assessment of diet and physical activity of brazilian schoolchildren: Usability testing of a web-based questionnaire', *Journal of Medical Internet Research*, 15(8).

Da Silva, R., Bach-Faig, A., Raidó Quintana, B., Buckland, G., Vaz De Almeida, M.D. and Serra-Majem, L. (2009) 'Worldwide variation of adherence to the Mediterranean diet, in 1961-1965 and 2000-2003', *Public health nutrition*, 12(9 SPEC. ISSUE 9A), pp. 1676-1684.

De Boer, E.J., Slimani, N., Van, T.V., Boeing, H., Feinberg, M., Leclercq, C., Trolle, E., Amiano, P., Andersen, L.F., Freisling, H., Geelen, A., Harttig, U., Huybrechts, I., Kaic-Rak, A., Lafay, L., Lillegaard, I.T., Ruprich, J., De Vries, J.H. and Ocké, M.C. (2011) 'The European Food Consumption Validation Project: Conclusions and recommendations', *European Journal of Clinical Nutrition*, 65(SUPPL. 1), pp. S102-S107.

de Lorgeril, M., Renaud, S., Salen, P., Monjaud, I., Mamelle, N., Martin, J.L., Guidollet, J., Touboul, P. and Delaye, J. (1994) 'Mediterranean alpha-linolenic acid-rich diet in secondary prevention of coronary heart disease', *The Lancet*, 343(8911), pp. 1454-1459.

De Lorgeril, M., Salen, P., Martin, J.L., Monjaud, I., Delaye, J. and Mamelle, N. (1999) 'Mediterranean diet, traditional risk factors, and the rate of cardiovascular complications after myocardial infarction: Final report of the Lyon Diet Heart Study', *Circulation*, 99(6), pp. 779-785.

Elsevier (2015) *Scopus homepage*. Available at: www.scopus.com/.

Esposito, K., Maiorino, M.I., Ceriello, A. and Giugliano, D. (2010) 'Prevention and control of type 2 diabetes by Mediterranean diet: A systematic review', *Diabetes Research and Clinical Practice*, 89(2), pp. 97-102.

Estruch, R., Martínez-González, M.A., Corella, D., Salas-Salvadó, J., Ruiz-Gutiérrez, V., Covas, M.I., Fiol, M., Gómez-Gracia, E., López-Sabater, M.C., Vinyoles, E., Arós, F., Conde, M., Lahoz, C., Lapetra, J., Sáez, G. and Ros, E. (2006) 'Effects of a Mediterranean-Style Diet on Cardiovascular Risk Factors a Randomized Trial', *Annals of Internal Medicine*, 145(1), pp. 1-11.

Estruch, R., Ros, E., Salas-Salvadó, J., Covas, M.I., Corella, D., Arós, F., Gómez-Gracia, E., Ruiz-Gutiérrez, V., Fiol, M., Lapetra, J., Lamuela-Raventos, R.M., Serra-Majem, L., Pintó, X., Basora, J., Muñoz, M.A., Sorlí, J.V., Martínez, J.A. and Martínez-González, M.A. (2013) 'Primary prevention of cardiovascular disease with a Mediterranean diet', *New England Journal of Medicine*, 368(14), pp. 1279-1290.

Fidanza, F., Alberti, A., Lanti, M. and Menotti, A. (2004) 'Mediterranean Adequacy Index: Correlation with 25-year mortality from coronary heart disease in the Seven Countries Study', *Nutrition, Metabolism and Cardiovascular Diseases*, 14(5), pp. 254-258.

Foods Standards Agency (2002) *Food Portion Sizes: Third Edition*. Third edn. London: TSO.

Foster, E., Delve, J. and Simpson, E. (2013) *Development of a web-based 24-hour dietary recall tool for use by 11-24 year olds: INTAKE24*. Food Standards Agency.

Foster, E., Delve, J., Simpson, E. and Breininger, S.-P. (2014a) *Comparison Study: INTAKE24 vs Interviewer led recall*. [Online]. Available at: www.food.gov.uk/sites/default/files/INTAKE24%20Comparison%20study%20final%20report.pdf.

Foster, E., Hawkins, A. and Adamson, A.J. (2010) *Young Person's Food Atlas: Secondary*. Foods Standards Agency.

Foster, E., Hawkins, A., Delve, J. and Adamson, A.J. (2014b) 'Reducing the cost of dietary assessment: Self-Completed Recall and Analysis of Nutrition for use with children (SCRAN24)', *Journal of Human Nutrition and Dietetics*, 27(SUPPL.1), pp. 26-35.

Foster, E., Hawkins, A., Simpson, E. and Adamson, A.J. (2014c) 'Developing an interactive portion size assessment system (IPSAS) for use with children', *Journal of Human Nutrition and Dietetics*, 27(SUPPL.1), pp. 18-25.

Fowles, E.R. and Gentry, B. (2008) 'The Feasibility of Personal Digital Assistants (PDAs) to Collect Dietary Intake Data in Low-income Pregnant Women', *Journal of Nutrition Education and Behavior*, 40(6), pp. 374-377.

Frankenfeld, C.L., Poudrier, J.K., Waters, N.M., Gillevet, P.M. and Xu, Y. (2012) 'Dietary Intake Measured from a Self-Administered, Online 24-Hour Recall System Compared with 4-Day Diet Records in an Adult US Population', *Journal of the Academy of Nutrition and Dietetics*, 112(10), pp. 1642-1647.

Fung, T.T., McCullough, M.L., Newby, P.K., Manson, J.E., Meigs, J.B., Rifai, N., Willett, W.C. and Hu, F.B. (2005) 'Diet-quality scores and plasma concentrations of markers of inflammation and endothelial dysfunction', *American Journal of Clinical Nutrition*, 82(1), pp. 163-173.

Gerber, M.J., Scali, J.D., Michaud, A., Durand, M.D., Astre, C.M., Dallongeville, J. and Romon, M.M. (2000) 'Profiles of a healthful diet and its relationship to biomarkers in a population sample from Mediterranean southern France', *Journal of the American Dietetic Association*, 100(10), pp. 1164-1171.

Goldberg, G.R., Black, A.E., Jebb, S.A., Cole, T.J., Murgatroyd, P.R., Coward, W.A. and Prentice, A.M. (1991) 'Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off limits to identify under-recording', *European Journal of Clinical Nutrition*, 45(12), pp. 569-581.

Goulet, J., Lamarche, B., Nadeau, G. and Lemieux, S. (2003) 'Effect of a nutritional intervention promoting the Mediterranean food pattern on plasma lipids, lipoproteins and body weight in healthy French-Canadian women', *Atherosclerosis*, 170(1), pp. 115-124.

Gregory, J., Lowe, S., Bates, C.J., Prentice, A., Jackson, L.V., Smithers, G., Wenlock, R. and Farron, M. (2000) *National Diet and Nutrition Survey: Young People Aged 4 to 18 Years. Volume 1: Report of the Diet and Nutrition Survey.* The Stationary Office, London.

Gregory, J.R., Collins, D.L., Davies, P.S.W., Hughes, J.M. and Clarke, P.C. (1995) *National Diet and Nutrition Survey: Children Aged 1 1/2 to 4 1/2 Years. Volume I: Report of the Diet and Nutrition Survey*. London: HMSO.

Grosso, G., Marventano, S., Buscemi, S., Scuderi, A., Matalone, M., Platania, A., Giorgianni, G., Rametta, S., Nolfo, F., Galvano, F. and Mistretta, A. (2013) 'Factors associated with adherence to the Mediterranean diet among adolescents living in Sicily, southern Italy', *Nutrients*, 5(12), pp. 4908-4923.

Hanning, R.M., Royall, D., Toews, J.E., Blashill, L., Wegener, J. and Driezen, P. (2009) 'Web-based food behaviour questionnaire: Validation with grades six to eight students', *Canadian Journal of Dietetic Practice and Research*, 70(4), pp. 172-178.

Heath, A.L.M., Roe, M.A., Oyston, S.L. and Fairweather-Tait, S.J. (2005) 'Meal-based intake assessment tool: Relative validity when determining dietary intake of Fe and Zn and selected absorption modifiers in UK men', *British Journal of Nutrition*, 93(3), pp. 403-416.

Hebestreit, A., Börnhorst, C., Barba, G., Siani, A., Huybrechts, I., Tognon, G., Eiben, G., Moreno, L.A., Fernández Alvira, J.M., Loit, H.M., Kovacs, E., Tornaritis, M. and Krogh, V. (2014) 'Associations between energy intake, daily food intake and energy density of foods and BMI z-score in 2-9-year-old European children', *European Journal of Nutrition*, 53(2), pp. 673-681.

Henderson, L., Gregory, J. and Swan, G. (2002) 'National Diet and Nutrition Survey: Adults Aged 19 to 64 Years: Volume 1: Types and quantities of foods consumed. '. The Stationary Office, London.

Henry, C.J.K. (2005) 'Basal metabolic rate studies in humans: Measurement and development of new equations', *Public Health Nutrition*, 8(7 A), pp. 1133-1152.

Hernández, T. (2001) 'Asian Assist: A Bilingual Dietary Assessment Program for Chinese Americans', *Journal of Food Composition and Analysis*, 14(3), pp. 245-252.

Hillier, F.C., Batterham, A.M., Crooks, S., Moore, H.J. and Summerbell, C.D. (2012) 'The development and evaluation of a novel Internet-based computer program to assess previous-day dietary and physical activity behaviours in adults: the Synchronised Nutrition and Activity Program for Adults (SNAPA™)', *The British journal of nutrition*, 107(8), pp. 1221-1231.

Hobbs, N., Godfrey, A., Lara, J., Errington, L., Meyer, T.D., Rochester, L., White, M., Mathers, J.C. and Sniehotta, F.F. (2013) 'Are behavioral interventions effective in increasing physical activity at 12 to 36 months in adults aged 55 to 70 years? A systematic review and meta-analysis', *BMC Medicine*, 11(1).

Hoffmann, K., Schulze, M.B., Schienkiewitz, A., Nöthlings, U. and Boeing, H. (2004) 'Application of a New Statistical Method to Derive Dietary Patterns in Nutritional Epidemiology', *American Journal of Epidemiology*, 159(10), pp. 935-944.

House of Commons Library Research (2010) *The Ageing Population In: Key Issues for the New Parliament 2010*.

Hu, F.B. (2002) 'Dietary pattern analysis: A new direction in nutritional epidemiology', *Current Opinion in Lipidology*, 13(1), pp. 3-9.

Hu, F.B., Bronner, L., Willett, W.C., Stampfer, M.J., Rexrode, K.M., Albert, C.M., Hunter, D. and Manson, J.E. (2002) 'Fish and omega-3 fatty acid intake and risk of coronary heart disease in women', *Journal of the American Medical Association*, 287(14), pp. 1815-1821.

Huybrechts, I., Casagrande, C., Nicolas, G., Geelen, A., Crispim, S.P., De Keyzer, W., Freisling, H., De Henauw, S., De Maeyer, M., Krems, C., Amiano, P., De Boer, E.J., Ocké, M.C., De Vries, J.H. and Slimani, N. (2011a) 'Inventory of experiences from national/regional dietary monitoring surveys using EPIC-Soft', *European Journal of Clinical Nutrition*, 65(SUPPL. 1), pp. S16-S28.

Huybrechts, I., Geelen, A., De Vries, J.H., Casagrande, C., Nicolas, G., De Keyzer, W., Lillegaard, I.T., Ruprich, J., Lafay, L., Wilson-Van Den Hooven, E.C., Niekerk, E.M., Margaritis, I., Rehurkova, I., Crispim, S.P., Freisling, H., De Henauw, S. and Slimani, N. (2011b) 'Respondents evaluation of the 24-h dietary recall method (EPIC-Soft) in the EFCOVAL Project', *European Journal of Clinical Nutrition*, 65(SUPPL. 1), pp. S29-S37.

Iestra, J., Knoops, K., Kromhout, D., De Groot, L., Grobbee, D. and Van Staveren, W. (2006) 'Lifestyle, Mediterranean diet and survival in European post-myocardial infarction patients', *European Journal of Cardiovascular Prevention and Rehabilitation*, 13(6), pp. 894-900.

Illner, A.K., Freisling, H., Boeing, H., Huybrechts, I., Crispim, S.P. and Slimani, N. (2012) 'Review and evaluation of innovative technologies for measuring diet in nutritional epidemiology', *International Journal of Epidemiology*, 41(4), pp. 1187-1203.

Illner, A.K., Harttig, U., Tognon, G., Palli, D., Salvini, S., Bower, E., Amiano, P., Kassik, T., Metspalu, A., Engeset, D., Lund, E., Ward, H., Slimani, N., Bergmann, M., Wagner, K. and Boeing, H. (2011) 'Feasibility of innovative dietary assessment in epidemiological studies using the approach of combining different assessment instruments', *Public Health Nutrition*, 14(6), pp. 1055-1063.

Ipsos MORI (2015) *Ipsos MORI Homepage*. Available at: www.ipsos-mori.com/.

Issa, C., Darmon, N., Salameh, P., Maillot, M., Batal, M. and Lairon, D. (2011) 'A Mediterranean diet pattern with low consumption of liquid sweets and refined cereals is negatively associated with adiposity in adults from rural Lebanon', *International Journal of Obesity*, 35(2), pp. 251-258.

Jagger, C., Collerton, J.C., Davies, K., Kingston, A., Robinson, L.A., Eccles, M.P., Von Zglinicki, T., Martin-Ruiz, C., James, O.F.W., Kirkwood, T.B.L. and

Bond, J. (2011) 'Capability and dependency in the Newcastle 85+ cohort study. Projections of future care needs', *BMC Geriatrics*, 11.

Jordan, P.W. (2000) *Designing Pleasurable Products: An Introduction to the New Human Factors.* Taylor & Francis, London.

Kant, A.K. (2004) 'Dietary patterns and health outcomes', *Journal of the American Dietetic Association*, 104(4), pp. 615-635.

Kennedy, E.T., Ohls, J., Carlson, S. and Fleming, K. (1995) 'The healthy eating index: Design and applications', *Journal of the American Dietetic Association*, 95(10), pp. 1103-1108.

Keys, A. (1980) *Seven Countries: A Multivariate Analysis of Death and Coronary Heart Disease*. Cambridge, Massachusetts: Harvard University Press.

Keys, A., Menotti, A. and Karvonen, M.J. (1986) 'The diet and 15-year death rate in the seven countries study', *American Journal of Epidemiology*, 124(6), pp. 903-915.

Kiefte-de Jong, J.C., Mathers, J.C. and Franco, O.H. (2014) 'Nutrition and healthy ageing: the key ingredients', *Proceedings of the Nutrition Society*, pp. 1-11.

Kirkpatrick, S.I., Subar, A.F., Douglass, D., Zimmerman, T.P., Thompson, F.E., Kahle, L.L., George, S.M., Dodd, K.W. and Potischman, N. (2014) 'Performance of the Automated Self-Administered 24-hour Recall relative to a measure of true intakes and to an interviewer-administered 24-h recall', *American Journal of Clinical Nutrition*, 100(1), pp. 233-240.

Knoops, K.T.B., de Groot, L.C., Fidanza, F., Alberti-Fidanza, A., Kromhout, D. and van Staveren, W.A. (2006) 'Comparison of three different dietary scores in relation to 10-year mortality in elderly European subjects: The HALE project', *European Journal of Clinical Nutrition*, 60(6), pp. 746-755.

Knoops, K.T.B., De Groot, L.C.P.G.M., Kromhout, D., Perrin, A.E., Moreiras-Varela, O., Menotti, A. and Van Staveren, W.A. (2004) 'Mediterranean diet, lifestyle factors, and 10-year mortality in elderly European men and women: The

HALE project', *Journal of the American Medical Association*, 292(12), pp. 1433-1439.

Kontogianni, M.D., Tileli, N., Margariti, A., Georgoulis, M., Deutsch, M., Tiniakos, D., Fragopoulou, E., Zafiropoulou, R., Manios, Y. and Papatheodoridis, G. (2014) 'Adherence to the Mediterranean diet is associated with the severity of non-alcoholic fatty liver disease', *Clinical Nutrition,* 33(4), pp. 678-683.

Kontou, N., Psaltopoulou, T., Soupos, N., Polychronopoulos, E., Xinopoulos, D., Linos, A. and Panagiotakos, D. (2012) 'Metabolic Syndrome and Colorectal Cancer: The Protective Role of Mediterranean Diet—A Case–Control Study', *Angiology*, 63(5), pp. 390-396.

Kovess-Masfety, V., Alonso, J., Brugha, T.S., Angermeyer, M.C., Haro, J.M., Sevilla-Dedieu, C., Bernert, S., Bruffaerts, R., De Girolamo, G., De Graaf, R., Demyttenaere, K., Gasquet, I., Katz, S.J., Kessler, R.C., Lépine, J.P., Ormel, J., Polidori, G. and Vilagut, G. (2007) 'Differences in lifetime use of services for mental health problems in six European countries', *Psychiatric Services*, 58(2), pp. 213-220.

Kushniruk, A.W., Patel, V.L. and Cimino, J.J. (2000) 'Evaluation of Web-based patient information resources: application in the assessment of a patient clinical information system', *Proceedings / AMIA ... Annual Symposium. AMIA Symposium*, pp. 443-447.

Landig, J., Erhardt, J.G., Bode, J.C. and Bode, C. (1998) 'Validation and comparison of two computerized methods of obtaining a diet history', *Clinical Nutrition*, 17(3), pp. 113-117.

Lara, J., Godfrey, A., Evans, E., Heaven, B., Brown, L.J.E., Barron, E., Rochester, L., Meyer, T.D. and Mathers, J.C. (2013) 'Towards measurement of the Healthy Ageing Phenotype in lifestyle-based intervention studies', *Maturitas*, 76(2), pp. 189-199.

Lara, J., Hobbs, N., Moynihan, P.J., Meyer, T.D., Adamson, A.J., Errington, L., Rochester, L., Sniehotta, F.F., White, M. and Mathers, J.C. (2014)

'Effectiveness of dietary interventions among adults of retirement age: A systematic review and meta-analysis of randomized controlled trials', *BMC Medicine*, 12(1).

Lassale, C., Fezeu, L., Andreeva, V.A., Hercberg, S., Kengne, A.P., Czernichow, S. and Kesse-Guyot, E. (2012) 'Association between dietary scores and 13-year weight change and obesity risk in a French prospective cohort', *International Journal of Obesity*, 36(11), pp. 1455-1462.

Lentjes, M.A.H., McTaggart, A., Mulligan, A.A., Powell, N.A., Parry-Smith, D., Luben, R.N., Bhaniani, A., Welch, A.A. and Khaw, K.T. (2014) 'Dietary intake measurement using 7Â d diet diaries in British men and women in the European prospective investigation into cancer-norfolk study: A focus on methodological issues', *British Journal of Nutrition*, 111(3), pp. 516-526.

Liu, B., Young, H., Crowe, F.L., Benson, V.S., Spencer, E.A., Key, T.J., Appleby, P.N. and Beral, V. (2011) 'Development and evaluation of the oxford WebQ, a low-cost, web-based method for assessment of previous 24 h dietary intakes in large-scale prospective studies', *Public Health Nutrition*, 14(11), pp. 1998-2005.

Logan, K.J., Woodside, J.V., Young, I.S., McKinley, M.C., Perkins-Porras, L. and McKeown, P.P. (2010) 'Adoption and maintenance of a Mediterranean diet in patients with coronary heart disease from a Northern European population: A pilot randomised trial of different methods of delivering Mediterranean diet advice', *Journal of Human Nutrition and Dietetics*, 23(1), pp. 30-37.

Ma, Y., Olendzki, B.C., Pagoto, S.L., Hurley, T.G., Magner, R.P., Ockene, I.S., Schneider, K.L., Merriam, P.A. and Hébert, J.R. (2009) 'Number of 24-Hour Diet Recalls Needed to Estimate Energy Intake', *Annals of Epidemiology*, 19(8), pp. 553-559.

Martinez-Gonzalez, M.A., De La Fuente-Arrillaga, C., Nunez-Cordoba, J.M., Basterra-Gortari, F.J., Beunza, J.J., Vazquez, Z., Benito, S., Tortosa, A. and Bes-Rastrollo, M. (2008) 'Adherence to Mediterranean diet and risk of developing diabetes: Prospective cohort study', *BMJ*, 336(7657), pp. 1348-1351.

Martínez-González, M.A., Fernández-Jarne, E., Serrano-Martínez, M., Marti, A., Martinez, J.A. and Martín-Moreno, J.M. (2002) 'Mediterranean diet and reduction in the risk of a first acute myocardial infarction: An operational healthy dietary score', *European Journal of Nutrition*, 41(4), pp. 153-160.

Martínez-González, M.A., Fernández-Jarne, E., Serrano-Martínez, M., Wright, M. and Gomez-Gracia, E. (2004) 'Development of a short dietary intake questionnaire for the quantitative estimation of adherence to a cardioprotective Mediterranean diet', *European Journal of Clinical Nutrition*, 58(11), pp. 1550-1552.

Mathers, J.C. (2013) 'Nutrition and ageing: Knowledge, gaps and research priorities', *Proceedings of the Nutrition Society*, 72(2), pp. 246-250.

Matthys, C., Pynaert, I., De Keyzer, W. and De Henauw, S. (2007) 'Validity and Reproducibility of an Adolescent Web-Based Food Frequency Questionnaire', *Journal of the American Dietetic Association*, 107(4), pp. 605-610.

McNaughton, S.A., Bates, C.J. and Mishra, G.D. (2012) 'Diet quality is associated with all-cause mortality in adults aged 65 years and older', *Journal of Nutrition*, 142(2), pp. 320-325.

Mennen, L.I., Bertrais, S., Galan, P., Arnault, N., de Couray, G.P. and Hercberg, S. (2002) 'The use of computerised 24 h dietary recalls in the French SU.VI.MAX Study: number of recalls required', *European Journal of Clinical Nutrition*, 56(7), pp. 659-665.

Milà-Villarroel, R., Bach-Faig, A., Puig, J., Puchal, A., Farran, A., Serra-Majem, L. and Carrasco, J.L. (2011) 'Comparison and evaluation of the reliability of indexes of adherence to the Mediterranean diet', *Public health nutrition*, 14(12 A), pp. 2338-2345.

Ministry of Health and Welfare Supreme Scientific Health Council of Greece (1999) 'Dietary guidelines for adults in Greece', *Archives of Hellenic Medicine*, 16(5), pp. 516-524.

Mitrou, P.N., Kipnis, V., Thiébaut, A.C.M., Reedy, J., Subar, A.F., Wirfält, E., Flood, A., Mouw, T., Hollenbeck, A.R., Leitzmann, M.F. and Schatzkin, A.

(2007) 'Mediterranean dietary pattern and prediction of all-cause mortality in a US population: Results from the NIH-AARP diet and health study', *Archives of Internal Medicine*, 167(22), pp. 2461-2468.

Monjardino, T., Lucas, R., Ramos, E. and Barros, H. (2014) 'Associations between a priori-defined dietary patterns and longitudinal changes in bone mineral density in adolescents', *Public Health Nutrition*, 17(1), pp. 195-205.

Moore, H.J., Ells, L.J., McLure, S.A., Crooks, S., Cumbor, D., Summerbell, C.D. and Batterham, A.M. (2008) 'The development and evaluation of a novel computer program to assess previous-day dietary and physical activity behaviours in school children: The Synchronised Nutrition and Activity Program™ (SNAP™)', *British Journal of Nutrition*, 99(6), pp. 1266-1274.

Moore, H.J., Hillier, F.C., Batterham, A.M., Ells, L.J. and Summerbell, C.D. (2014) 'Technology-based dietary assessment: Development of the Synchronised Nutrition and Activity Program (SNAP™)', *Journal of Human Nutrition and Dietetics*, 27(SUPPL.1), pp. 36-42.

Mozaffarian, D., Marfisi, R., Levantesi, G., Silletta, M.G., Tavazzi, L., Tognoni, G., Valagussa, F. and Marchioli, R. (2007) 'Incidence of new-onset diabetes and impaired fasting glucose in patients with recent myocardial infarction and the effect of clinical and lifestyle risk factors', *Lancet*, 370(9588), pp. 667-675.

Muñoz, M.A., Fíto, M., Marrugat, J., Covas, M.I. and Schröder, H. (2009) 'Adherence to the Mediterranean diet is associated with better mental and physical health', *British Journal of Nutrition*, 101(12), pp. 1821-1827.

Murphy, M. and Di Cesare, M. (2012) 'Use of an age-period-cohort model to reveal the impact of cigarette smoking on trends in Twentieth-century adult cohort mortality in England and Wales', *Population Studies*, 66(3), pp. 259-277.

Murtaugh, M.A., Ma, K.N., Greene, T., Redwood, D., Edwards, S., Johnson, J., Tom-Orme, L., Lanier, A.P., Henderson, J.A. and Slattery, M.L. (2010) 'Validation of a dietary history questionnaire for American Indian and Alaska native people', *Ethnicity and Disease*, 20(4), pp. 429-436.

NatCen Social Research, MRC Human Nutrition Research and University College London Medical School (2015) 'National Diet and Nutrition Survey Years 1-4, 2008/09-2011/12' 7th Edition. UK Data Service. Available at: https://discover.ukdataservice.ac.uk/catalogue/?sn=6533&type=Data%20catalogue.

Nelson, M., Erens, B., Bates, B., Church, S. and Boshier, T. (2007) *Low Income Diet and Nutrition Survey*. HMSO: London.

Newby, P.K. and Tucker, K.L. (2004) 'Empirically derived eating patterns using factor or cluster analysis: A review', *Nutrition Reviews*, 62(5), pp. 177-203.

Nielsen, J. (1993) 'Usability heuristics', in *Usability engineering*. San Francisco: Academic Press. pp. p 115–155.

Ocké, M.C., Slimani, N., Brants, H., Buurma-Rethans, E., Casagrande, C., Nicolas, G., Dofkova, M., Le Donne, C., Freisling, H., Geelen, A., Huybrechts, I., De Keyzer, W., Van Der Laan, J.D., Lafay, L., Lillegaard, I.T., Niekerk, E.M., De Vries, J.H., Wilson-Van Den Hooven, E.C. and De Boer, E.J. (2011) 'Potential and requirements for a standardized pan-European food consumption survey using the EPIC-Soft software', *European Journal of Clinical Nutrition*, 65(SUPPL. 1), pp. S48-S57.

Office for National Statistics (2011) *2010-based National Population Projections - Principle Projection and Key Variants* [Online]. Available at: http://www.ons.gov.uk/ons/rel/npp/national-population-projections/2010-based-projections/index.html.

Office for National Statistics (2013) *Measuring National Well-being - Health, 2013*. [Online]. Available at: http://www.ons.gov.uk/ons/dcp171766_310300.pdf.

Osler, M. and Schroll, M. (1997) 'Diet and mortality in a cohort of elderly people in a north European community', *International Journal of Epidemiology*, 26(1), pp. 155-159.

Øverby, N.C., Johannesen, E., Jensen, G., Skjaevesland, A.K. and Haugen, M. (2014) 'Test-retest reliability and validity of a web-based food-frequency questionnaire for adolescents aged 13-14 to be used in the Norwegian Mother and Child Cohort Study (MoBa)', *Food and Nutrition Research*, 58.

Panagiotakos, D., Kalogeropoulos, N., Pitsavos, C., Roussinou, G., Palliou, K., Chrysohoou, C. and Stefanadis, C. (2009) 'Validation of the MedDietScore via the determination of plasma fatty acids', *International Journal of Food Sciences and Nutrition*, 60(SUPPL. 5), pp. 168-180.

Panagiotakos, D.B., Milias, G.A., Pitsavos, C. and Stefanadis, C. (2006a) 'MedDietScore: A computer program that evaluates the adherence to the Mediterranean dietary pattern and its relation to cardiovascular disease risk', *Computer Methods and Programs in Biomedicine*, 83(1), pp. 73-77.

Panagiotakos, D.B., Pitsavos, C., Arvaniti, F. and Stefanadis, C. (2007a) 'Adherence to the Mediterranean food pattern predicts the prevalence of hypertension, hypercholesterolemia, diabetes and obesity, among healthy adults; the accuracy of the MedDietScore', *Preventive Medicine*, 44(4), pp. 335-340.

Panagiotakos, D.B., Pitsavos, C., Skoumas, Y. and Stefanadis, C. (2007b) '{A figure is presented}The Association between Food Patterns and the Metabolic Syndrome Using Principal Components Analysis: The ATTICA Study', *Journal of the American Dietetic Association*, 107(6), pp. 979-987.

Panagiotakos, D.B., Pitsavos, C. and Stefanadis, C. (2006b) 'Dietary patterns: A Mediterranean diet score and its relation to clinical and biological markers of cardiovascular disease risk', *Nutrition, Metabolism and Cardiovascular Diseases*, 16(8), pp. 559-568.

Panagiotakos, D.B., Polystipioti, A., Papairakleous, N. and Polychronopoulos, E. (2007c) 'Long-term adoption of a Mediterranean diet is associated with a better health status in elderly people; a cross-sectional survey in Cyprus', *Asia Pacific Journal of Clinical Nutrition*, 16(2), pp. 331-337.

Patterson, R.E., Haines, P.S. and Popkin, B.M. (1994) 'Diet Quality Index: Capturing a multidimensional behavior', *Journal of the American Dietetic Association*, 94(1), pp. 57-64.

Pearce, M.S., Unwin, N.C., Parker, L. and Craft, A.W. (2009) 'Cohort profile: The Newcastle thousand families 1947 birth cohort', *International Journal of Epidemiology*, 38(4), pp. 932-937.

Pérez-López, F.R., Chedraui, P., Haya, J. and Cuadros, J.L. (2009) 'Effects of the Mediterranean diet on longevity and age-related morbid conditions', *Maturitas*, 64(2), pp. 67-79.

Pitsavos, C., Panagiotakos, D.B., Tzima, N., Chrysohoou, C., Economou, M., Zampelas, A. and Stefanadis, C. (2005) 'Adherence to the Mediterranean diet is associated with total antioxidant capacity in healthy adults: the ATTICA study', *American Journal of Clinical Nutrition*, 82(3), pp. 694-9.

Polychronopoulos, E., Panagiotakos, D.B. and Polystipioti, A. (2005) 'Diet, lifestyle factors and hypercholesterolemia in elderly men and women from Cyprus', *Lipids in Health and Disease*, 4.

Probst, Y. and Tapsell, L. (2007) 'Over- and underreporting of energy intake by patients with metabolic syndrome using an automated dietary assessment website', *Nutrition and Dietetics*, 64(4), pp. 280-284.

Psaltopoulou, T., Sergentanis, T.N., Panagiotakos, D.B., Sergentanis, I.N., Kosti, R. and Scarmeas, N. (2013) 'Mediterranean diet, stroke, cognitive impairment, and depression: A meta-analysis', *Annals of Neurology*, 74(4), pp. 580-591.

Puchau, B., Ángeles Zulet, M., de Echávarri, A.G., Hermsdorff, H.H.M. and Alfredo Martínez, J. (2009) 'Dietary total antioxidant capacity: A novel indicator of diet quality in healthy young adults', *Journal of the American College of Nutrition*, 28(6), pp. 648-656.

Puel, C., Coxam, V. and Davicco, M.J. (2007) 'Mediterranean diet and osteoporosis prevention', *Régime Méditerranéen et osteóporose*, 23(8-9), pp. 756-760.

Reedy, J., Mitrou, P.N., Krebs-Smith, S.M., Wirfält, E., Flood, A., Kipnis, V., Leitzmann, M., Mouw, T., Hollenbeck, A., Schatzkin, A. and Subar, A.F. (2008)

'Index-based dietary patterns and risk of colorectal cancer', *American Journal of Epidemiology*, 168(1), pp. 38-48.

Rienks, J., Dobson, A.J. and Mishra, G.D. (2013) 'Mediterranean dietary pattern and prevalence and incidence of depressive symptoms in mid-aged women: Results from a large community-based prospective study', *European Journal of Clinical Nutrition*, 67(1), pp. 75-82.

Rivas, A., Romero, A., Mariscal-Arcas, M., Monteagudo, C., Feriche, B., Lorenzo, M.L. and Olea, F. (2013) 'Mediterranean diet and bone mineral density in two age groups of women', *International Journal of Food Sciences and Nutrition*, 64(2), pp. 155-161.

Romaguera, D. (2011) 'Mediterranean diet and type 2 diabetes risk in the European prospective investigation into cancer and nutrition (EPIC) study: The interAct project', *Diabetes Care*, 34(9), pp. 1913-1918.

Romaguera, D., Norat, T., Vergnaud, A.C., Mouw, T., May, A.M., Agudo, A., Buckland, G., Slimani, N., Rinaldi, S., Couto, E., Clavel-Chapelon, F., Boutron-Ruault, M.C., Cottet, V., Rohrmann, S., Teucher, B., Bergmann, M., Boeing, H., Tjønneland, A., Halkjaer, J., Jakobsen, M.U., Dahm, C.C., Travier, N., Rodriguez, L., Sanchez, M.J., Amiano, P., Barricarte, A., Huerta, J.M., Luan, J., Wareham, N., Key, T.J., Spencer, E.A., Orfanos, P., Naska, A., Trichopoulou, A., Palli, D., Agnoli, C., Mattiello, A., Tumino, R., Vineis, P., Bueno-de-Mesquita, H.B., Büchner, F.L., Manjer, J., Wirfält, E., Johansson, I., Hellstrom, V., Lund, E., Braaten, T., Engeset, D., Odysseos, A., Riboli, E. and Peeters, P.H.M. (2010) 'Mediterranean dietary patterns and prospective weight change in participants of the EPIC-PANACEA project', *American Journal of Clinical Nutrition*, 92(4), pp. 912-921.

Rossi, M., Negri, E., Bosetti, C., Dal Maso, L., Talamini, R., Giacosa, A., Montella, M., Franceschi, S. and La Vecchia, C. (2008) 'Mediterranean diet in relation to body mass index and waist-to-hip ratio', *Public Health Nutrition*, 11(2), pp. 214-217.

Rumawas, M.E., Dwyer, J.T., McKeown, N.M., Meigs, J.B., Rogers, G. and Jacques, P.F. (2009) 'The development of the Mediterranean-Style Dietary

Pattern Score and its application to the American diet in the Framingham Offspring Cohort', *Journal of Nutrition*, 139(6), pp. 1150-1156.

Sánchez-Castillo, C.P., Franklin, M., McNeill, G., De Lourdes Solano, M., Bonner, S., López, N., Davidson, L. and James, W.P.T. (2001) 'Are the proposed limits of energy intake:basal metabolic rate and dietary nitrogen:urinary nitrogen ratios suitable for validation of food intake?', *British Journal of Nutrition*, 85(6), pp. 725-731.

Sánchez-Villegas, A., Bes-Rastrollo, M., Martínez-González, M. and Serra-Majem, L. (2006) 'Adherence to a Mediterranean dietary pattern and weight gain in a follow-up study: The SUN cohort', *International Journal of Obesity*, 30(2), pp. 350-358.

Sauro, J. (2011) *A practical guide to the System Usability Scale: Background, benchmarks, & best practices*. Denver, CO: Measuring Usability LLC.

Scarmeas, N., Luchsinger, J.A., Mayeux, R. and Stern, Y. (2007) 'Mediterranean diet and Alzheimer disease mortality', *Neurology*, 69(11), pp. 1084-1093.

Scarmeas, N., Stern, Y., Mayeux, R. and Luchsinger, J.A. (2006) 'Mediterranean diet, alzheimer disease, and vascular mediation', *Archives of Neurology*, 63(12), pp. 1709-1717.

Scarmeas, N., Stern, Y., Mayeux, R., Manly, J.J., Schupf, N. and Luchsinger, J.A. (2009) 'Mediterranean diet and mild cognitive impairment', *Archives of Neurology*, 66(2), pp. 216-225.

Schatzkin, A., Kipnis, V., Carroll, R.J., Midthune, D., Subar, A.F., Bingham, S., Schoeller, D.A., Troiano, R.P. and Freedman, L.S. (2003) 'A comparison of a food frequency questionnaire with a 24-hour recall for use in an epidemiological cohort study: Results from the biomarker-based Observing Protein and Energy Nutrition (OPEN) study', *International Journal of Epidemiology*, 32(6), pp. 1054-1062.

Schröder, H., Fitó, M., Estruch, R., Martínez-González, M.A., Corella, D., Salas-Salvadó, J., Lamuela-Raventós, R., Ros, E., Salaverría, I., Fiol, M., Lapetra, J., Vinyoles, E., Gómez-Gracia, E., Lahoz, C., Serra-Majem, L., Pintó, X., Ruiz-Gutierrez, V. and Covas, M.I. (2011) 'A Short screener is valid for assessing mediterranean diet adherence among older spanish men and women', *Journal of Nutrition*, 141(6), pp. 1140-1145.

Schröder, H., Marrugat, J. and Covas, M.I. (2006) 'High monetary costs of dietary patterns associated with lower body mass index: A population-based study', *International Journal of Obesity*, 30(10), pp. 1574-1579.

Schuit, S.C.E., Van Der Klift, M., Weel, A.E.A.M., De Laet, C.E.D.H., Burger, H., Seeman, E., Hofman, A., Uitterlinden, A.G., Van Leeuwen, J.P.T.M. and Pols, H.A.P. (2004) 'Fracture incidence and association with bone mineral density in elderly men and women: The Rotterdam Study', *Bone*, 34(1), pp. 195-202.

Seiquer, I., Mesías, M., Hoyos, A.M., Galdó, G. and Navarro, M.P. (2008) 'A Mediterranean dietary style improves calcium utilization in healthy male adolescents', *Journal of the American College of Nutrition*, 27(4), pp. 454-462.

Serra-Majem, L., Ribas, L., Ngo, J., Ortega, R.M., García, A., Pérez-Rodrigo, C. and Aranceta, J. (2004) 'Food, youth and the Mediterranean diet in Spain. Development of KIDMED, Mediterranean Diet Quality Index in children and adolescents', *Public Health Nutrition*, 7(7), pp. 931-935.

Shaw, C.A., Lara, J., Adamson, A.J., Jones, A.R. and Mathers, J.C. (2013) 'Dietary patterns as predictors of childhood adiposity', *Proceedings of the Nutrition Society*, 72(OCE4), p. E190.

Skarupski, K.A., Tangney, C.C., Li, H., Evans, D.A. and Morris, M.C. (2013) 'Mediterranean diet and depressive symptoms among older adults over time', *Journal of Nutrition, Health and Aging*, 17(5), pp. 441-445.

Slattery, M.L., Murtaugh, M.A., Schumacher, M.C., Johnson, J., Edwards, S., Edwards, R., Benson, J., Tom-Orme, L. and Lanier, A.P. (2008) 'Development, Implementation, and Evaluation of a Computerized Self-Administered Diet History Questionnaire for Use in Studies of American Indian and Alaskan Native People', *Journal of the American Dietetic Association*, 108(1), pp. 101-109.

Slimani, N., Casagrande, C., Nicolas, G., Freisling, H., Huybrechts, I., Ocké, M.C., Niekerk, E.M., Van Rossum, C., Bellemans, M., De Maeyer, M., Lafay, L., Krems, C., Amiano, P., Trolle, E., Geelen, A., De Vries, J.H. and De Boer, E.J. (2011) 'The standardized computerized 24-h dietary recall method EPIC-Soft adapted for pan-European dietary monitoring', *European Journal of Clinical Nutrition*, 65(SUPPL. 1), pp. S5-S15.

Slimani, N., Deharveng, G., Charrondière, R.U., Van Kappel, A.L., Ocké, M.C., Welch, A., Lagiou, A., Van Liere, M., Agudo, A., Pala, V., Brandstetter, B., Andren, C., Stripp, C., Van Staveren, W.A. and Riboli, E. (1999) 'Structure of the standardized computerized 24-h diet recall interview used as reference method in the 22 centers participating in the EPIC project', *Computer Methods and Programs in Biomedicine*, 58(3), pp. 251-266.

Smith, A.D.A.C., Emmett, P.M., Newby, P.K. and Northstone, K. (2011) 'A comparison of dietary patterns derived by cluster and principal components analysis in a UK cohort of children', *European Journal of Clinical Nutrition,* 65, pp. 1102-1109.

Smithers, G., Finch, S.A., Doyle, W., Lowe, C., Bates, C.J., Prentice, A. and Clarke, P.C. (1998) 'The National Diet and Nutrition Survey: people aged 65 years and over.', *Nutrition & Food Science*, 98(3), pp. 133-134.

Sofi, F., Abbate, R., Gensini, G.F. and Casini, A. (2010a) 'Accruing evidence on benefits of adherence to the Mediterranean diet on health: An updated systematic review and meta-analysis', *American Journal of Clinical Nutrition*, 92(5), pp. 1189-1196.

Sofi, F., Macchi, C., Abbate, R., Gensini, G.F. and Casini, A. (2010b) 'Effectiveness of the mediterranean diet: Can it help delay or prevent Alzheimer's disease?', *Journal of Alzheimer's Disease*, 20(3), pp. 795-801.

Sotos-Prieto, M., Luben, R., Khaw, K.T., Wareham, N.J. and Forouhi, N.G. (2014) 'The association between Mediterranean Diet Score and glucokinase regulatory protein gene variation on the markers of cardiometabolic risk: An analysis in the European Prospective Investigation into Cancer (EPIC)-Norfolk study', *British Journal of Nutrition*, 112(1), pp. 122-131.

Stanner, S. and Denny, A. (2009) 'Healthy ageing: The role of nutrition and lifestyle - a new British Nutrition Foundation task force report', *Nutrition Bulletin*, 34(1), pp. 58-63.

Subar, A.F., Crafts, J., Zimmerman, T.P., Wilson, M., Mittl, B., Islam, N.G., McNutt, S., Potischman, N., Buday, R., Hull, S.G., Baranowski, T., Guenther, P.M., Willis, G., Tapia, R. and Thompson, F.E. (2010) 'Assessment of the Accuracy of Portion Size Reports Using Computer-Based Food Photographs Aids in the Development of an Automated Self-Administered 24-Hour Recall', *Journal of the American Dietetic Association*, 110(1), pp. 55-64.

Subar, A.F., Thompson, F.E., Potischman, N., Forsyth, B.H., Buday, R., Richards, D., McNutt, S., Hull, S.G., Guenther, P.M., Schatzkin, A. and Baranowski, T. (2007) 'Formative Research of a Quick List for an Automated Self-Administered 24-Hour Dietary Recall', *Journal of the American Dietetic Association*, 107(6), pp. 1002-1007.

The Institute for Fiscal Studies (2011) *English Longitudinal Study of Ageing Documentation: Main self-completion questionnaire*. Available at: http://www.elsa-project.ac.uk/documentation.

The NHS Information Centre for Health and Social Care (2011) *Health Survey for England 2010 Trend Tables*. [Online]. Available at: http://www.ic.nhs.uk/pubs/hse10trends.

Thompson, F.E. and Subar, A.F. (2008) 'Dietary Assessment Methodology', in Coulston, A.M. and Boushey, C.J. (eds.) *Nutrition in the prevention and treatment of disease.* 2nd Edition edn. San Diego, CA: Academic Press, pp. 3-39.

Thompson, F.E., Subar, A.F., Loria, C.M., Reedy, J.L. and Baranowski, T. (2010) 'Need for Technological Innovation in Dietary Assessment', *Journal of the American Dietetic Association*, 110(1), pp. 48-51.

Timon, C.M., Astell, A.J., Hwang, F., Adlam, T.D., Smith, T., Maclean, L., Spurr, D., Forster, S.E. and Williams, E.A. (2015) 'The validation of a computer-based food record for older adults: the Novel Assessment of Nutrition and Ageing (NANA) method', *British Journal of Nutrition*, 113(4), pp. 654-664.

Tinuviel Software (2014) *WISP 4* [Online]. Available at: http://www.tinuvielsoftware.co.uk/wisp4.htm (Accessed: 01.02.2015).

Tognon, G., Hebestreit, A., Lanfer, A., Moreno, L.A., Pala, V., Siani, A., Tornaritis, M., De Henauw, S., Veidebaum, T., Molnár, D., Ahrens, W. and Lissner, L. (2014) 'Mediterranean diet, overweight and body composition in children from eight European countries: Cross-sectional and prospective results from the IDEFICS study', *Nutrition, Metabolism and Cardiovascular Diseases*, 24(2), pp. 205-213.

Tognon, G., Rothenberg, E., Eiben, G., Sundh, V., Winkvist, A. and Lissner, L. (2011) 'Does the Mediterranean diet predict longevity in the elderly? A Swedish perspective', *Age*, 33(3), pp. 439-450.

Togo, P., Osler, M., Sorensen, T. and Heitmann, B. (2001) 'Food intake patterns and body mass index in observational studies', *International Journal of Obesity*, 25(12), pp. 1741-1751.

Toledo, E., Carmona-Torre, F.D., Alonso, A., Puchau, B., Zulet, M.A., Martinez, J.A. and Martinez-Gonzalez, M.A. (2010) 'Hypothesis-oriented food patterns and incidence of hypertension: 6-year follow-up of the SUN (Seguimiento Universidad de Navarra) prospective cohort', *Public Health Nutrition*, 13(3), pp. 338-349.

Touvier, M., Kesse-Guyot, E., Mejean, C., Pollet, C., Malon, A., Castetbon, K. and Hercberg, S. (2011) 'Comparison between an interactive web-based self-administered 24 h dietary record and an interview by a dietitian for large-scale epidemiological studies', *British Journal of Nutrition*, 105(7), pp. 1055-1064.

Trichopoulou, A. (2005) 'Modified Mediterranean diet and survival: EPIC-elderly prospective cohort study', *British Medical Journal*, 330(7498), pp. 991-995.

Trichopoulou, A., Bamia, C., Lagiou, P. and Trichopoulos, D. (2010) 'Conformity to traditional Mediterranean diet and breast cancer risk in the Greek EPIC

(European Prospective Investigation into Cancer and Nutrition) cohort', *American Journal of Clinical Nutrition*, 92(3), pp. 620-625.

Trichopoulou, A., Bamia, C. and Trichopoulos, D. (2005) 'Mediterranean diet and survival among patients with coronary heart disease in Greece', *Archives of Internal Medicine*, 165(8), pp. 929-935.

Trichopoulou, A., Bamia, C. and Trichopoulos, D. (2009) 'Anatomy of health effects of Mediterranean diet: Greek EPIC prospective cohort study', *BMJ (Online)*, 339(7711), pp. 26-28.

Trichopoulou, A., Costacou, T., Bamia, C. and Trichopoulos, D. (2003) 'Adherence to a Mediterranean diet and survival in a Greek population', *New England Journal of Medicine*, 348(26), pp. 2599-2608.

Trichopoulou, A., Kouris-Blazos, A., Wahlqvist, M.L., Gnardellis, C., Lagiou, P., Polychronopoulos, E., Vassilakou, T., Lipworth, L. and Trichopoulos, D. (1995) 'Diet and overall survival in elderly people', *British Medical Journal*, 311(7018), pp. 1457-1460.

Trichopoulou, A., Lagiou, P., Kuper, H. and Trichopoulos, D. (2000) 'Cancer and Mediterranean dietary traditions', *Cancer Epidemiology Biomarkers and Prevention*, 9(9), pp. 869-873.

Trolle, E., Amiano, P., Ege, M., Bower, E., Lioret, S., Brants, H., Kaic-Rak, A., De Boer, E.J. and Andersen, L.F. (2011) 'Feasibility of repeated 24-h dietary recalls combined with a food-recording booklet, using EPIC-Soft, among preschoolers', *European Journal of Clinical Nutrition*, 65(SUPPL. 1), pp. S84-S86.

Trovato, F.M., Catalano, D., Martines, G.F., Pace, P. and Trovato, G.M. (2015) 'Mediterranean diet and non-alcoholic fatty liver disease. The need of extended and comprehensive interventions', *Clinical Nutrition,* 34(1), pp. 86-88.

Uchida, K., Kimura, Y., Shirota, T. and Kono, S. (2007) 'Validity and Reproducibility of the PC-assisted Dietary Interview Used in the Fukuoka Colorectal Cancer Study', *Asian Pacific Journal of Cancer Prevention*, 8(4), pp. 583-590.

United Nations Department of Economic and Social Affairs Population Division (2002) *World Population Ageing: 1950-2050*. New York: Publications, U.N. [Online]. Available at: http://www.un.org/esa/population/publications/worldageing19502050/.

University of Oxford (2014) *National Perinatal Epidemiology Unit (NPEU) IMD Tool*. Available at: http://tools.npeu.ox.ac.uk/imd/.

Vance, V.A., Woodruff, S.J., McCargar, L.J., Husted, J. and Hanning, R.M. (2009) 'Self-reported dietary energy intake of normal weight, overweight and obese adolescents', *Public Health Nutrition*, 12(2), pp. 222-227.

Vereecken, C.A., Covents, M., Haynie, D. and Maes, L. (2009) 'Feasibility of the Young Children's Nutrition Assessment on the Web', *Journal of the American Dietetic Association*, 109(11), pp. 1896-1902.

Vereecken, C.A., Covents, M., Matthys, C. and Maes, L. (2005) 'Young adolescents' nutrition assessment on computer (YANA-C)', *European Journal of Clinical Nutrition*, 59(5), pp. 658-667.

Vereecken, C.A., Covents, M., Sichert-Hellert, W., Alvira, J.M.F., Le Donne, C., De Henauw, S., De Vriendt, T., Phillipp, M.K., Béghin, L., Manios, Y., Hallström, L., Poortvliet, E., Matthys, C., Plada, M., Nagy, E. and Moreno, L.A. (2008) 'Development and evaluation of a self-administered computerized 24-h dietary recall method for adolescents in Europe', *International Journal of Obesity*, 32(SUPPL. 5), pp. S26-S34.

Waijers, P.M.C.M., Feskens, E.J.M. and Ocké, M.C. (2007) 'A critical review of predefined diet quality scores', *British Journal of Nutrition*, 97(2), pp. 219-231.

Whittle, C.R., Woodside, J.V., Cardwell, C.R., McCourt, H.J., Young, I.S., Murray, L.J., Boreham, C.A., Gallagher, A.M., Neville, C.E. and McKinley, M.C. (2012) 'Dietary patterns and bone mineral status in young adults: The Northern Ireland Young Hearts Project', *British Journal of Nutrition*, 108(8), pp. 1494-1504.

Willett, W.C., Sacks, F., Trichopoulou, A., Drescher, G., Ferro-Luzzi, A., Helsing, E. and Trichopoulos, D. (1995) 'Mediterranean diet pyramid: A cultural model for healthy eating', *American Journal of Clinical Nutrition*, 61(6 SUPPL.), pp. 1402S-1406S.

Woodruff, S.J. and Hanning, R.M. (2010) 'Development and implications of a revised Canadian Healthy Eating Index (HEIC-2009)', *Public Health Nutrition*, 13(6), pp. 820-825.

World Health Organisation (2000) *Obesity: preventing and managing the global epidemic. Report of a WHO Consultation*. Geneva.

World Health Organisation (2011) *Global Atlas on Cardiovascular Disease Prevention and Control*. Geneva. [Online]. Available at: http://www.who.int/cardiovascular_diseases/publications/atlas_cvd/en/index.html.

Wyatt, J.C. (2000) 'When to use web-based surveys', *Journal of the American Medical Informatics Association*, 7(4), pp. 426-430.

Zickuhr, K. and Madden, M. (2012) *Older Adults and Internet Use*. [Online]. Available at: www.sainetz.at/dokumente/Older_adults_and_internet_use_2012.pdf.

Zimmerman, T.P., Hull, S.G., McNutt, S., Mittl, B., Islam, N., Guenther, P.M., Thompson, F.E., Potischman, N.A. and Subar, A.F. (2009) 'Challenges in converting an interviewer-administered food probe database to self-administration in the National Cancer Institute automated self-administered 24-hour recall (ASA24)', *Journal of Food Composition and Analysis*, 22(SUPPL.), pp. S48-S51.

Zoellner, J., Anderson, J. and Gould, S.M. (2005) 'Comparative validation of a bilingual interactive multimedia dietary assessment tool', *Journal of the American Dietetic Association*, 105(8), pp. 1206-1214.